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Points of bone and antler from the Late Mesolithic settlement in Motala, eastern central Sweden

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Abstract
Excavations in Motala, eastern central Sweden, have yielded a large and diverse material of osseous tools dating from the Late Mesolithic, c. 6000–4500 cal. BC. The assembled collection comprises some 1500 pieces. About half of the identified tool types consist of different types of bone points among which barbed points dominate. The utilised raw materials were predominantly red deer (Cervus elaphus) metatarsals and antler, but other elements do also occur, as do bones from other species such as elk (Alces alces) and roe deer (Capreolus capreolus).
More than 450 fragments of barbed points have been identified and interpreted as leister points or harpoon heads. The barbed points were classified morphologically according to the general appearance of their corpuses (setting of barbs), but more specifically to their basal ends. Aside from harpoons eight different groups of leister points were defined. The leister points are interpreted as prongs or single-hafted points for fish-spears. Plain bone points are the second largest group; these may be sorted into several types, which are primarily interpreted as projectiles like arrowheads. Small bullet-like arrowheads and some rhombic points as well as club-shaped points made of antler are also present. Slotted points appear in two different types, either with uni- or bi-lateral edges.
Based on the collection from the site Strandvägen and with the help of defined morphological groups as well as a large number of radiocarbon dates, we have identified a change in the utilisation of fishing implements at Motala at c. 5000 cal. BC. The change is detected as a discontinuation in the use of barbed leister points and a possible shift from bi-laterally to uni-laterally slotted points in addition to decreasing human activities on the settlement in general, despite a continued presence at the site.

1 Introduction

The Mesolithic settlement, c. 9000–4500 cal. BC, in Motala in eastern central Sweden has seen major archaeological work (Fig. 1a). The first excavations were undertaken in 1999–2003 in connection to the construction of a new railway bridge over the river Motala Ström (Carlsson 2008). These were followed by a series of more recent excavations during the years 2009–2013. Three sites have been subject to investigations: Strandvägen along the southern shore of the river as well as Verkstadsvägen and Kanaljorden on its northern side (Hagberg/Westermark 2015; Hallgren/Fornander 2016; Molin et al. 2014).

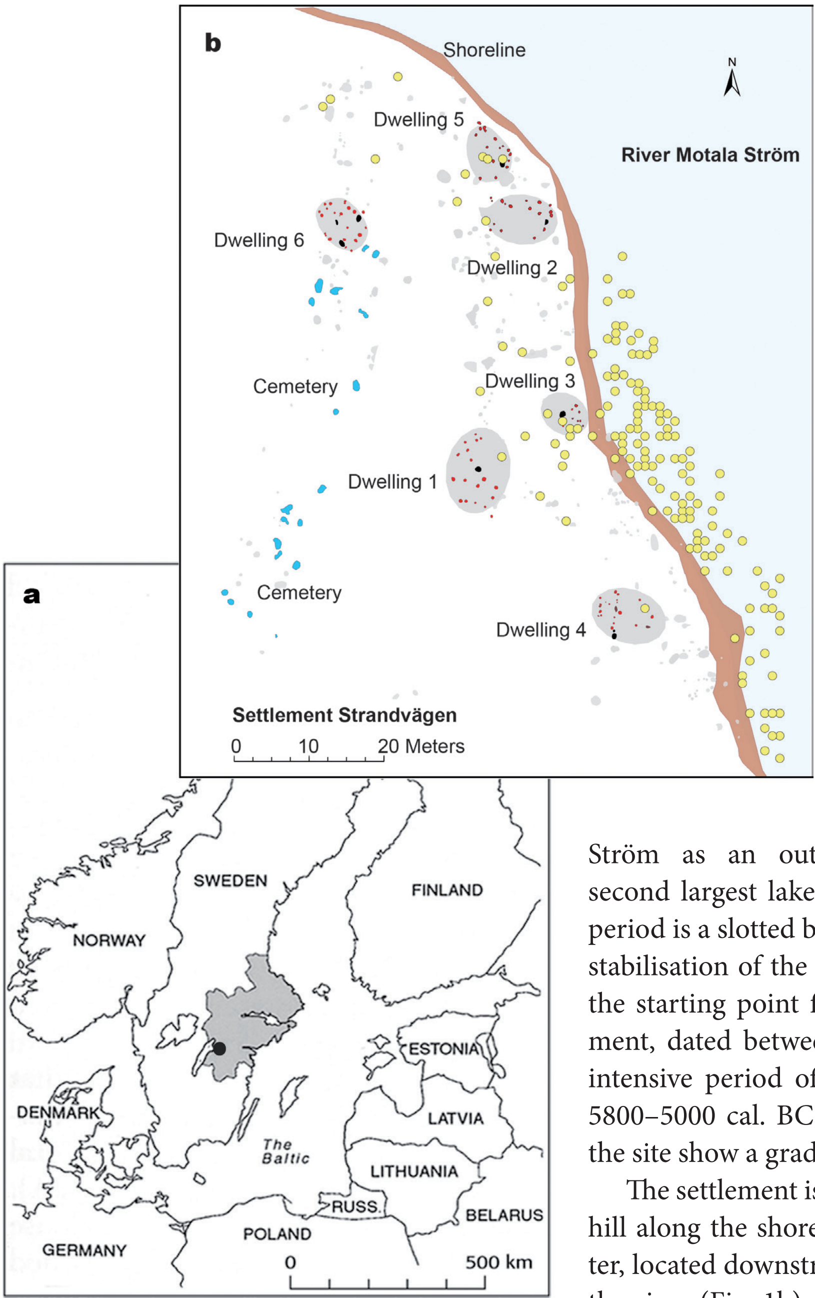

Fig. 1. a – Map of Northern Europe and the Baltic region. The shaded area indicates the region of eastern central Sweden. A dot marks the position of Motala beside Lake Vättern; b – Site plan of the settlement at Strandvägen, Motala, showing dwellings and burials along the shoreline of River Motala Ström. The yellow dots mark deposited tips of barbed leister points, indicating the main area for leister fishing along the shoreline (graphics F. Molin/ P. Zetterlund, Swedish National Historical Museums).

The largest excavations were conducted at Strandvägen. The first traces of settlement activity on the site are seen around 7000 cal. BC, in conjunction with the initial stages of the forming of Motala Ström as an outlet to Lake Vättern, Sweden's second largest lake. Among the few finds from this period is a slotted bone point with small notches. The stabilisation of the river shortly after 6000 cal. BC is the starting point for a large Late Mesolithic settlement, dated between 6000–4500 cal. BC. The most intensive period of settlement activities is dated to 5800–5000 cal. BC, while thereafter the activities at the site show a gradual decline.

The settlement is centered on a low sandy moraine hill along the shores of a shallow and calm backwater, located downstream from the first small rapids in the river (Fig. 1b). Six dwellings – post-built houses or huts – have been excavated as well as a cemetery with at least 19 identified burials (Gummesson/Molin 2016). Adjacent to the dwellings there were areas for cooking and storage as well as knapping floors (Molin et al. in press). The site comprises thick occupation layers which also continue from the shore out into the river, where they mix with gyttja layers formed by the sedimentation at the bottom of the backwater. A large number of tools of bone and antler as well as production waste were deposited on land and in the submerged sediments. High pH-values of the soil and an anaerobic environment underwater have provided excellent conditions for the preservation of osseous material.

Fishing was of significant importance, and the rich aquatic resources were probably one reason for the location and intensity of the settlement (Carlsson 2008; Molin et al. in press). Stable isotope analyses on human remains show a protein intake dominated by aquatic resources, probably consisting of both freshwater and marine fish in varied proportions (Eriksson et al. 2018). Perch (*Perca fluviatilis*) and pike (*Esox lucius*) dominate the fish assemblage, and in addition eel (*Anguilla anguilla*), smaller Salmonids, pike-perch (*Sander lucioperca*), roach (*Rutilus rutilus*), European whitefish (*Coregonus lavaretus*), and Cyprinids have also been identified (Gummesson et al. 2017a). Previous research suggested that large brown trout (*Salmo trutta*), unique to Lake Vättern and one of two species targeted for fishing there during historical times, could also have been the main attraction during the Mesolithic (Carlsson 2008, 177). But as no larger-sized bones of Salmonids have been identified among the fish bones, pike and eel seem to have been the main target of Mesolithic leister-fishing there instead. Among other fishing implements from Strandvägen are also finds of gorges (toggle hooks) and netting needles (*navettes*) made of bone, and there is evidence of nets in the form of bark floats and stone net sinkers. Most important finds are a fish-weir and the remains of several wicker (basket) fish traps from the inner part of the backwater. The fish traps have been dated to two separate chronological phases, c. 5600–5000 and 4800–4600 cal. BC (Molin et al. in press).

The site's bone industry seems to have been mainly geared to the manufacture of bone points. Most obvious are the large numbers of barbed points, interpreted as points for leisters, either single-hafted for fish-spears or fork-like in pairs as leister prongs. Barbed points from the first excavations (1999–2003) have previously been examined by Bergstrand (2005) in an initial typo-chronological classification attempt. 23 points, mainly broken tips (one point was complete, and three finds consisted of basal ends), were classified, and the results were supported by five radiocarbon dates. Four types, types A–D, were recognised according to their different general morphology as well as the shapes and setting of their barbs (Bergstrand 2005, table 1). According to this classification, type A points are strikingly uniform with convex angular barbs set at regular intervals (Fig. 2). Type B points have a more concave form and are slightly asymmetrical, with barbs at greater angles and with a convex triangular shape. Types C and D consist of singular tips of antler harpoons. The radiocarbon dates display a narrow sequence. Type A was dated to around 5500 cal. BC, type B was the latest one, dated to between 5400–5000 cal. BC, and the harpoons were of an older date, before 5500 cal. BC (Bergstrand 2005, table 3; Fig. 3).

