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It looks fishy! The role of bone needles and pins in fish processing at the early medieval riverine settlement of Dorestad (The Netherlands)

Le rôle des aiguilles et des épingles en os dans la transformation du poisson dans la colonie fluviale médiévale de Dorestad (Pays-Bas)

Cynthia Lucie Satinem Kromotaroeno

Abstract: This paper shares some results of research into the bone artefacts from early medieval Dorestad with a focus on the functional analysis of pointed bone tools that are typologically labelled as bone pins (without perforation) or bone needles (with perforation). To more thoroughly understand the development of an *emporium* like Dorestad, the role of the settlement within the exchange system has become the subject of an ongoing debate interrogating the role of the inhabitants as either the producers of trade goods or as tradesmen. Due to poor preservation of suitable trade goods such as wool and hide, it is not clear to what degree the inhabitants produced goods that were exchanged. However, use-wear analysis can be used to examine whether the bone tools from Dorestad show traces of use and, if so, to which contact materials and activities they can be linked. Because fish exploitation took place in Dorestad, fish experiments were included in the experimental programme. Experimental bone tools were used to pierce a fresh piece of salmon, a fresh salmon skin, and tanned salmon skins. The use-wear traces on two archaeological bone tools resemble those found on the experimental bone tool with fresh salmon. This suggests that these common bone tools, which are often interpreted as hairpins or textile tools, were instead part of the subsistence strategy of the inhabitants of Dorestad. Use wear analysis has, thus, provided evidence of a surprising alternative use of these bone tools.
Keywords: Use-wear (bone), experimental approach, fish, Early Middle Ages, Dorestad.

Résumé : Pour mieux comprendre le développement d'un emporium comme celui de Dorestad, le rôle de la colonisation au sein du système d'échange fait l'objet d'un débat permanent, interrogeant le rôle des habitants en tant que producteurs de biens d'échange ou simplement en tant que commerçants. En raison de la mauvaise conservation des biens commerciaux, il n'est pas clairement établi si les habitants produisaient les biens échangés. Cependant, l'analyse des micro-usures peut être employée pour rechercher d'éventuelles traces d'utilisation sur les outils en os et en bois de cerf de Dorestad, et, le cas échéant, pour définir à quels matériaux et activités ces outils pourraient être liés. L'exploitation de ressources ichtyologiques étant attestée sur le site, des expérimentations sur des poissons ont été incluses dans le programme de recherche. Des outils expérimentaux en os ont été utilisés au contact d'un morceau de saumon frais, d'une peau de saumon fraîche et de peaux de saumon tannées. L'analyse des micro-usures sur ces outils expérimentaux montre qu'un poli rugueux et gras et un aspect ondulé sont typiques du contact avec de la chair ou de la peau de poisson. De plus, des spots (zones microscopiques) de poli lisse et brillant sont visibles dans les parties supérieures de la topographie. Les différences entre les trois types de restes de poissons concernent la topographie et la répartition des usures, la disposition et la morphologie des stries. Le contact avec la peau de poisson tannée produit un amas relativement dense de stries parallèles. Ces stries sont longues, fines et ont une direction longitudinale. La topographie est homogène. Le contact avec la peau fraîche et humide entraîne des stries relativement peu profondes et plus dispersées, et la topographie est hétérogène. Enfin, le contact avec la peau, les écailles, la chair et les os du poisson donne lieu à un motif plus varié de stries relativement larges et courtes ainsi qu'à des groupes de stries parallèles rapprochées ; la topographie est

