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# The wood of Merovingian weaponry

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ABSTRACT

After metal, wood was the second most important material for weapon production in early medieval Europe. The weaponry of Merovingian warriors consisted of a double-edged long sword (*spatha*), a single-edged short sword (*seax*), a shield, a spear, an axe, as well as a bow and arrows. Belowground organic material remains have often been preserved through mineralisation processes over centuries to millennia. Although these objects are frequently found as grave goods in burials, systematic material identification is still missing. Here, we present wood anatomical features of 316 weapons from 42 cemeteries of the Merovingian Dynasty in northeastern France. The most commonly used wood for weapons was ash (*Fraxinus excelsior*), followed by alder (*Alnus* sp.) and hazel (*Corylus avellana*). While guaranteeing optimum quality and utility, these taxa were mostly considered for spears, arrows, *spatha* scabbards and shields. Density and mechanical properties further influenced wood selection. An attractive appearance of representative weaponry also affected species preference. At the same time, wood choice rooted in tradition, as knowledge transfer persisted over many centuries and cultures.



## 1. Introduction

The early medieval society of Europe (c. 500–1000 C.E.) was dominated by rural structures and a domestic indigenous production. The development of specialised, commercial crafts was still in its early stages. The creation of occupations such as miller, potter and blacksmith, who required extensive equipment and expert knowledge, rapidly led to the first workshops. Armourers seemed to enjoy a special standing, as indicated by various sources from the 7th and 8th century, e.g. sagas and legends such as the Völundarkviða (Elder Edda), Beowulf or Wayland the Smith, and illustrated, for example on the Franks Casket (Henning, 1991). Aside from practical use in combat, weapons had important symbolic value as an emblem of an independent warrior and the social rank of the bearer.

Burials are the most prevalent archaeological source for the Early Middle Ages, often loaded with grave goods, including weaponry. These material remains are of particular importance for historical research, as documentary evidence is generally absent for this period.

During the transition from the Late Antiquity to the Early Middle Ages in the mid-5th century, burial customs suddenly changed. Individual burials and grave groups, often in form of cremation burials disappeared (Périn and Kazanski, 2011). Subsequently during the Merovingian Dynasty between the 5th and 8th centuries, linear cemeteries with numerous inhumation burials arranged in parallel rows were located in proximity to settlements (Périn, 2006). This funeral tradition was often associated with rich grave goods. It ended in the first decades of the 8th century with the dissolution of social structures and the emergence of a feudal system with nobility by birth (Steuer, 2004). Furthermore, the increasing significance of Christianity in society was another reason to end the custom of furnishing the dead with material goods. Rich medieval archaeological finds from graves are therefore primarily limited to the Merovingian period.

Thousands of Merovingian grave goods have been excavated, studied and archived in museums and depots. Many of such objects consist of metal, ranging from coffin nails to parts of horse harnesses, vessels, jewellery and weaponry. The assemblage of weaponry covers almost the complete contemporary armament (Périn, 2006; Steuer, 1979), including *spatha* (double-edged long

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sword), seax (single-edged short sword), spear, shield, axe, knife, and arrow (Fig. 1B and D).

Organic materials are rapidly degraded by belowground microorganisms. Under certain conditions, however, organic tissue in contact with metal of weapons, can be preserved for centuries. Chemical processes, comparable to fossilisation, are responsible for this preservation. Organic acids dissolve metal salts, which may act as biocides, and thus prevent the degradation of organic substances by fungi and bacteria. Wooden remains are denoted as mineralised wood (Fischer, 1994). Mineralisation of organic matter in a burial environment depends on several factors, such as metal ion concentration, soil type, temperature, pH level, and soil moisture availability (Chen et al., 1998). The quality of wood remains can differ considerably with wooden structures being either completely, or only partially steeped in metal compounds.