Fig. 2. Examples of barbed tips from leister points from Strandvägen, Motala. These tips correspond to Bergstrand's type A and are strikingly uniform with convex angular barbs set at regular intervals (photo and graphics P. Zetterlund, Swedish National Historical Museums).

The present classification of barbed points does not follow this previous work. Instead the barbed points are now classified according to the morphology of their basal ends, as the morphology of barbs can change during use or re-shaping of each point. We do, however, link our results to those of the previous study.

The aim of this paper is to present the complete collection of bone points and possible chronological changes in the inventory at Strandvägen, using a detailed osteological analysis and a morphological classification combined with an extensive set of radiocarbon data. We have also incorporated radiocarbon data from six bone points from Kanaljorden, a ceremonial context with a short chronological timespan of c. 5800 cal. BC (Hallgren/Fornander 2016), corresponding to the earlier phase of the settlement at Strandvägen as well as the previous radiocarbon data from the Strandvägen site. Additionally, we have included a brief evaluation of context and studied depositional patterns of bone tools, considering taphonomic aspects of spatial distribution patterns at Strandvägen.

2 Methods of analysis and dating

The complete assemblage has undergone a technological analysis concerning the production of bone tools (Gummesson 2018). The assemblage was analysed and classified by the authors, with regards to the identification of different techniques (David 2007) and the identification of different waste products such as flakes and blanks, but also debitage in form of cut-off metapodial epiphyses. Waste products were identified in regard to a general operational chain including several steps; the removal of the distal epiphyses and occasional calibration of the proximal epiphyses, splitting and forming of the bones by percussion or, more seldom, with grooving, and finally scraping or grinding the surface of the object. Both waste products and finished tools were registered with regards to visible surfaces modifications, e.g. scraping and grinding (David 2007; 2008; Gummesson 2018). Tools have been registered as to part of the identified object and assessed in regard to a general degree of completeness (i.e. fragments, half of a complete object, or complete). The description of the orientation of tools follows the one published by Voruz (1984).

All bone fragments including bone tools were identified as to species or to higher taxa, and to bone element and part of element (bones identified as those of Suidae have been grouped as wild boar, as it is considered most likely that they represent wild animals in this context). Quantification was made according to the number of identified specimens, NISP (Lyman 1994, 100). A relatively high level of fragmentation and significant human modifications made it difficult to use other methods. The minimum number of individuals (MNI) represented among the tools and the waste products was calculated based on the minimum number of elements (MNE; Lyman 1994, 100–104). A detailed taphonomic analysis was conducted on a major part of the assemblage (finds from 2009–2013), including observations of fragment size and fracture analysis according to methods presented by Outram (2001) and Johnson (1985). Calculated results presented in the paper are based on data from this detailed analysis.

Most radiocarbon analyses were conducted at the Ångström Laboratory in Uppsala. A few finds were also dated at the ICA in Miami. All dates included are presented in Appendix 1 (previously unpublished radiocarbon dates) as well as Appendix 2 (previously published dates). Dates provided are those reported by the laboratories and in referenced sources (Appendix 2): no further modelling of the radiocarbon data was conducted for this paper. All dates (Fig. 3) are calibrated using OxCal 3.10 (Bronk Ramsey 2001; 2005), using the IntCal04.14c calibration curve (Reimer et al. 2004).

Most finds were dated on collagen from bone or antler (n = 33), but 16 finds were also dated on traces of resin still attached to basal ends or slots. The pretreatment of the dated resin samples (at the Ångström Laboratory) included a separation of soluble and insoluble parts. Soluble fractions consist mostly of washed and dried humus material, called fraction SOL. The insoluble part, called INS, consists mainly of the original organic material and forms the dated part in the current survey. Prior to AMS determination the content was burnt to CO_2 gas, which in turn was converted to solid graphite through a Fe-catalytic reaction (Possnert/Pettersson 2016).

3 The Strandvägen collection

A total of 1468 finds of bone and antler tools or objects have been identified in the material of the excavations 1999–2013. The most common implements are barbed bone points (leister points and harpoon heads: 31 %), followed by plain bone points (12 %; see Table 1). Everyday utensils and personal ornaments occur, too, but the numbers are comparably low. The finds are mostly unburned (14 % of the fragments are charred or burned), and the collection comprises approximately 4 % (NISP) of all the faunal remains recovered from the site. These numbers are probably an underestimation due to a high degree of fragmentation hindering secure identifications of broken objects (see: Deposition and spatial patterns, Table 5). Despite a high level of fragmentation 27 % of the bone tools represent half or even more than half of a complete tool. Almost all identified tools, 85 %, exhibit fractures indicative of fragmentation during usage, i.e. bones broken while still fresh; 8 % have fractures which originated in dry bone.

Most of the osseous tools were made of metatarsals or antler of red deer (*Cervus elaphus*). Elk (*Alces alces*), roe deer (*Capreolus capreolous*), and wild boar (*Sus scrofa*) bones are also commonly represented. Objects made of bones from birds, brown bear (*Ursus arctos*) and beaver (*Castor fiber*) are uncommon (Table 2); the only securely identified finds are beads made of tubular bird bones. Two finds made of teeth of brown bear and beaver also likely represent personal ornaments such as pendants, as such are known for example from Zvejnieki in Latvia (Lõugas 2006). Points were made of bone or antler of large ungulates such as red deer or elk (then mostly from the metapodium, or the shinbone); there are also examples of points (n = 6) made of roe deer bone and antler and bone from wild boar. The majority of the fragments, however, cannot be identified as to species or element due to both modifications and heavy fragmentation.

An important aspect of the bone industry is the production waste. At Strandvägen 6 % (NISP, n = 2185) of the faunal remains have been classified as waste products, including remnants of steps from primary reduction to finished products; raw material, debitage, blanks and preforms, demonstrating an extensive on-site production (Gummesson 2018). As among the finished tools, bones from red deer dominate the waste products (60 % [n = 1083]). Most common is antler (n = 756), but since antler fragments more easily than bone, yet still remains identifiable, direct comparisons of the frequencies are difficult. The most common bone elements are metatarsals (n = 171), in agreement with the element distribution among finished tools. Another important feature is the reshaping and re-use of broken tools. 27 items exhibit evidence of re-use, mostly in form of grinding after breakage and new use-wear; another 17 finds also exhibit traces that could indicate re-use, but mostly either the fragments or the modifications are too small to allow an interpretation of the original shape and type of modification. There are also flakes of tools (n = 38) with modified (often scraped) surfaces suggesting breakage during use or the re-knapping of broken items.

No less than 49 bone or antler tools have been radiocarbon dated, including six items from the site Kanaljorden. The radiocarbon data set from Motala represents one of the largest dating sequences of Mesolithic osseous tools from Sweden. A general overview of dated tools (Fig. 3) demonstrates a narrow chronological time span, between c. 5800–4500 cal. BC, correlating to the Late Mesolithic settlement, with the exception of one older point.

Table 1. Numbers of bone tool finds and waste products (NISP) and depositional contexts. Tool types are ranked in descending order. Numbers in brackets represent identified finds of re-used tools (re-used tools were catalogued representing the most recent identified use). Dry stratigraphy = tools recovered from occupation layers on land. Submerged sediments = tools recovered in sediments of River Motala Ström.

Bone tool	**Number of finds**	**Dry stratigraphy**	**%**	**Submerged sediments**	**%**
Leister point	446 (10)	117	26	329 (10)	74
Plain bone point	180 (2)	137	76	43 (2)	24
Awl	71 (4)	15	21	56 (4)	79
Chisel	53 (2)	4	8	49 (2)	92
Slotted bone point	43 (2)	30	70	13 (2)	30
Needle	35 (1)	33	94	2 (1)	6
Pressure flaker/Puncher	33	0	0	33	100
Unident. antler object	31	20	65	11	35
Spearhead	16 (3)	4	25	12 (3)	75
Harpoon head	14 (1)	3	21	11 (1)	79
Bead/Pendant	13	11	85	2	15
Adze/Mattock	10	0	0	10	100
Slotted dagger	8	1	12.5	7	87.5
Arrowhead	8	3	37.5	5	62.5
Navette	7 (2)	1	14	6 (2)	86
Knife, boar tusk	7	1	14	6	86
Enamel tool	7	6	86	1	14
Decorated antler object	6	1	17	5	83
Burin, boar tusk	6	0	0	6	100
Knife	5	0	0	5	100
Antler club	6	1	17	5	83
Fish hook	4	2	50	2	50
Antler shaft	4	0	0	4	100
Antler sleeve	3	0	0	3	100
Stopper/Cork	3	0	0	3	100
Spatula	2	0	0	2	100
Figurine	2	0	0	2	100
Wedge	1	0	0	1	100
Ulna dagger	1	0	0	1	100
Unident. tool	447	385	86	62	14
Total	1468 (27)	771	52	697 (27)	48
Waste products					
Flake	837 (38)	804 (35)	96	33 (3)	4
Blank	427	97	23	330	77
Preform	101	29	29	72	71
Distal epiphyses	64	11	17	53	83
Micro-splinter	13	9	69	4	31
Waste, unident.	743	193	26	550	74
Total	2185	755	42	1043	58

Table 2. Species distribution (NISP, MNI) among bone tools and production waste from Strandvägen, Motala. M.c. = Metacarpalia, M.t. = Metatarsalia, M.p. = Metapodia, Mand. = Mandibula, PE = proximal epiphyses, DE = distal epiphyses, Dxt = dexter (right), Sin = sinister (left).