relativement homogène. Les micro-usures sur deux outils archéologiques en os de Dorestad (musée national des Antiquités de Leiden, no inv. WD357 et WD385) ressemblent à celles observées sur des outils expérimentaux en os ayant été au contact d'un poisson frais. Comme cela a été observé lors de l'expérimentation avec du poisson frais, percer la peau, la chair et les os est une tâche difficile, et l'outil pointu en os ne s'est pas révélé très efficace. Pour résoudre ces difficultés, l'épingle archéologique en os (musée national des Antiquités de Leiden, no inv. WD 357) a pu être emmanchée ou recouverte d'un autre matériau pour protéger les mains, ce qui aurait alors laissé des traces (de ligature ou d'emmanchement) sur les parties médiane et supérieure de l'artefact. De fait, des traces de manipulation sont visibles sur la partie supérieure de l'épingle. Les endommagements fonctionnels, en forme d'indentations, observés sur un côté de l'apex peuvent avoir été causés par la pression appliquée lors de l'utilisation. L'aiguille archéologique en os (musée national des Antiquités de Leiden, no inv. WD 385) a eu une activité principalement longitudinale et transversale. Les courtes stries transversales se présentent dans un alignement étroit et parallèle et ont peut-être été causées par le contact avec des écailles de poisson. Étant donné que les micro-usures indiquent qu'un fil grossier est passé à travers la perforation, l'aiguille pourrait avoir été utilisée pour enfiler du poisson. L'aiguille et l'épingle en os archéologiques pourraient avoir été utilisées dans le processus de préservation du poisson. Si tel est le cas, la présence de ces outils en os indiquerait que la conservation du poisson avait lieu dans l'habitat. Sur la base de ces résultats, il n'est pas possible de déterminer si la production était destinée à la consommation personnelle ou si elle était liée à un excédent pour le domaine seigneurial, les institutions ecclésiastiques ou le commerce. Cela suggère cependant que les aiguilles et les épingles en os faisaient partie de la stratégie de subsistance des habitants de Dorestad.
Mots-clés : trace d'usage (os), approche expérimentale, poisson, haut Moyen Âge, Dorestad.

INTRODUCTION

This paper discusses some results from a PhD research project which focusses on the functional analysis of more than seventy pointed bone tools from early medieval Dorestad. The pointed bone tools, typologically labelled as bone pins (without perforation) and bone needles (with perforation), are commonly at the settlement and often interpreted as hair pins and tools for textile or fibre-working. Dorestad, with its strategic location near the rivers Rhine and Lek, is considered to have been an important trading centre in the Early Middle Ages. The role of the settlement within the exchange system is, however, the subject of ongoing debate (e.g. Theuws, 2004, pp. 133–135; Henning, 2008; Kemme, 2021, p. 29). In order to understand the development of an *emporium* such as Dorestad more thoroughly, the question remains to what extent the inhabitants acted as producers of trade goods or were they more tradesmen. Because organic materials are rarely preserved and therefore largely invisible in the archaeological record, it is not clear if suitable trade goods from materials such as wool and hide were produced at the settlement (Kemme, 2021, p. 324). Use-wear analysis is being carried out on the bone and antler artefacts from Dorestad to gain more insight into their function. This type of analysis can provide indirect evidence for craft or subsistence activities involving organic materials like textile production, hide-working or food treatment. Use-wear analysis involves the study of the traces of wear that develop on the tools' surface resulting from different activities.

Pointed bone tools such as the types formally categorised as pins and needles can actually be used for a wide variety of purposes such as hairpins, clothing pins, awls and other tools used in fibre and skin-working (Prummel et al., 2011). At least two bone pins and needles with similar use-wear traces could not be connected to expected functions such as textile production or hide-working. One hypothesis is that some bone tools from Dorestad may have been used on fish. Evidence of fish exploitation at the settlement includes fishing equipment such as a fish tank, fishhooks, fish traps and a basket (*viskaar*). The latter was kept in the river to hold living fish such as eels (Prummel, 1983, p. 11; Willemsen, 2009, pp. 112–113). Fish remains have also been found, although these represent only a small part of the total bone assemblage. Of the many thousands of bones from Dorestad that have been examined and identified, domesticated mammals constitute the largest category, including animals like goats (*Capra hircus*), sheep (*Ovis aries*), pigs (*Sus domesticus*) and horses (*Equus caballus*). More than half of the hand-collected animal remains, however, consisted of cattle (*Bos taurus*; Prummel, 1983, pp. 74, 90, 94, 103, 108; Slopsma, 2004, pp. 52–54). Fish remains were found, coming from a wide variety of species, including eleven freshwater species, four anadramous species and at least five marine species, such as the eel (*Anguilla Anguilla* L.), perch (*Perca fluviatilis* L.), pike (*Esox Lucius* L.), sturgeon (*Acipenser sturio* L.), salmon (*Salmo cf salar* L.), herring (*Clupea harengus* L.), flounder (*Platichthys flesus* L.), plaice (*Pleuronectes platessa* L.) and turbot (*Scophthalmus maximus* L.; Prummel, 1983, pp. 11, 90, 94, 108). For this study, three experiments with fish were included in the experimental programme. These experiments ought not to be considered exhaustive, but rather as exploratory. They complement the reference collection of the Laboratory for Material Culture Studies (Faculty of Archaeology, Leiden University) that has been used for interpreting the microwear traces on the bone tools from Dorestad.