So far, explicit material analyses of grave goods have mainly focused on metal, textile and leather (e.g. Koch, 1990). In many cases, wooden remains were destroyed due to improper restoration. Only recently has this material attracted more scientific attention, which has forced the development of new methods for the analysis and preservation (Fischer, 2012; Haneca et al., 2012). Although numerous weapons include large fractions of well preserved wooden remains (Willerding, 1982; Feindt and Fischer, 1994), systematic wood anatomical assessments are still missing.

Here, we aim at providing the first supra-regional study of wood utilisation in weaponry across the heartland of the Merovingian Dynasty. A sufficient replication of wood samples from northeastern France was therefore analysed to provide new insight into work-piece quality and craftsmanship, as well as the motivation behind specific wood selection. The newly obtained evidence is expected to help answering further questions associated with the historical utilisation of wood.

## 2. Material and methods

The rapid increase of preventive archaeology in northeastern France over the past decades has permitted the systematic wood anatomical analysis of 316 weapons from 42 Merovingian cemeteries (Fig. 1A). All wood samples were examined directly after excavation and are now, for the first time, synthesised in this article.

Concerning preservation status, two situations are distinguishable. Firstly, if the wooden object is in contact with a corroding metal, a corrosion layer forms around the wood or the corrosion products permeate the wooden structure directly. In such cases only a negative imprint of the cellular structure is obtained or the wood is transformed entirely into a metal-like substance, which is interspersed with corrosion products (Fig. 1C). Hence such mineralised woods are relatively difficult to determine. The second possibility is much more conducive to wood analysis. In this case, the