Species	**Element**	**Bone tools**	**MNI**	**Waste products**	**MNI**
Red deer (*Cervus elaphus*)		280	6, *M.t., PE, Dxt (dorsal view)*	1083	7, *M.p., DE (Sin+Dxt)*
	Cornu	105		756	
	Cranium	0		6	
	Mandibula	3		2	
	Radius	3		26	
	Ulna	0		3	
	Metacarpalia	31		59	
	Femur	1		0	
	Tibia	18		26	
	Metatarsalia	108		171	
	Metapodium	12		34	
Elk (*Alces alces*)		35	1, *M.t., Sin*	17	2, *M.t., PE, Dxt*
	Cornu	3		2	
	Humerus	1		0	
	Radius	2		1	
	Metacarpalia	1		2	
	Telemetacarpalia	1		0	
	Tibia	11		1	
	Metatarsalia	11		7	
	Metapodium	3		0	
	Ossa longa	2		0	
Roe deer (*Capreolus capreolus*)		30	2, *Cornu, Sin*	57	1, *M.c., DE, Sin*
	Cornu	13		16	
	Metacarpalia	4		8	
	Tibia	1		1	
	Metatarsalia	11		31	
	Metapodium	1		1	
Wild boar (*Sus scrofa*)		24	1, *Canini, Mand., Sin*	11	1, *Canini, Mand., Dxt*
	Dentes (Incisivi et Canini)	21		8	
	Scapula	1		0	
	Femur	0		1	
	Tibia	2		2	
Brown bear (*Ursus arctos*)		1	1, *Canini*	0	
	Dentes (Canini)	1		0	
Beaver (*Castor fiber*)		1	1, *Incisivi, Mand., Dxt*	2	1, *Incisivi, Mand., Sin*
	Dentes (Incisivi)	1		2	
Cervidae		13		97	
Large Ungulate		381		82	
Unident. Mammalia		691		836	
Aves		11	1, *Humerus, PE, Sin*	0	
	Humerus	1		0	
	Ossa longa	10		0	
Total		1468		2185	

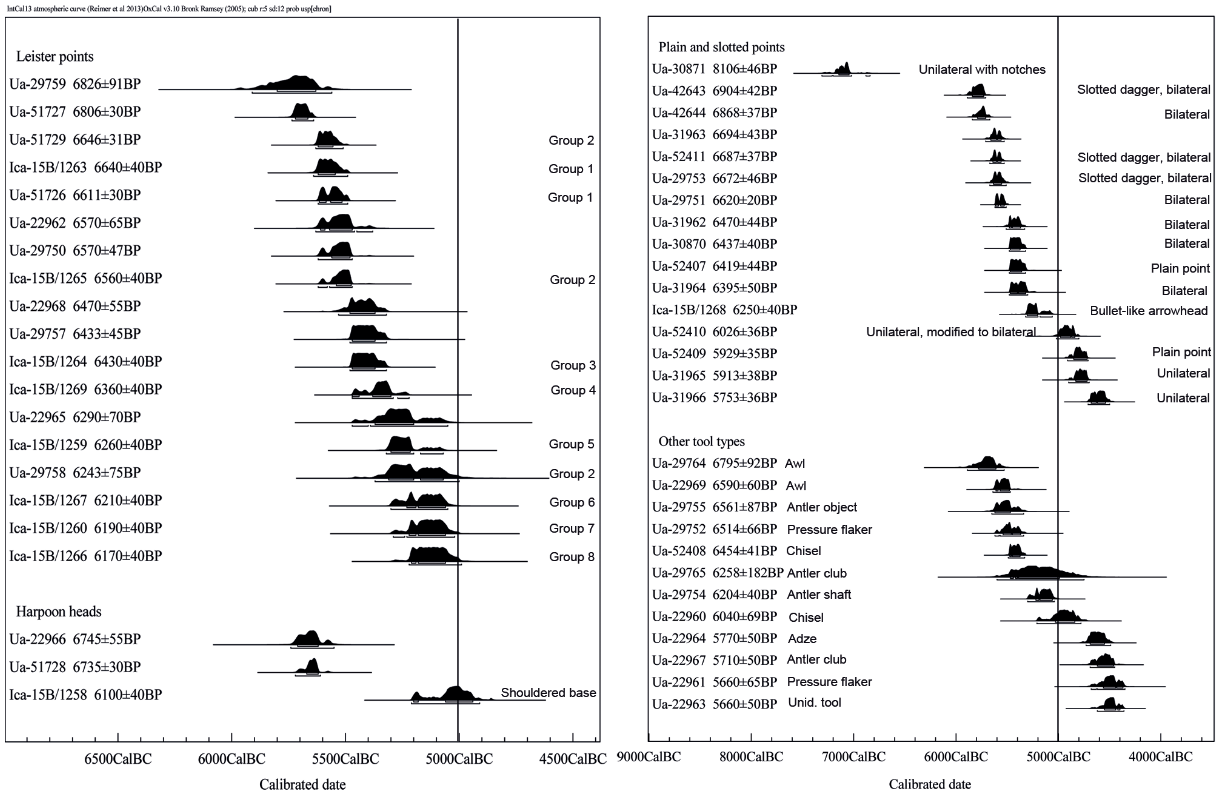

Fig. 3. All radiocarbon dated osseous tools from Motala. No dated barbed points are later than c. 5000 cal. BC. Plots from OxCal v3.10 (Bronk Ramsey 2005). All dates are presented in Appendices 1–2 (graphics P. Zetterlund, Swedish National Historical Museums).

4 Typology of barbed points

Barbed points (n = 460) are interpreted as leister points (n = 446) or as harpoon heads (n = 14). In general, the finished points exhibit surfaces modified by scraping, and 7 % of the barbed points are decorated. The decorations mostly consist of transverse lines and notches along the dorsal side, the broad side, or of smaller notches on the barbs (Larsson/Molin 2017).

4.1 Leister points

The leister points are rather uniform; all are uni-lateral and most of them exhibit convex angular barbs with a transverse margin towards the base (Fig. 2). The present study is based on the morphology of the basal ends of the leister points, although we have also taken into account the general appearance of the barbed corpus and the tips. Only 15 more or less intact points have been recovered. Eight groups of leister points (groups 1–8) were identified, and in total 96 leister points (93 of 125 basal ends) have been classified to specific groups (Table 3; Fig. 4). The main criteria for classification were the morphological traits of the basal ends, also reflecting the shape of the bone element, or a part thereof. Additional characteristics were also noted, for example the presence of diagonal striations from grinding, but these were not considered diagnostic for the classification.

Group 1 represents leister points with small notches extending up on the base. The notches are slightly oblique to perpendicular. Leisters within this group show similarities with barbed points from, for example,

Table 3. Identified groups of leister points (groups 1–8), with general descriptions and radiocarbon dates of basal ends; ungrouped finds are not included.

Group	Description	Number of points	Comment	14C age BP	cal. BC, 95.4 % prob.	Lab.-nr.
1	Small (perpendicular) notches on the base.	5	F500	6640±40	5640-5490	Ica-15B/1263
			F3642 (Kanaljorden)	6611±30	5620-5480	Ua-51726
2	Truncated bases and curved profiles. Interpreted as double-hafted prongs.	8	F507	6243±75	5370-5000	Ua-29758
			F1553	6560±40	5620-5470	Ica-15B/1265
			F3661 (Kanaljorden)	6646±31	5630-5510	Ua-51729
3	Half of the plantar/palmar surface of a metapodial bone. No traces of diagonal grinding on the basal ends.	12	F1453	6430±40	5480-5320	Ica-15B/1264
4	Rounded and elongated bases with oval cross section. Diagonal striation on bases.	23	F1753	6360±40	5470-5220	Ica-15B/1269
5	The cross section of the corpus of the point extends up on the base. The cross-section is narrowed on the barbed side.	4	F3986	6260±40	5320-5070	Ica-15B/1259
6	Made of the complete plantar surface of a metatarsal bone. Diagonal striation on bases.	10	F1624	6210±40	5300-5050	Ica-15B/1267
7	Made of the dorsal side of a metapodial bone. Diagonal striation on bases.	31	F47880	6190±40	5300-5020	Ica-15B/1260
8	Not distinguished by the morphology of the bases. Instead they represent a group made of thinner bones, e.g. the mandible. They exhibit a distinct C-profile and have larger, sparsely placed oblique barbs.	3	F1556	6170±40	5220-4990	Ica-15B/1266

Kunda-Lammasmägi in Estonia (e.g. No. 3410 [1936], Archaeology Museum at the Institute of History of Tallinn University), Zvejnieki II (e.g. ZVII: 931, National History Museum of Latvia), and Lake Lubãna in Latvia (e.g. A10519:1430 [Vankina 1999, 38 fig. XIV:6]).

Group 2 points have curved profiles and flat truncated bases and are interpreted as fork-like double-hafted prongs, representing Clark's (1936) type 14. The closest parallel is from Hörninge mosse on the Swedish island of Öland (Åberg 1913, 44 fig. 2).