The first part of this paper describes the methodology that was employed, consisting of use-wear analysis and experimental archaeology. Subsequently, the experiments are considered, both the procedures and the resulting use-wear traces. The use-wear traces on two bone tools from Dorestad are then described and compared with those traces found on the experiments. Finally, the role of bone needles and pins in fish-processing at the early medieval riverine settlement of Dorestad is discussed.

1. METHODOLOGY

By conducting both macro and microscopic examinations, it is possible to characterise use-wear traces such as polish, striations and volume alterations (e.g. Van Gijn, 1989, p. 3; Maigrot, 2003; Griffitts, 2006; Legrand and Sidera, 2007; Buc, 2011; Struckmeyer, 2011; Bradfield, 2015; Evora, 2015). Bone tool experiments are conducted as a source of reference to interpret the microwear traces on these artefacts. Furthermore, experimental archaeology can also be used to increase our understanding of specific bone tools and how well they could be used for certain tasks (e.g. Van Gijn, 1989, pp. 24–25; Buc, 2011).

Both the experimental and the archaeological material were examined in the Laboratory for Material Culture Studies of the Faculty of Archaeology of Leiden University. A stereomicroscope was used to study manufacture traces and to obtain a general overview of the use-wear traces, while a more detailed analysis of the use-wear traces was carried out with a metallographic microscope (following = among others Griffitts, 2006; Legrand and Sidera, 2007; Buc, 2011; Bradfield, 2015; Evora, 2015). The artefacts were examined under a SMZ800 Nikon stereomicroscope (magnifications 10× to 64×) with adjustable oblique light and a Leica DM6000 M metallurgical microscope (magnifications 100× to 200×). Microscopic images were taken with a Leica DFC450 camera that allows multiple photos to be merged into one sharp image.

1.1. Experiments with fish

The following three bone tool experiments were carried out with fish: piercing a piece of fresh salmon, piercing fresh salmon skin and piercing tanned salmon skin. Two bone fragments were selected as a bone tool because they already had a pointed shape. No further modifications were made. These two bone tools were used for the experiments on fresh fish. The choice of ad hoc bone tools was pragmatic, because the fish remains had to be processed in as fresh a state as possible. The third bone tool was a pin that was worked with a knife before being used for the experiment on the tanned fish skin. After use, the experimental bone tools were washed with soap and water.

For the experiment on a fresh salmon, a pointed bone tool was pierced repeatedly through the tail of a piece of salmon for 15 minutes. Before use, the piece of salmon was stored in a plastic bag filled with water. During the activity, the bone tool pierced the scales, skin, flesh and bones of the fish. It was quite a difficult task, and the bone tool was not very effective. After use, some rounding of the edges is visible macroscopically. At higher magnifications the bone tool has a greasy and slightly rough polish with a corrugated character (fig. 1a). There are also smooth, bright spots of polish present on the higher parts of the topography. The topography is somewhat domed. On the tip, wide and short striations are visible in diagonal, transversal and longitudinal directions. Above the tip, spots of greasy, bright polish are visible with short and wide striations in multiple directions. Some spots have dense clusters of closely-spaced, parallel striations (fig. 1b). A linked polish developed at the edges together with wide longitudinal and transversal striations (fig. 2a).

For the second experiment, the skin of a fresh salmon (without scales) was pierced with a pointed bone tool for 30 minutes. Prior to use, the fish skin was kept in a bag with water. The tool was not very effective. Because the skin was very elastic, it had to be pulled tight during the activity. This was very tiring and harmful to the hands, as a lot of force had to be applied to the back of the tool. After use, the tip and the edges of the pointed tool were clearly rounded. The bone tool developed a rough, greasy and corrugated polish (fig. 2b). Bright, smooth spots of polish are also visible on the higher parts of the topography. The topography is heterogenous and domed. Short, shallow striations are scattered across the surface in a transversal and longitudinal direction. A smooth and bright polish is visible on the tip with wide, short striations in all directions.