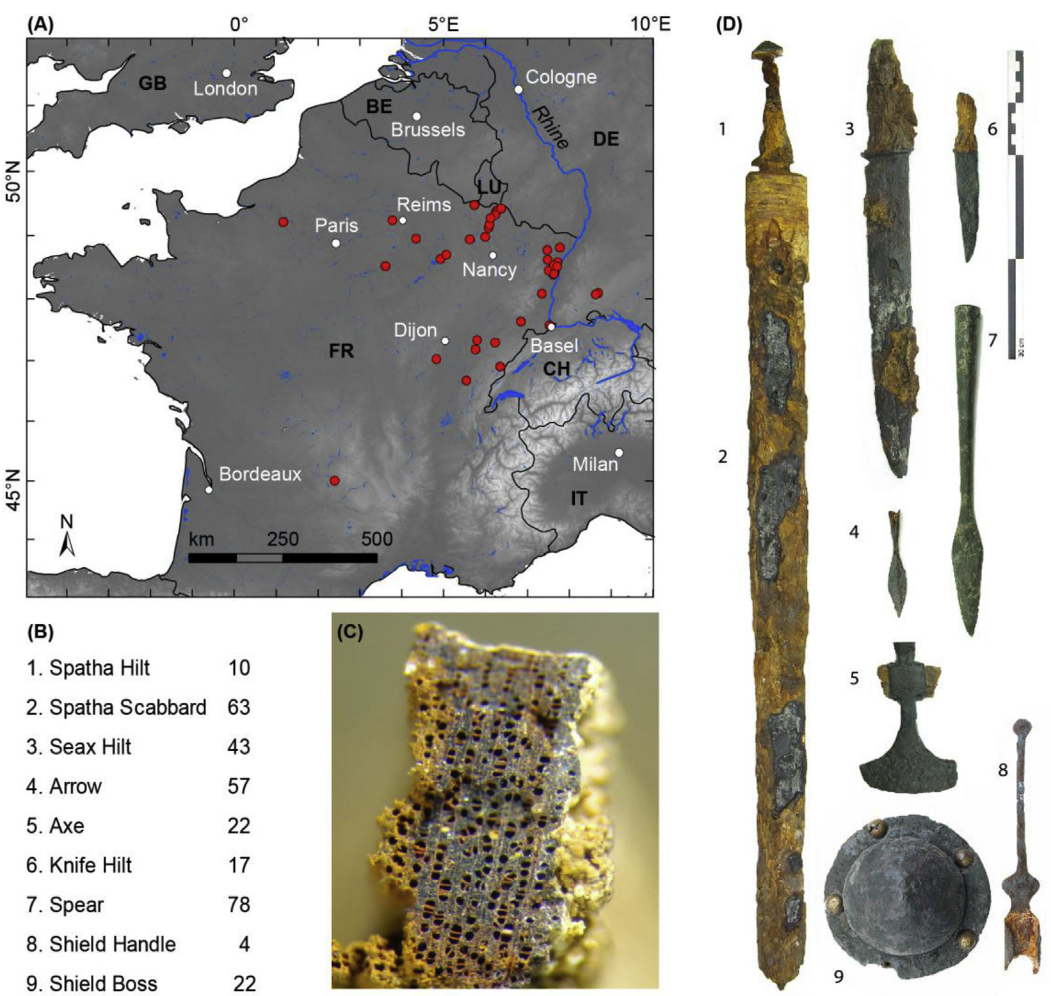


**Fig. 1.** (A) 42 study sites with preserved wooden weapon parts. (B) Weapon types and total number of objects examined. (C) Cross-sectional area of mineralised alder (*Alnus sp.*), fragment of a *spatha* scabbard. (D) Merovingian weaponry with partially preserved wood.

preservation is favoured primarily by the toxicity of metal compounds. The wood-destroying organisms are inhibited and a thin wood layer of 1–5 mm is preserved (Fig. 2).

While recent wood can usually be determined to the genus and, sometimes even, species-specific level by visual inspection, this is not possible with partially degraded wood, especially if mineralised. This limitation is due to the subsequent change of initially distinctive macroscopic characteristics such as colour, gloss, smell, hardness and weight. Nevertheless, a safe determination of genus or species can often be achieved by microscopic observation of the anatomical features. Distinctive features are, for example, axial parenchyma, rays, vessel distribution, vessel perforation plates, pits, and fibres. The wood anatomical atlas and identification key of Schweingruber (2011) herein served as a basis for wood identification. All anatomical features were observed under reflected-light microscope at 40–400x magnification, along cross-sectional, radial and tangential fractured surfaces (Fig. 2). Wood fragments of a few millimetres were often sufficient to detect key anatomical features and thus to determine species or genus.

## 3. Results

A total of 316 wood samples from 42 excavation sites reveal seven different types of weapons (Fig. 3). Anatomical identification was successful in 85%; exclusively wood from deciduous trees has been identified. The most commonly found taxa were ash (*Fraxinus excelsior*), alder (*Alnus* sp.) and hazel (*Corylus avellana*) (Fig. 3), which were frequently considered for spears, arrows, *spatha* scabbards and shields. All other types of arms or parts of weapons indicate a less specific wood selection. At least 63 *spathae* from 25 sites provided evidence of wooden scabbards. From these fragments, five taxa were detected, of which ~80% were alder. The species composition of the hilts of *spathae* is, however, considerably more diverse: Oak (*Quercus* sp.), ash and maple (*Acer* sp.) dominated a total of ten species. Hilts of seaxes (43 from 18 sites) as well as knives (17 from 10 sites) show a similar spectrum. For both groups of short-blade weapon, there is no evidence of wooden sheaths. With ~90% the majority of knife hilts was made of bone and more rarely of horn. This material was also sporadically detected on the hilts of *spathae* and seaxes.

Shafts of spears and arrows reveal a distinct species selection. A total of 82 spears from 14 cemeteries were examined, 57 were made of ash and 19 of hazel. Of the 57 arrows 42 were made of ash and 10 of hazel and have as such, a similar wood spectrum compared to the spear shafts. Determining the residues on shield bosses provided strong evidence of specific taxa selection for these defensive weapons, with alder, poplar (*Populus* sp.) and willow (*Salix* sp.) being clearly preferred. All these are wood species with a low density. In contrast, high density and tough wood species such as ash and maloideae, for instance, were preferentially used for axe handles.