Group 3 consists of barbed points made from half of the plantar/palmar surface of a metapodial bone each; the group also comprises a possible subgroup with narrowed tangs. Basal ends in this group do not exhibit diagonal striations from grinding as those of many points of the following groups do.

Group 4 is defined by points with rounded elongated bases with an oval cross-section. Bases in this group often exhibit diagonal striations from grinding.

Group 5 is represented by points where the cross-section of the corpus extends on to the basal end. The cross-section is drop-shaped and deliberately narrowed (thinned out) on the barbed side, with distinct marks of scraping on the surface of the bone.

Group 6 consists of larger points made from the complete plantar surface of a metatarsal bone. This portion of the bone has a natural foramen (i.e. hole), and it is important to stress that none of the points in this group exhibits any traces of hafting with a line through this hole, but many points instead exhibit diagonal striations on the base. These objects should therefore be interpreted as leister points and not as harpoons.

Group 7 represents leister points made of the dorsal side of a metapodial bone, with the natural furrow of the bone (*sulcus dorsalis*) visible in the central axis of the basal end. Many of the finds within this group show traces of diagonal grinding.

Additionally, *group 8* can be distinguished. These points are not characterised by the morphology of their basal ends; instead they represent a group of points made of thinner bones, for example mandibles, which prevents them from being classified into any of the other groups. They exhibit a distinct C-profile in the mid-section and have larger, sparsely placed oblique barbs.

Group 7 is the largest group, comprising 32 % of the classified points, followed by group 4, representing 24 % of the assessed finds. Groups 1, 5 and 8 are the smallest, containing 5 %, 4 % and 3 %, respectively (Table 3).

Collagen from 18 leister points has been radiocarbon dated, but of these objects only ten basal ends (including two items from Kanaljorden) could be identified as belonging to a specific group. The remaining eight represent barbed mid-sections or tips of points. No leister points are dated later than c. 5000 cal. BC.

Group 1 points date to the older part of the leister sequence and are among the first leister-types used at Motala, between 5600–5500 cal. BC. This is also the case with group 2, of which two out of three dated points belong to the same period. A third date (Ua-29758), however, shows that leister fishing with curved prongs most likely continued throughout the whole sequence, until 5000 cal. BC. Groups 3 and 4 are represented by one date each, positioned in the middle of the chronological sequence, and were likely used after 5400 cal. BC, but no later than 5200 cal. BC. Groups 5, 6 and 7 all range between 5300–5000 cal. BC, and group 8 constitutes the youngest dated group.

Mid-sections and tips of Bergstrand's type A, with regular barbs of convex angular shape (Fig. 2), occur in almost all the groups identified above and consequently throughout the whole leister sequence. Thus, barb morphology did not correlate with base morphology, although leister points of group 8, with sparsely placed oblique barbs, could correspond with Bergstrand's type B. It is interesting to note that these also date to the youngest phase of leister fishing at Strandvägen, as some similarities in the morphology are recognised. It is also interesting that points of this group were made of different bone elements than the main part of the leister point collection.

The leister point groups correlate to choices of raw material, i.e. utilised bone elements and the specific part of each element. Whether this was a conscious choice or just a consequence of different craftsmen or available raw material, function or even an analytical artefact, is hard to evaluate. Some of the differences (e.g. a curved profile with flat truncated base, a drop-shaped, narrowed basal end, and traces of grinding) could, however, be of importance, representing morphological traits that provide insights into hafting techniques. Leister points remain solidly fixed to the shaft during use.

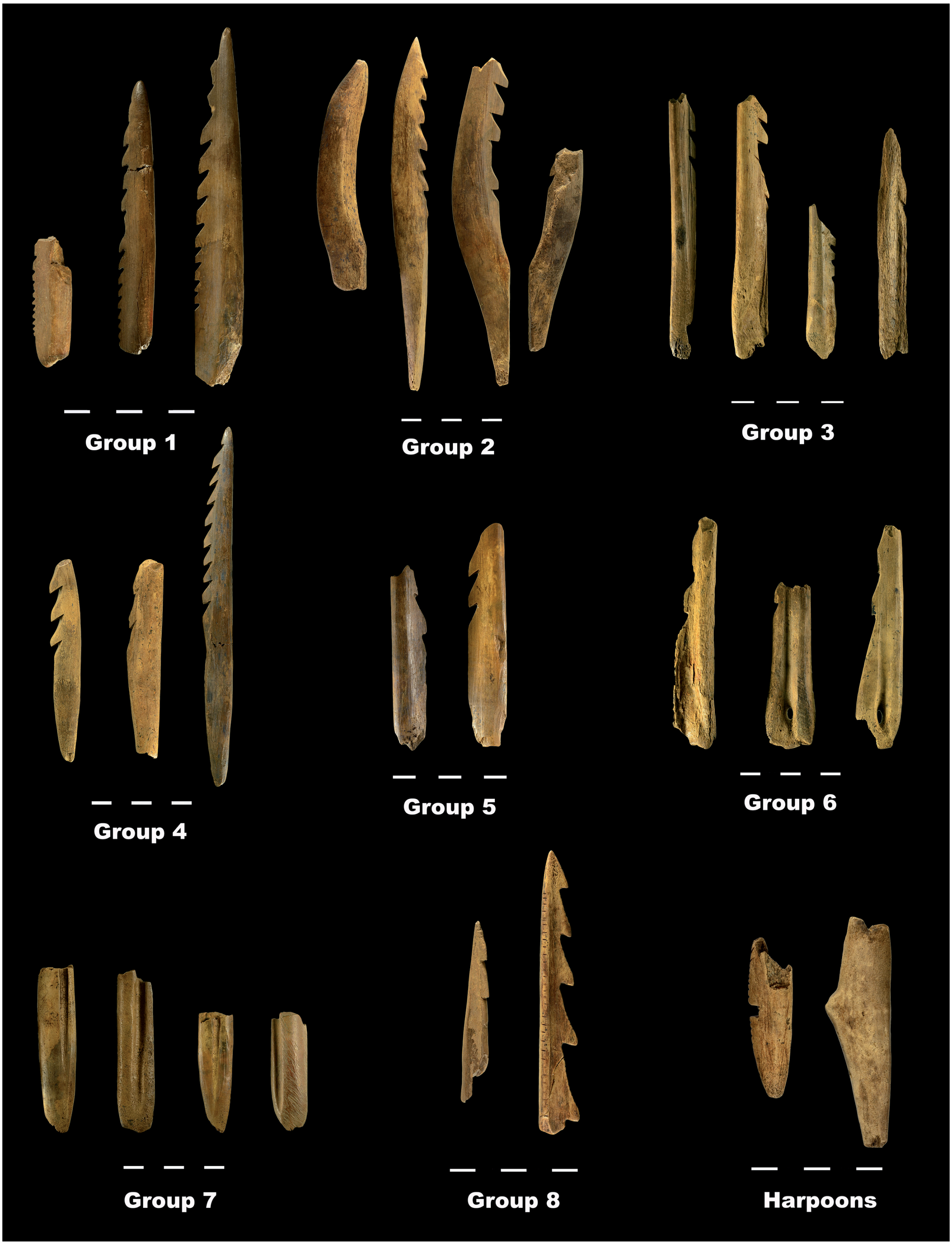

Fig. 4. Leister points, groups 1–8, and basal ends of harpoons from Strandvägen, Motala (photos and graphics P. Zetterlund, Swedish National Historical Museums).

Several of the points exhibit traces of diagonal grinding on the basal end. All points with such traces belong to groups 4, 6, or 7 (which together constitute 67 % of all assessed points). The grinding traces, in form of diagonal striations, have been interpreted as a technical aid which roughens the surface, providing a better fixing to the shaft (Pétillon 2008). When these traces cover the full length of the basal end, hafting is proposed to have been fixed (Pétillon 2008). This is the case with most of the assessable points in the Strandvägen collection. Group 2 points have been interpreted as fork-like double-hafted prongs. Group 5 points may also be interpreted as double-hafted prongs in analogy with a find of two leister points from Siretorp, Scania (Fornvännen 1913, 271 fig. 1). These points were found together, vertically driven down into gyttja sediments, and, due to the position in which they were found as well as from the similarities in shape, have been interpreted as double-hafted prongs (Clark 1936, 121–122 fig. 46; Fornvännen 1913, 271 fig. 1). The similarity of the basal ends of these points and those of group 5 points makes it likely that leister points in this group were hafted in a similar manner, although the shape of the barbs from the Siretorp leisters are very different from those at Motala. In turn this would suggest that most or even all of the leister points from Motala indeed had a fixed hafting.

4.2 Harpoon heads

In addition to leister points there are further 14 finds of barbed points which have been interpreted as parts of harpoons. Only five represent basal ends, with bases that enabled an easy removal from the shaft so that a line could be applied between point and shaft. These basal ends consist of two distinct different morphological types, one with a rounded base with oval cross-section and large notches, and a second type with a shouldered base with one or two protuberances (Fig. 4). The notches were made by nicking, creating one harpoon base with two slightly oblique notches and two bases with singular perpendicular notches. A similar harpoon was recovered at Hylteberga in Scania (SHM:12716:1, Fornvännen 1906, 211 fig. 10), but a closer analogy is a harpoon found in the Baltic Sea during fishing at a depth of 44 m, 4 nautical miles west off the island Utklippan in Blekinge (BLM:24131, Larsson 1999, figs. 2; 5). Another harpoon of this type was found during trenching at Lake Open in Lännäs (ÖLM: 19716), only some 70 km northeast of Motala. The harpoons with shouldered bases have protuberances resembling Ertebølle harpoons of types C and D (Andersen 1971, fig. 42a; Jensen 2006, 190). The Strandvägen bases exhibit flattened oval cross-sections and are deliberately shaped.