For the third experiment, a bone pin was used to pierce three tanned salmon skins for 40 minutes. These salmon skins had been brain tanned. The pin was very effective and could be easily thrust through the hides. After the experiment, some rounding occurred at the tip of the bone tool. Microscopically, the pin has a rough, greasy polish (fig. 3a). A smooth, very bright and reflective polish developed on the higher parts of the topography. The topography is domed. Fine and long longitudinal striations are present in a closely spaced, parallel arrangement (fig. 3b). The tip displays short striations developed in a diagonal, transversal and longitudinal direction.

2. RESULTS

The bone tools under study derive from a collection at the National Museum of Antiquities in Leiden that was excavated in the 19th century.[1] Although many years have passed since the artefacts from this collection were excavated, previous research has shown that use-wear traces are well enough preserved to allow the past use of these artefacts to be interpreted.[2] Use-wear traces on an archaeological bone pin and a bone needle are consistent with the observations made on the experimental bone tools. These two bone tools and their microwear traces are described in this section.

The bone pin (National Museum of Antiquities, Leiden, inv. No. WD357) has a length of 10.6 cm and a width of 1.4 cm (fig. 4)[3]. The pin is made from a pig fibula with relatively little processing of the head, which naturally

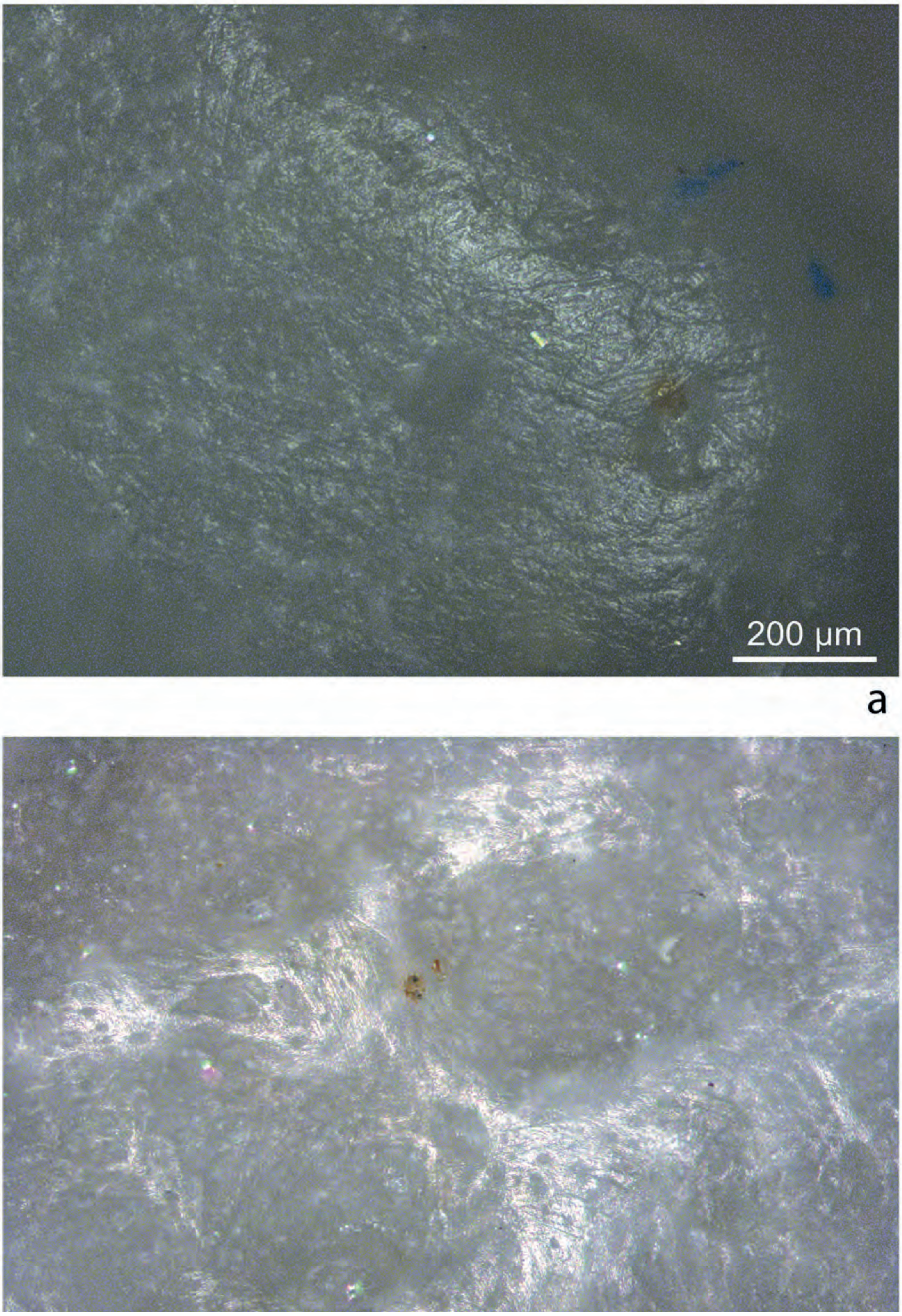

Fig. 1 – Microscopic images of the use-wear traces on an experimental bone tool that was in contact with a fresh piece of salmon: a) Note the rough, greasy polish with spots of bright, smooth polish; b) Spots of smooth, bright polish with a corrugated character and dense clusters of closely spaced, parallel striations.

***Fig. 1** – Vues microscopiques des usures formées sur un outil en os après un contact avec du saumon frais : a) poli rugueux et gras avec des spots conservant un poli brillant et lisse ; b) zones microscopiques sur lesquelles est visible un poli lisse et brillant avec un caractère ondulé et des amas denses de stries parallèles rapprochées.*