The original position of the worked piece in the tree trunk is recognisable by retracing the orientation of wood fibre. This is best visible on a cross-section. Thus, conclusions on the raw material of a worked piece may be drawn, e.g. which area of the trunk it was taken from or how it was manufactured. Three versions could be distinguished in the study material. Roundwood from small-dimensioned stems or shoots shows concentric annual rings round the pith. In contrast, splitwood or slabbed timber without pith, displays a significant orientation of tree-rings (Fig. 4A, B and D and Urbon, 1991). The third version uses abnormal wood growths such as burrs or knotty parts of roots or limbs (Fig. 4C). The random nature of these structures hardly allows for any orientation. In combination with the selected tree species, the trunk source area largely affects the mechanical properties of a work-piece (Schweingruber, 1976).

The use of burrs could only be detected in the handles of two seaxes. A clear distinction between roundwood and splitwood, respectively slabbed timber, was possible in 79 cases, being most prevalent in spears (n = 36) and arrows (n = 36). Twenty-seven spears were manufactured of cleft raw material and nine from roundwood. Thirty-five arrow shafts were made of cleft timber, while roundwood with pith was observed only once. Both the scabbards (n = 4) as well as the axe handles (n = 3) were exclusively produced from split or slabbed raw material.

## 4. Discussion and conclusions

Mineralised wood residues in the context of graves are relatively common across Europe; systematic and comparative studies,

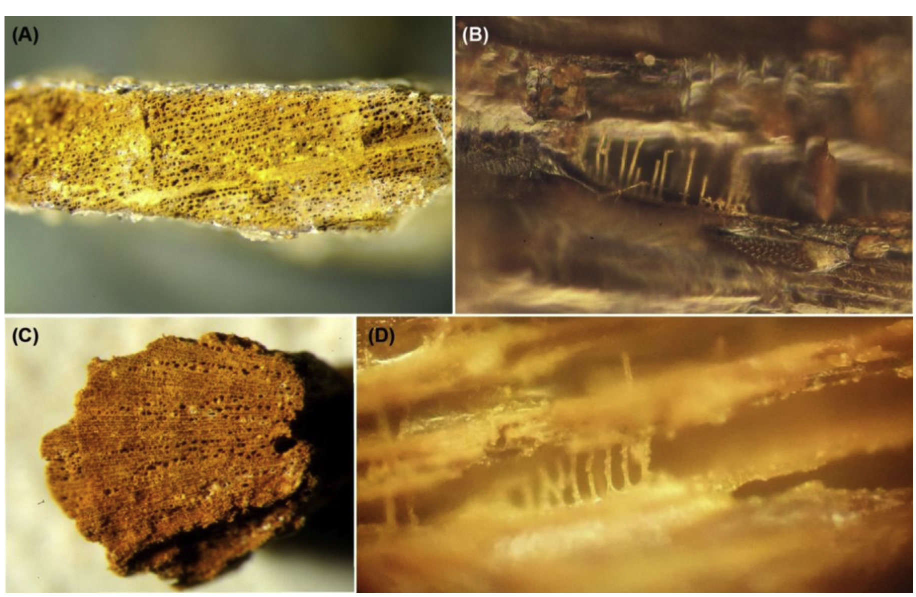


**Fig. 2.** (A) Cross-sectional surface of alder (*Alnus sp.*). (B) Radial section of alder with fragments of scalariform perforation plates in the vessels. (C) Cross-sectional surface of hazel (*Corylus avellana*). (D) Radial section of hazel with scalariform perforation plates.