The remaining pieces (n = 9) consist of mid-sections and tips with large sparsely placed barbs. The morphology of the barbs is generally triangular; however, two pieces exhibit more elongated and slightly rhombic barbs. Both of these also display decorations in form of small perpendicular notches. These fragments are very similar to the harpoon from Utklippan (Larsson 1999), and closely resemble an Ertebølle harpoon find from Ravnstrup mose in Denmark (Andersen 1971, 88 fig. 16).

The harpoons are mostly made of red deer antler, except for one shouldered base find, one large mid-section and one large tip, which are all made of elk bones. Three of the harpoons have been radiocarbon dated (collagen), two made of antler (including one item from Kanaljorden) and one made of bone (Table 4). The two antler harpoons date to an early phase, c. 5700–5500 cal. BC (Ua-22966, 6745±55 BP, 5740–5550 cal. BC; Ua-51728, 6735±30 BP, 5720–5570 cal. BC), whereas the bone harpoon with the shouldered base dates to around 5000 cal. BC (Ica-15B/1258, 6100±40 BP, 5210–4910 cal. BC).

4.3 Plain bone points

Plain bone points from Strandvägen are represented by 180 finds, either as fragments or as more or less intact points. As a common type of bone points in Mesolithic inventories, they appear in various sizes. In general, the points from Strandvägen are thin and straight with circular to oval or slightly rectangular

Table 4. Different types of bone points (other than leister points, see Table 3), with general descriptions and radiocarbon dates.

Type	Group/description	Number of points	Comment	14C age BP	cal. BC, 95.4 % prob.	Lab.-nr.
Harpoon		14				
	Rounded base, oval cross-section with large notches	3	Utklippan, Blekinge	7440±130	6600-6000	LuA-4418
	Shouldered base, with one or two protuberances	2	F12831	6100±40	5210-4910	Ica-15B/1258
	Not grouped		F11698	6745±55	5740-5550	Ua-22966
			F3645 (Kanaljorden)	6735±30	5720-5610	Ua-51728
Plain point		180				
	Thin, straight; with circular to oval or slightly rectangular cross-section, pointed or flattened bases		F1485	6419±44	5480-5320	Ua-52407
			F1696	5929±35	4910-4710	Ua-52409
	Bullet-like-arrowhead, with short tapered base	6	F687	6250±40	5320-5060	Ica-15B/1268
Slotted point		43				
	Bi-lateral	21				
			F1911 (Kanaljorden)	6868±37	5840-5670	Ua-42644
			F425	6620±40	5630-5480	Ua-29751
			F656	6470±44	5510-5330	Ua-31962
			F1467	6437±40	5480-5320	Ua-30870
			F1678	6395±50	5480-5300	Ua-31964
	Uni-lateral	8				
			F1705 (bi-lateral, modified)	6026±36	5020-4800	Ua-52410
			F1706	5913±38	4900-4700	Ua-31965
			F1726	5753±36	4710-4500	Ua-31966
	Uni-lateral with notches	1				
			F1469	8106±46	7310-6840	Ua-30871
	Not grouped		F1643	6694±43	5710-5530	Ua-31963
Slotted dagger	(Bi-lateral)	8				
			F1910 (Kanaljorden)	6904±42	5890-5710	Ua-42643
			F451	6672±46	5670-5510	Ua-29753
			F1727	6687±37	5670-5530	Ua-52411

cross-sections and pointed or flattened bases (Fig. 5d; cf. Galiński 2013, fig. 2). The collection also includes six finds of small bullet-like arrowheads with short tapering or squat pointed bases (Fig. 5c; Galiński 2013, fig. 2.6). Many of the plain points show traces of resin for hafting on their basal ends. The plain points are mainly interpreted as projectiles, but could also represent mid-points for leisters, hafted in combination with double or multiple leister prongs. In comparison with, for example, finds from the Lubāna collection many of the largest points could also have served as spearheads (cf. Vankina 1999, figs. XXXII–XXXIII), being used as fish-spears along the riverbed.

Only three plain bone points from Motala have been radiocarbon dated, two on resin and one on bone collagen (Table 4). The results span the entire chronological sequence. One complete bone point with a slightly rectangular cross-section is dated to 6419±44 BP, 5480–5320 cal. BC (Ua-52407); it is the oldest one of the dated points. The youngest item is a point with a round cross section, dated to 5929±35 BP, 4910–4710 cal. BC (Ua-52409). One of the smaller bullet-like arrowheads was dated to the centuries before 5000 cal. BC and represents a middle date: 6250±40 BP, 5320–5060 cal. BC (Ica-15B/1268).

4.4 Arrowheads and spearheads

There are a few types (n = 8) of arrowheads present in the collection from Strandvägen. Four more or less complete blunted (club-shaped) arrowheads made of antler tines, with round cross-sections, have been recovered (Fig. 6a). These are very similar to Russian finds (cf. Zhilin 1998, 162 fig. 14.5), which are interpreted as projectiles for hunting birds or fur-bearing animals. Further three fragments derive from distal ends (tips) of arrowheads with rhombic cross-sections, further accentuating eastern (or possibly northern) connections (Fig. 6d). A notched arrowhead should also be mentioned, which is very similar to the oldest slotted point in the collection (see below). This bone point, however, has a slightly more irregular appearance, measuring c. 76.5 mm in length, with a broken tip and displaying a triangular and flattened cross-section and short tapered base (Fig. 6c). The point shows small, irregular, closely spaced perpendicular notches on the distal half (towards the tip) of one longitudinal side.

The spearheads from Strandvägen (n = 16) are of three different types; however, none have been dated so far. In Bergstrand's study (2005; table 2) a further 21 ´pointed bone pieces` were discussed. Finds of this group appear to be heterogeneous and crudely cut; they were interpreted as plain bone points intended for leister fishing. Two of these yielded dating results later than 5000 cal. BC, and, consequently, coarse bone points without barbs were proposed to have successively replaced the barbed points. All of these finds have been re-examined and were reclassified mainly as chisels or awls, and in some cases even as production waste or just unworked bones. This makes the interpretation of the coarse bone points as fishing instruments inaccurate. Nonetheless, one artefact is indeed a complete finely worked long slender bone spearhead without barbs, entirely similar to the more recent finds. None of these spearheads have barbs or notches, and all show flat oval cross-sections (Fig. 6e). One find exhibits an incised groove on one of the lateral edges. Almost all have broken tips or show other signs of impact damage.

A second type is represented by three broken tips with bi-laterally finely notched edges (Fig. 6b). One has incised grooves along the lateral edges and a slightly triangular cross-section, closely resembling a find recovered at Zvejnieki II, Latvia (Zagorska 1974, 30 fig. 4.14). The third type is represented by one almost complete point with a rhombic cross-section, a short tapered tang and a long broadened point, showing four widely spaced notches on the lateral sides (Fig. 6f). This point is interpreted as a spearhead, but could also represent a large arrowhead, as it resembles finds of both spear- and arrowheads from Lake Lubãna (Vankina 1999, 93; 95; 154 fig. XXXIX.1, 3; LXVII) and an arrowhead from Eggvena, Sweden (GAM:47564, Montelius 1917, 7 fig. 66). The find from Eggvena was recovered together with a bi-laterally slotted bone point with flint inserts (Montelius 1917, 7 fig. 66, GAM:47565).

4.5 Slotted bone points

Slotted bone points are represented by 43 finds from Strandvägen, either as bi-lateral (n = 21) or unilateral points (n = 9). 13 fragments were too small or damaged to be classified. Basal ends are predominantly pointed or slightly flattened, often with traces of resin or other traces of hafting. Most cross-sections are rounded, though several points with slightly flattened cross-sections are also recognised (Fig. 5a). In general, the grooves for inserts extend over more or less the full length of the narrowed sides of the points.