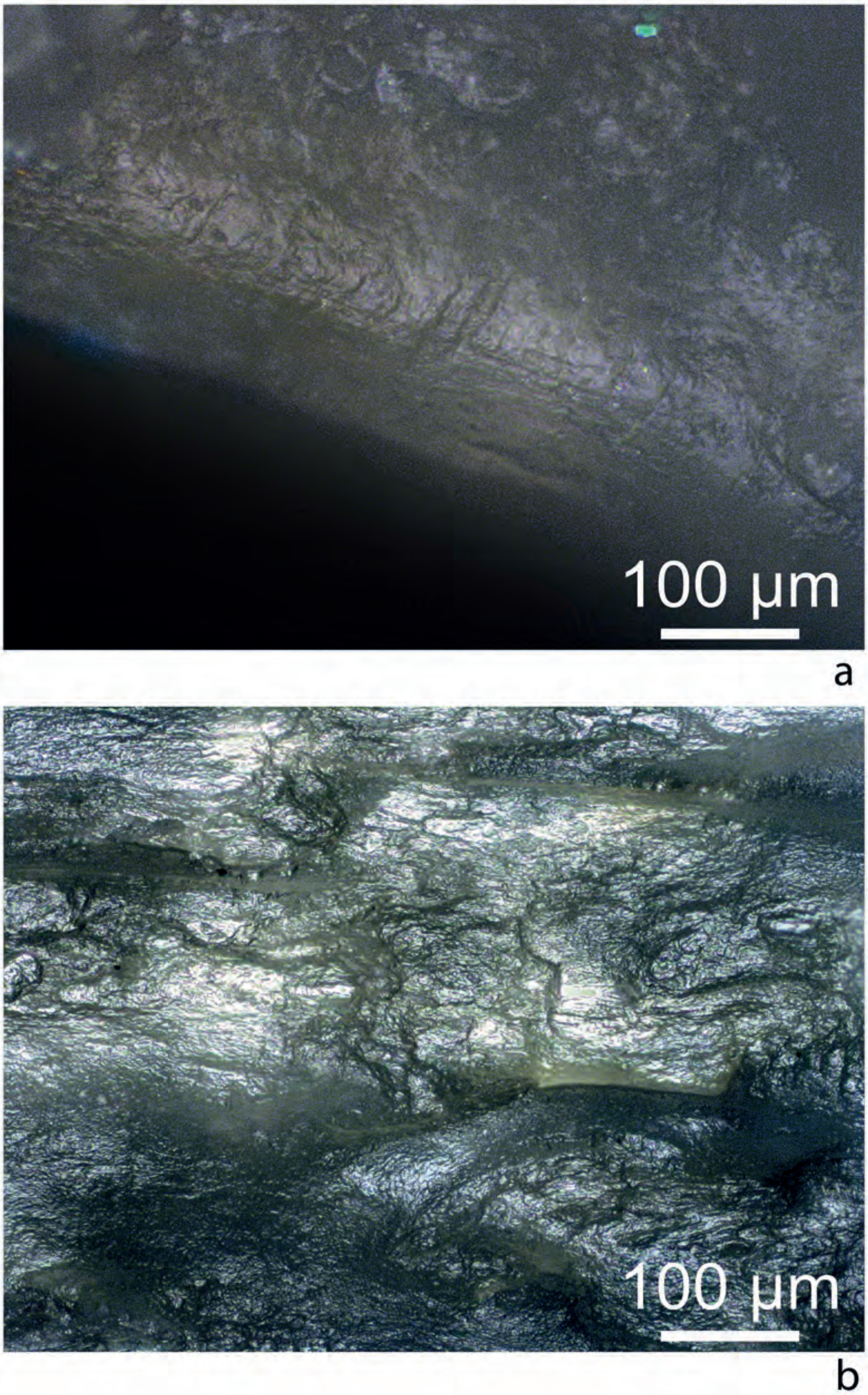

Fig. 2 – Experimental bone tools: a) One in contact with a fresh piece of salmon (including skin, flesh, bones, and other tissue). A greasy, linked polish with wide longitudinal and transversal striations is microscopically visible at the edges; b) The other in contact with fresh salmon skin (microscopic image). Note the rough, greasy and corrugated polish with some bright, smoot spots, a heterogenous topography, and randomly oriented short, shallow striations.

Fig. 2 *– Outils expérimentaux en os : a) celui testé sur du saumon frais (avec la peau, mais aussi la chair, les os et les autres tissus) montre, sur les bords, un poli gras et continu, avec de larges stries longitudinales et transversales ; b) le second testé sur une peau de saumon fraîche (image microscopique) montre un poli rugueux, gras et ondulé, avec quelques points brillants et lisses, une topographie hétérogène et des stries courtes et peu profondes orientées de manière aléatoire.*