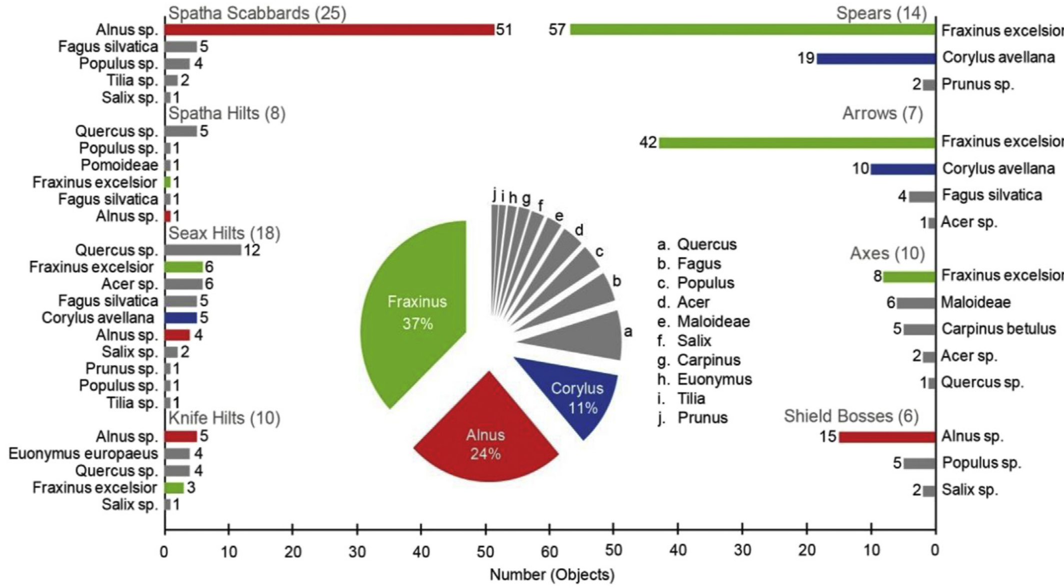


**Fig. 3.** Wood species used for specific weapons and weapon parts. In brackets the numbers of cemeteries with finds of this weapon type. The pie chart shows the percentage of wood species used. The three most common taxa are highlighted.

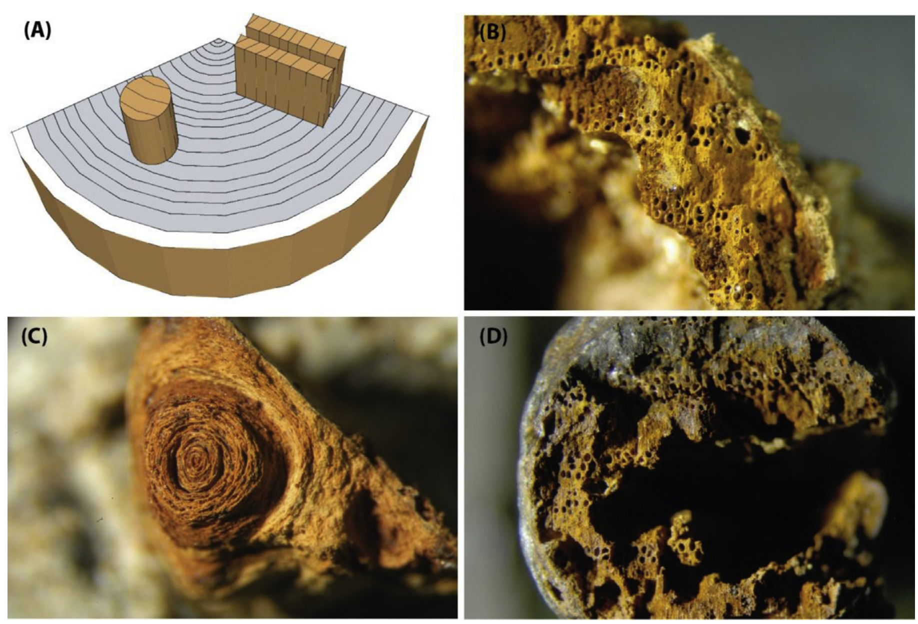


**Fig. 4.** (A) Extraction area for arrow/spear shafts and scabbards from the tree trunk (simplified). (B) Cross-sectional surface of a spear shaft made of cleft ash wood. Transverse section with annual rings and earlywood vessels (ring-porous species) are clearly visible. (C) Grain structure of a burr (*Acer sp.*) on a seax hilt; fibres grown in a deformed manner. (D) Cross-sectional surface of an arrow shaft made of cleft ash wood.