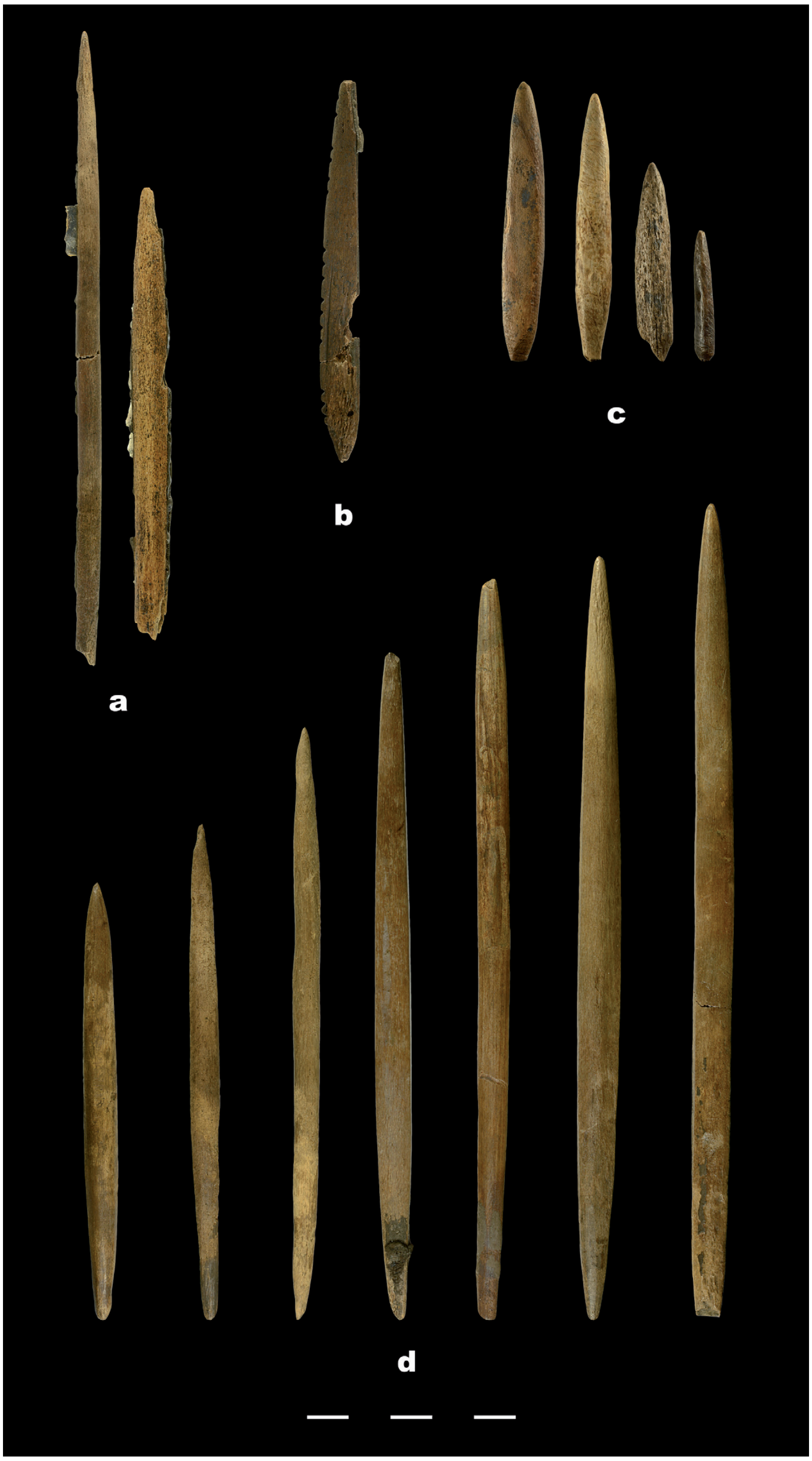

Fig. 5. Slotted and plain bone points from Strandvägen, Motala: a – uni-laterally slotted point with a single remaining insert of flint (left), bi-laterally slotted point with damaged inserts of mylonitic quartz (right), both tips are broken; b – uni-laterally slotted point with small perpendicular notches and short tapered base, no remaining inserts, the tip is broken; c – small bullet-like arrowheads with short tapering bases; d – various sizes of straight plain bone points, circular to oval cross-sections with pointed or flattened bases (photos and graphics P. Zetterlund, Swedish National Historical Museums).

One exception could be a slotted point from burial 03 (Knutsson et al. 2016, figs. 6–7; 11), though here only the very tip of the bone point is preserved and it is therefore not possible to reconstruct its exact shape. Due to the size and width of the quartz insert it is further possible that this point could be interpreted as a knife or dagger instead. Further seven fragmented slotted daggers or knives and one almost complete item with incised decoration (Molin et al. 2014, fig. 3) have been recovered at the site.

The oldest bone point in the collection is a small uni-laterally slotted arrowhead, with one side slotted and the other one showing small perpendicular notches, spaced in groups (Fig. 5b). This is the only slotted point from Motala with notches. The point has a short tapered base and shows small incised grooves along the notched edge. It measures approximately 92 mm in length with a slightly damaged tip. It is notably old in the Strandvägen collection, dated to 8106±46 BP, 7310–6840 cal. BC (Ua-30871) and belongs to the earliest phase of the settlement. The point closely resembles finds from the Baltic, for example from Kunda-Lammasmägi, Estonia (No. 1579:12, collection at University of Tartu) and from Lake Lubāna in Latvia (e.g. A10519:1815, National History Museum of Latvia, Vankina 1999, 79 fig. XXIX.2). This notched attribute can also be seen on a narrow bi-laterally slotted point from Bussjö mosse in Scania, with fine oblique notches on one side (SHM:13075, Clark 1936, plate V.6).

In total 13 slotted bone tools have been radiocarbon dated (including two finds from Kanaljorden); all were dated on traces of resin from slots or basal ends (Table 4). Three of these items are interpreted as daggers or knives. All six dated bi-lateral points derive from between 5800–5300 cal. BC, but two uni-lateral points are dated much later, between 4900–4500 cal. BC. The exception is one bi-lateral point with two slots still filled with resin. Only one slot, however, has imprints of inserts. The other slot appears to have never been used, as it is completely filled with resin without imprints, thus creating a point with only one cutting edge. This point is dated to 6026±36 BP, 5020–4800 cal. BC (Ua-52410), i.e. to approximately the same period as the other uni-lateral points. These late radiocarbon dates for slotted points are noteworthy in comparison to other dated slotted tools from the Mesolithic. The dates also seem to indicate a shift from bi-lateral to uni-lateral points around 5000 cal. BC. Previously, Larsson (1978) also suggested that uni-lateral points occur during the final phase of the Late Mesolithic in southern Sweden.

5 Deposition and spatial patterns

At Strandvägen the occupation layers from the settlement extend into the backwater of Motala Ström. Bone tools were recovered from an excavation area of approximately 7000 m^2, including both dry and submerged stratigraphies (Table 1). The occupation layers on land cover the larger part of this area, and 52 % of the identified bone tool fragments have been recovered from dry stratigraphy. The find frequency, on the other hand, is higher in the submerged areas, 0.7 compared to 0.36 finds per m^2 on land.

Fragmentation is generally high in the (unmodified) faunal remains, as 62 % of the fragments are smaller than 2 cm in diameter. The fragmentation of bone tools, however, seems in general to be somewhat lower, as only 30 % of the bone tools are smaller than 2 cm. Not surprisingly, fragmentation is higher on land, specifically regarding bone tools, than in the submerged sediments (Table 5).

Burned fragments were mostly recovered from the dry occupation layers and display close spatial relations to archaeological features, such as dwellings and hearths, correlating to different activity areas of the site. The differences in fragmentation and find frequency affect the identification of different tool types and the spatial distribution patterns. For example, specific tool types made of antler are almost absent on land. This is most likely an effect of the fragmentation, as dry antler tends to fragment more easily, causing problems during identification. Other tool types seem to occur more commonly on land, e.g. plain bone points, needles and personal ornaments. Caution, however, is called for, as a high level of fragmentation might cause several scattered pieces of the same broken tool to be interpreted as different finds.

Some general patterns of spatial distribution are, however, recognisable. Barbed points were most commonly found underwater, and 74 % of the points were recovered from submerged sediments, several *in situ* in a vertical position in the sediments (Fig. 1b). Fracture patterns and impact damages indicate that points were mostly broken during usage. Many points demonstrate fractures on the mid-section in transition to the base; 53 % of the basal fragments show fresh fractures towards the missing barbed mid-section and tip. Of the barbed tips 49 % exhibit fresh fractures towards the basal end of the point (Fig. 2), and of the pointed tips 44 % show impact damages observed as crush-marks or as small negative flake scars. Nonetheless, 113 pieces were recovered from dry occupation layers. The many fragments from the settlement could probably testify to the process of re-hafting points and of re-shaping and a re-use of broken points. It may be noted that identified re-used items were only recovered from submerged sediments whereas flakes with modified surfaces were primarily recovered on land (only three of 38 flakes were recovered from submerged sediments). The numbers of finds within the eight identified leister point groups are too low, which hinders a full spatial analysis, and thus no differences in spatial distribution between the groups can be identified.

Table 5. Fragmentation levels of bone tool fragments and unmodified faunal remains from dry vs. submerged stratigraphies at Strandvägen, Motala. N.B. that only the Mesolithic faunal remains from Strandvägen excavated in 2009–2013 are included (see Gummesson et al. 2017), and that teeth and burned fragments (bone and tools) have been excluded.

	Tool fragments					Faunal remains				
Fragment size	**Dry stratigraphy**		**Submerged sediments**		**Total**	**Dry stratigraphy**		**Submerged sediments**		**Total**
	NISP	% NISP	NISP	% NISP		NISP	% NISP	NISP	% NISP	
0–1 cm	38	8 %	6	1 %	44	1725	19 %	1238	18 %	2963
1–2 cm	255	55 %	34	5 %	289	5305	58 %	1684	24 %	6989
2–4 cm	140	30 %	105	16 %	245	1779	20 %	2309	34 %	4088
4–6 cm	16	3 %	118	19 %	134	196	2 %	918	13 %	1114
6–10 cm	14	3 %	231	36 %	245	53	1 %	543	8 %	596
> 10 cm	3	1 %	148	23 %	151	12	0.1 %	178	3 %	190
Total	466		642		1108	9070		6870		15,940

Plain bone points were, unlike barbed points, concentrated in occupation layers on land; they are, however, mostly represented by fragments. Only 24 % of the plain points were recovered from submerged sediments, but no less than 21 complete or almost complete points were recovered from submerged sediments, including all small bullet-like arrowheads. A majority of the spearheads, 75 %, were also recovered underwater. One was found positioned vertically in the gyttja (Bergstrand 2005, 66), like many of the leister points. Slotted bone points were recovered both from the settlement and from the submerged sediments, but were predominantly (70 %) recovered on land. Slotted bone daggers or knives contrast this pattern as 88 % of these were recovered from submerged areas. No differences in spatial distribution patterns can be identified between uni-laterally and bi-laterally slotted points. One slotted point is also the only bone tool that has been recovered as a grave gift.