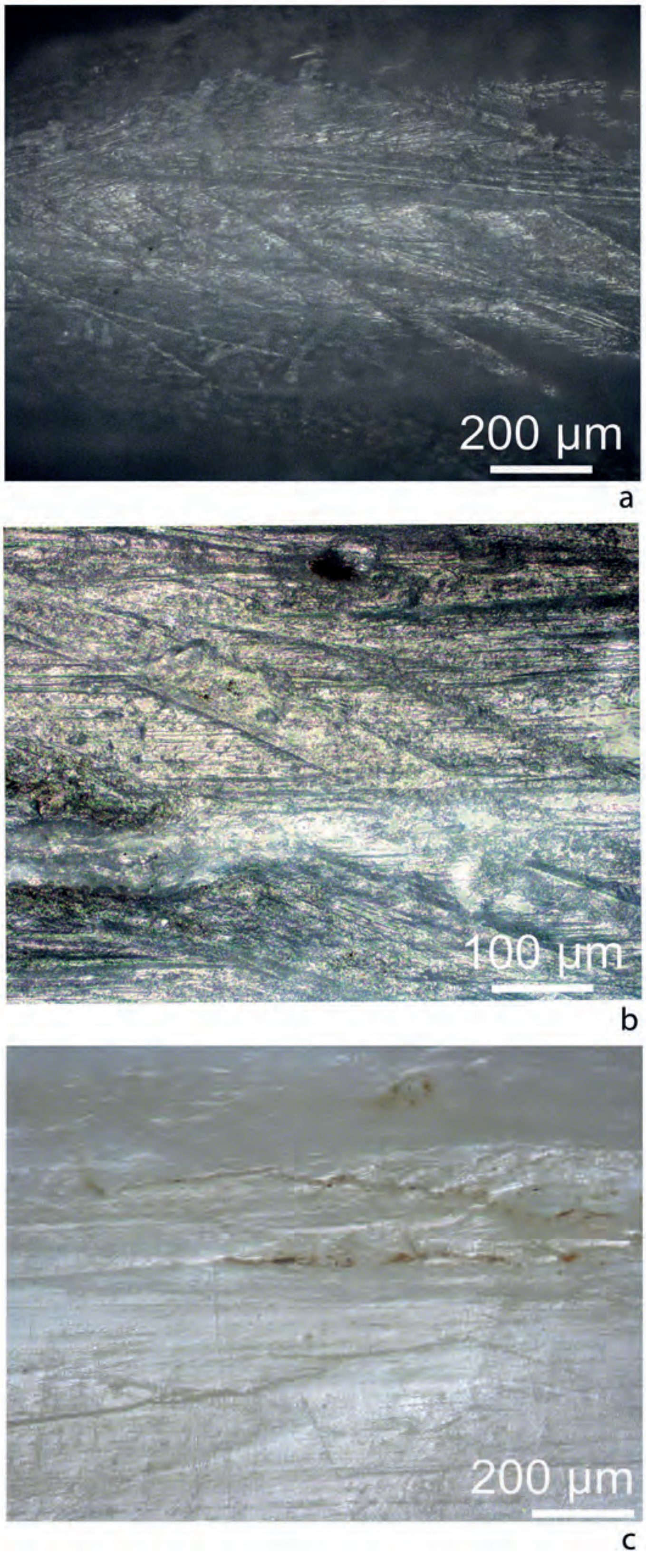

Fig. 3 – Microscopic images of the use-wear traces. On an experimental bone pin used on tanned salmon skin: a) Note the rough, greasy polish with a smooth, bright polish on the higher parts of the topography; b) A greasy polish is visible with fine, long and parallel striations in a longitudinal direction. On an experimental bone tool used on flax (20 minutes); note c) the flat, smooth and bright polish.
Fig. 3 – *Images microscopiques de micro-usures. Sur une épingle expérimentale en os utilisée sur de la peau de saumon tannée, on observe a) un poli rugueux et gras associé à un poli lisse et brillant sur les parties supérieures de la topographie ; b) un poli gras, aux stries fines, longues et parallèles dans le sens longitudinal. Sur un outil en os expérimental testé sur du lin (20 minutes), on observe c) un poli plat, lisse et brillant.*

widens towards one end. The pin has been worked with a knife, creating a faceted surface with broad striations in a longitudinal and sometimes also in a diagonal direction. The point is flat in cross-section and shows traces of (re)working in a diagonal direction. The end of the point is broken off. Functional damage in the form of indentation occurred on one side of the tip probably due to the pressure exerted during use (fig. 4a). Use-wear traces at the tip are well developed and extend, although slightly less developed, halfway along the length of the needle (fig. 4). The pin is covered with a rough, greasy polish and has a corrugated appearance. The topography is domed. There are also some spots of smooth, bright polish on the higher