however, have not yet been executed. The results presented in this study, for the first time allow us to discuss the anthropogenic selection of wood species for early medieval weapon parts on a wider base. Some basic principles for choosing the type of wood and the production technique were identified. A preference for certain species may be explicit for specific weapon parts. At the heart of this constancy of choice in material are the technological characteristics of the wood species, related to the function of each object. The more unique the wood selection, the more we have to consider tradition-bound ideas as a further component. “Know-how” is discovered and passed on, particularly in specialised groups. We can recognise this most clearly when looking at the *spatha* scabbards. Only five species were detected, their technological properties are very similar, except for beech (*Fagus silvatica*). Alder, poplar, willow and lime wood (*Tilia* sp.) have a low density, are soft and easy to work. Their durability is low, whereas beech has higher density, is hard but can still be processed easily.

A selection according to optical aspects, such as colour, is negligible since the scabbards were usually coated with leather or textiles (Lehmann, 2007). In contrast, the suitability for carving might have been of acute importance, particularly for shaping the corresponding scabbard halves and assembling relief carvings (Menghin, 1983; Lehmann, 2007). The clear dominance of alder (81%) can be ascribed to its low density and very good workability.

The constant use of alder for the construction of scabbards can also be observed in the few comparative early medieval finds from the Alemannic areas east of the river Rhine as well as in the alpine upland (Menghin, 1983; Hopf, 1974; Lehmann, 2007). The deliberate selection of alder indicates a supra-regional tradition in craftsmanship.

Alder is also one of the most important materials for constructing shields. Around 68% of the determined shield remains were made of alder. It is the dominant species for this purpose, followed by poplar and willow. The targeted selection of these types of wood with low density, guaranteed the lightest defensive weapon possible. Previous wood anatomical studies on individual Alemannic shields from Oberflacht (DE) and Altdorf (CH) also identified alder (Schiek, 1992; Marti, 1995). Sporadic finds of shields with wooden remains from the Lombard cemetery at Vörs in Hungary, show poplar as the construction material (Füzes, 1964). A comparison with written sources extends the range of species used: The Lay of Hildebrand decidedly mentions shields of linden: *"do stoptun to samane staimbort chludun, heuwun harmlicco huitte* ***scilti****, unti im iro* ***lintun*** *luttilo wurtun, giwigan miti wabnum"/"There they stopped together, split their shieldboards, hewn were harmfully white the* ***shields****, until their* ***limes*** *became little, wrecked with weapons"* (Müller, 2007).

Five different species of wood were used for axe handles (Fig. 3). Their common properties are high density, impact bending strength and hardness, which may have had a positive impact on longevity and efficiency of this top-heavy weapon type. The most frequently used species in the examined material was ash with 36.4%. This wood is very tough with high impact bending strength (Sell, 1997; Wagenführ, 2007). As already described in earlier ethnological and archaeological investigations, ash wood was preferably used for all kinds of tool handles in various eras (Blau, 1917; Schweingruber, 1976). During the Merovingian period however, a clear preference of ash for axe handles is not the case. In the study material, *Maloideae* and hornbeam (*Carpinus betulus*) are represented almost in equal number, and less frequently maple and oak. The cemetery at Broechem (BE) on the northern border of the Merovingian Empire indicates the use of holly (*Ilex aquifolium*), another dense and hard species for axe handles (Haneca et al., 2012). Hilts of *spathae*, seaxes and knives show no discernible pattern to favour certain taxa or a particular wood property.

Different wood types, some with divergent mechanical properties, were used for the same purpose. The reason for this is simple: hilts and handles are hardly exposed to any great mechanical stress. Their only function is to improve comfort and appearance. In two cases, the utilization of maple burrs has been documented, which would certainly have increased the attractiveness of the weapon.