6 Discussion

In Motala a standardised bone tool production, dating to c. 5800–5000 cal. BC, has been identified. The bone industry was mainly focused on leister points for fishing, and the two most common groups of leisters were predominantly made of the dorsal part of red deer metatarsals. At Strandvägen, large quantities of waste products also demonstrate a local on-site production. Strontium analyses of tooth enamel from wild boar tusk-scrapers show that the raw material originated from local surroundings in the vicinity of the site (Eriksson et al. 2018, fig. 8), which also supports a local production.

The results from 49 radiocarbon dated tools indicate a rather narrow time span of production and use. We have attempted a typo-chronological analysis of barbed points, mainly based on morphological traits on basal ends of leister points. Eight groups were identified (groups 1-8), and the radiocarbon data indicate some chronological differences. The data also demonstrate that barbed points only occur before c. 5000 cal. BC, and that plain and slotted points are represented throughout the whole chronological sequence.

Group 1 represents the oldest leister-type used in Motala, dated to 5600–5500 cal. BC. Group 2 points testify to leister fishing with curved double- or multi-hafted prongs, representing a type of leister used throughout the whole chronological sequence, whereas group 5 points, also interpreted as once having been multi-hafted leisters, are dated to the later part of the time period. Group 8 could possibly reflect a technological change in raw material use after c. 5200 cal. BC, as these points are made of other, thinner bones. Some of the artefacts within the identified groups of leister points exhibit traces of diagonal grinding on their basal ends, testifying to a fixed hafting of points to the leister shaft. Many of the points were recovered *in situ* in vertical position in the sediments at the bottom of the river, showing that the points were deposited broken off as the leister was pushed deep into the gyttja. Considering the depositional pattern of spearheads and the fact that one spear was recovered vertically in the submerged sediments, it is likely that these implements also were used as barbless fishing spears.

No dated barbed points are later than 5000 cal. BC, suggesting that leister fishing with barbed points ceased at this point. None of the mentioned (plain) spearheads have been dated, so the question whether leister fishing was continued with this type of points is left unanswered. At the same time, c. 5000 cal. BC, bi-laterally slotted points seem to have been replaced by uni-lateral points, also indicating a shift in the utilisation of different bone tools. This shift is probably connected to an overall decline in settlement activity at Motala. The decline is also seen in the utilised dwellings at Strandvägen, were only one out of five dated features was in use after 5000 cal. BC. Several other changes in human activities at Strandvägen also occur during this period, not least a change in burial practices. Of the excavated inhumation burials, the latest one is dated to between 5200–4800 cal. BC, and only one other burial has been dated to an even later period. This burial is instead a cremation pit from the time c. 4000 cal. BC. The fishing in Motala Ström continued, however, probably by means of new technologies, as indicated by a bark net float dated to after 4500 cal. BC. The use of fish weirs and wicker traps also continued. Five out of six radiocarbon dates from the fishing station are earlier than 5200 cal. BC, and only one wicker trap is dated later, around 4700 cal. BC, attesting to a continued but probably reduced intensity of fishing at the site (Molin et al. in press).

The shift in the bone inventory also correlates to other tentatively observed patterns among the bone tools. For example, a chronological shift in the morphology of basal ends of harpoons could be proposed, even if the number of dated harpoons is low. Two different types of basal ends of harpoons have been identified; notched ends and basal parts with protuberances. In analogy with the harpoon from Utklippan, Blekinge, dated to 7440±130 BP, 6600–6000 cal. BC (LuA-4418), notched basal ends could be suggested to have been replaced by shouldered bases, the latter occurring in Motala after the proposed inventory shift. Other morphological differences on bone points could represent smaller chronological changes. Small notches, for example, occur as decorative elements on arrowheads, spearheads and leisters, where they possibly also acted as functional features for hafting the basal ends of the leister points. Six items with notches have been dated, and the latest one is a leister point with notched barbs, dating to 6570±47 BP (5620-5470 cal. BC [Ua-29750]). This characteristic trait, therefore, seems to date to an earlier part of the settlement sequence.

The shift in material culture and the decrease in human activities do not correspond to changes in the spatial organisation of the site. The differential fragmentation of bone tools (land vs. submerged sediments) makes it precarious to draw conclusions about spatial patterns, as well as impossible to evaluate the spatial distribution patterns of categories with few finds. If the hypothesis that bi-laterally slotted points were replaced by uni-laterally slotted points is accepted, then the bi-lateral and uni-lateral points can be compared in terms of being chronological markers. The spatial distribution of these two types of points is however similar and no clear separation can be detected, showing that the chronological shift in morphology of the points is not reflected spatially. The fish traps dated to two different chronological phases, one pre-dating and one post-dating the inventory shift, are also located in the same area of the shore. This raises questions as to the nature of this development, the deposition of bone tools and site-use continuity, as it seems that large parts of the site continued to function in a similar manner though in reduced intensity.

The frequency of bone tools is higher in submerged sediments, and the fragmentation level is higher on land. The differences in fragmentation, identification, and find frequencies thus need to be considered when analysing the composition of the collection and comparing it with other Mesolithic collections.

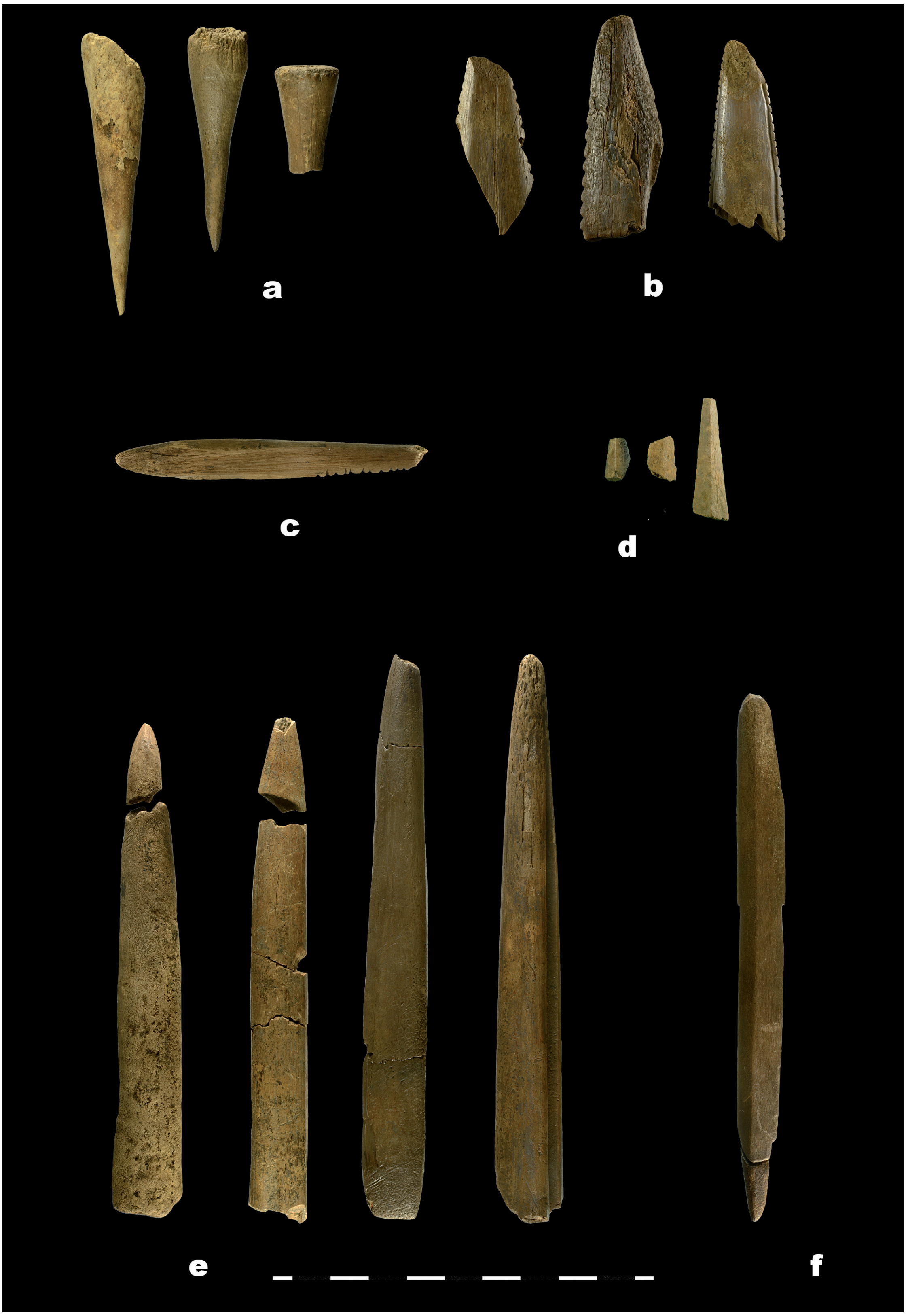

Fig. 6. Spear- and arrowheads from Strandvägen, Motala: a – blunted (club-shaped) arrowheads of antler tines, with round cross-sections; b – broken tips of spears with bi-laterally notched edges; c – notched arrowhead with a triangular and flattened cross-section and short tapered base; d – fragments of arrowheads with rhombic cross-sections; e – bone spearheads with flat oval cross sections; f – bone point with rhombic cross-section and a short tapered tang, the tip is broken (photos and graphics P. Zetterlund, Swedish National Historical Museums).