The numerous spears examined show a clear preference for two wood species. The most commonly used was ash, represented by 69.5% of the total material. In addition to ash, hazel was also frequently employed, comprising 23.2%. The use of ash can easily be explained by its physical advantages such as high impact bending strength, compressive and flexural strength. Hazel as a shrub consists of numerous straight shoots. Entire shoots can be used for spears without much processing. This would make hazel a preferential material for short-term repairs of damaged shafts, despite its poorer mechanical properties. All investigated hazel shafts were made of roundwood (entire shoots). In contrast, the ash shafts were manufactured from cleft wood without exception (Fig. 4B, and D). The intentional selection of these two taxa for the construction of spear shafts is further confirmed when compared to earlier studies of individual Merovingian burials. In the Alemannic cemetery of Oberflacht (DE), two shafts of ash and one of hazel were identified (Schiek, 1992). In Dortmund-Asseln (DE) and Krefeld-Gellep (DE) the same two wood species were detected (Tegtmeier, 2011; Hopf, 1974, 1979). Individual finds from the southern foothills of the Alps provide a similar picture (Maspero, 1990). The aforementioned Lay of Hildebrand specifically refers to ash ("*asckim*") for spear (Braune and Ebbinghaus, 1965; Müller, 2007).

A comparison with the examined arrow shafts shows a similar relation. The material comprises mostly of ash with 73.7%, followed by hazel with 17.5%. Despite a somewhat greater variety of species, a distinct preference for these two types of wood is distinguishable (Fig. 3). Individual studies of arrows in Germany and Switzerland, however, show a much greater variety: In Altdorf-St. Martin (CH), apart from ash and hazel, honeysuckle (*Lonicera* sp.) was identified (Marti, 1995). In Fellbach-Schmiden (DE), at least seven species were used for arrows (Willerding, 1982). In the Merovingian cemetery of Cologne-Müngersdorf (DE), shaft remains identified as spruce (*Picea abies*), fir (*Abies alba*), pine (*Pinus sylvestris*), beech and *Maloideae* were detected (Fremersdorf, 1955). From Oberflacht (DE), an arrow shaft fragment of wayfaring tree (*Viburnum lantana*) and one of birch (*Betula* sp.) was preserved (Schiek, 1992). All previous studies demonstrate that arrows were made from both roundwood shoots as well as cleft timber. As discussed earlier with spears, it may be presumed that, arrow shafts were replaced individually, perhaps even more frequently than the more robust shafts of spears.

The wood residues examined in this study come from 42 Merovingian cemeteries and make a data-set of 316 samples, divisible into nine groups of objects (Fig. 1B). Seven different types of weapon were present, reflecting a large part of Merovingian weaponry, specifically weapons constructed using a combination of metal and wood. The wide geographic distribution within the study area (Fig. 1A) makes local vegetation differences negligible when considering wood species selection.

Examination of the data reveals diverse levels of consistency in the material used and intentional wood selection for different ranges of application. In addition to purely mechanical-practical advantages that lead to the preference of certain taxa, elements of tradition and popular belief must be considered. Early medieval written sources provide further information by clearly naming wood types (Lay of Hildebrand) or by giving substantial value to wooden elements of weaponry (Beyerle and Buchner, 1954) thus adding a human component, which can not be ascertained from archaeological find material alone.

The results of wood anatomical research indicate that the selection and processing of wood in Merovingian times was predominantly based on specific knowledge and supra-regional traditions. However, written records and archaeological finds do not suggest a specialised woodcraft in the context of weaponry production. Presumably wood "know-how" and knowledge was instead developed and transferred through time by skilled armourers.

## Author Contributions

W.T. analysed the material. W.T. and B.M. designed and coordinated the study with input from U.B. All authors contributed to writing the paper.

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## Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.jas.2015.11.011.

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