In both a regional and interregional context Motala represents a chronological period and a geographical area from which only few larger collections of bone tools are known. The discontinuation of the use of barbed leister points at Motala is, however, a phenomenon that appears to mirror similar circumstances in other areas, but with a slight temporal shift. In the Baltic region, for example, fishing spears do not occur during the Late Mesolithic period (Zagorska 1992). Interestingly, the shift in bone tool inventories in the Baltic region seems to parallel a shift in the diet, occurring at c. 5600 cal. BC. Prior to this people appear to have targeted high trophic level aquatic species, and at c. 5600 cal. BC a transition to a more broadly based diet occurs (Meadows et al. 2018). In Motala, no unburned human remains postdate the inventory shift at c. 5000 cal. BC, and therefore a similar correlating shift in diet cannot be verified.

7 Conclusions

A large collection of osseous tools dating from the Late Mesolithic and unique to the region have been recovered at Motala, Sweden. The tool collection and associated waste products offer new insights into the production and utilisation of bone tools. The presented data suggest a chronological change in the bone tool inventory at Strandvägen at c. 5000 cal. BC, recognised in the discontinuation of the use of barbed leister points, a possible shift from bi-laterally to uni-laterally slotted points as well as a corresponding decrease or change in human activities on the site.

Morphological differences among the barbed points may be interpreted as results of smaller chronological changes, as well as the abandonment of small notches as a functional or decorative element on bone points. This paper has demonstrated a nuanced picture of differences among bone points from a rather narrow chronological sequence and may hopefully provide a basis for further in-depth studies.

Acknowledgements
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Museums and referenced collections

Estonia

Kunda: Archaeology Museum at the Institute of History of Tallinn University, Rüütli 6, Tallinn; University of Tartu, Jakobi 2-206, Tartu

Latvia

Lubāna and Zvejnieki II: National History Museum of Latvia, Lāčplēša iela 106/108, Rīga

Sweden

BLM, Blekinge Museum, Borgmästaregatan 21, 371 35 Karlskrona
GAM, Göteborgs stadsmuseum, Norra Hamngatan 12, 411 14 Göteborg
SHM, Statens historiska museum, Storgatan 41, 114 84 Stockholm
ÖLM, Örebro läns museum, Engelbrektsgatan 3, 702 12 Örebro

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Appendix

Appendix 1. Previously unpublished radiocarbon dates from Strandvägen. * = standard value.

Site	Lab.-code	BP	±	Material/Sample	δ13C‰ VPDB	Context	Comment	Find No.
Strandvägen	Ua-30871	8106	46	Resin	-30.2	A3037	Slotted bone point	F1469
Strandvägen	Ua-31963	6694	43	Resin	-26.4	A1305	Slotted bone point	F1643
Strandvägen	Ua-52411	6687	37	Resin	-28.8	A3037	Slotted dagger	F1727
Strandvägen	Ua-31962	6470	44	Resin	-26.3	A1305	Slotted bone point	F656
Strandvägen	Ua-52408	6454	41	Resin	-25.2	A3037	Chisel	F1677
Strandvägen	Ua-30870	6437	40	Resin	-29.5	A3037	Slotted bone point	F1467
Strandvägen	Ua-52407	6419	44	Resin	-27.7	A3037	Plain bone point	F1485
Strandvägen	Ua-31964	6395	50	Resin	-26.6	A1305	Slotted bone point	F1678
Strandvägen	Ua-52410	6026	36	Resin	-25 *	A26000	Slotted bone point	F1705
Strandvägen	Ua-52409	5929	35	Resin	-25 *	A3037	Plain bone point	F1696
Strandvägen	Ua-31965	5913	38	Resin	-27.5	A26000	Slotted bone point	F1706
Strandvägen	Ua-31966	5753	36	Resin	-27.7	A3037	Slotted bone point	F1726

Appendix 2. Published radiocarbon dates from the investigated sites.

Site	Lab.-code	BP	±	Material/Sample	Reference	Context	Comment	Find No.
Strandvägen	Ua-22966	6745	55	*Cervidae* (antler)	Carlsson 2008	A3037 (A1627)	Harpoon	F11698
Strandvägen	Ua-22969	6590	60	Large ungulate (bone)	Carlsson 2008	A3037 (A1627)	Awl	F12422
Strandvägen	Ua-22962	6570	65	*Cervus elaphus* (bone)	Carlsson 2008	A3037 (A1627)	Leister point	F8868
Strandvägen	Ua-22968	6470	55	Large ungulate (bone)	Carlsson 2008	A3037 (A1627)	Leister point	F12421
Strandvägen	Ua-22965	6290	70	*Cervus elaphus* (bone)	Carlsson 2008	A3037 (A1627)	Leister point	F11675
Strandvägen	Ua-22960	6040	69	*Cervus elaphus* (bone)	Carlsson 2008	A3037 (A1626)	Chisel	F8721
Strandvägen	Ua-22964	5770	50	*Cervus elaphus* (antler)	Carlsson 2008	A3037 (A1626)	Adze	F9531
Strandvägen	Ua-22967	5710	50	*Capreolus capreolus* (antler)	Carlsson 2008	A3037 (A1627)	Antler club	F11890
Strandvägen	Ua-22961	5660	65	*Cervus elaphus* (antler)	Carlsson 2008	A3037 (A1626)	Pressure flaker	F8867
Strandvägen	Ua-22963	5660	50	*Cervus elaphus* (bone)	Carlsson 2008	A3037 (A1626)	Unident. tool	F8884
Kanaljorden	Ua-51727	6806	30	Large Ungulate (bone)	Eriksson et al. 2018		Bone point/leister	3640
Kanaljorden	Ua-51728	6735	30	*Cervus elaphus* (antler)	Eriksson et al. 2018		Harpoon	3645
Kanaljorden	Ua-51729	6646	31	Large Ungulate (bone)	Eriksson et al. 2018		Bone leister	3661
Kanaljorden	Ua-51726	6611	30	*Cervus elaphus* (bone)	Eriksson et al. 2018		Bone leister	3642
Strandvägen	Ua-29759	6826	91	Large ungulate (bone)	Gummesson et al. 2017b	A1305	Leister point	F606
Strandvägen	Ua-29764	6795	92	*Cervus elaphus* (bone)	Gummesson et al. 2017b	A1305	Awl	F634
Strandvägen	Ua-29753	6672	46	Resin	Molin et al. 2014	A1305	Slotted dagger	F451
Strandvägen	Ica-15B/1263	6640	40	Large ungulate (bone)	Gummesson et al. 2017b	A1306	Leister point	F500
Strandvägen	Ua-29751	6620	40	Resin	David et al. 2015	A3037	Slotted bone point	F425
Strandvägen	Ua-29750	6570	47	Large ungulate (bone)	Gummesson et al. 2017b	A1307	Leister point	F416
Strandvägen	Ua-29755	6561	87	*Cervus elaphus* (antler)	Molin et al. 2014	A1305	Figurative object	F454
Strandvägen	Ica-15B/1265	6560	40	*Alces alces* (bone)	Gummesson et al. 2017b	A3037	Leister point	F1553
Strandvägen	Ua-29752	6514	66	*Cervus elaphus* (antler)	Gummesson et al. 2017b	A1305	Pressure flaker	F429
Strandvägen	Ua-29757	6433	45	Large ungulate (bone)	Gummesson et al. 2017b	A1304	Leister point	F471
Strandvägen	Ica-15B/1264	6430	40	*Cervus elaphus* (bone)	Gummesson et al. 2017b	A3037	Leister point	F1453
Strandvägen	Ica-15B/1269	6360	40	Large ungulate (bone)	Gummesson et al. 2017b	A1305	Leister point	F1753
Strandvägen	Ica-15B/1259	6260	40	*Cervus elaphus* (bone)	Gummesson et al. 2017b	A3037	Leister point	F3986
Strandvägen	Ua-29765	6258	182	*Cervus elaphus* (antler)	Gummesson et al. 2017b	A1305	Antler club	F636
Strandvägen	Ica-15B/1268	6250	40	Large ungulate (bone)	Gummesson et al. 2017b	A1305	Plain bone point	F687
Strandvägen	Ua-29758	6243	75	Large ungulate (bone)	Gummesson et al. 2017b	A1305	Leister point	F507
Strandvägen	Ica-15B/1267	6210	40	*Cervus elaphus* (bone)	Gummesson et al. 2017b	A3037	Leister point	F1624
Strandvägen	Ua-29754	6204	40	*Cervus elaphus* (antler)	Gummesson et al. 2017b	A1305	Antler shaft	F453
Strandvägen	Ica-15B/1260	6190	40	*Cervus elaphus* (bone)	Gummesson et al. 2017b	A49515	Leister point	F47880
Strandvägen	Ica-15B/1266	6170	40	*Cervus elaphus* (bone)	Gummesson et al. 2017b	A3037	Leister point	F1556
Strandvägen	Ica-15B/1258	6100	40	*Alces alces* (bone)	Gummesson et al. 2017b	A1304	Harpoon head	F12831
Kanaljorden	Ua-42643	6904	42	Resin	Hallgren 2017		Slotted knife	1910
Kanaljorden	Ua-42644	6868	37	Resin	Hallgren 2017		Slotted bone point	1911