parts of the topography (fig. 4c). Wide longitudinal striations are predominantly present with some diagonal striations. Short and wide diagonal, transversal and longitudinal striations can be observed on the tip. There are some crossing diagonal striations along the edge of the needle. Broad transversal striations are present near the proximal epiphysis of the fibula and on the middle part of the pin. It is possible that the pin was hafted or encased in another material to protect the hands. Moreover, the surface of the proximal epiphysis shows handling traces, resulting in a greasy polish with striations running in a criss-cross direction, a domed topography and pitting (fig. 4b).

The bone needle (National Museum of Antiquities, Leiden, inv. No. WD385) is 9.9 cm long and 0.9 cm wide (fig. 5)[4]. The needle was produced with a knife. The perforation is irregular in shape and made with a chisel. The point has been (re)worked on both sides with a fine file. In addition, the point shows slight indentation. The point of the needle has a flat profile. Use-wear traces can be seen across the entire surface of the needle, although the traces at the tip are most heavily developed (fig. 5). Microscopically, the surface appears rough with a greasy, corrugated polish and a domed topography. The surface is somewhat pitted. Spots with a very bright and smooth polish are mainly present on the higher parts of the topography and on the edges of the needle. Striations have developed in a transversal and longitudinal direction. Sometimes the transversal striations occur in close and parallel alignment (fig. 5a and fig. 5b). Short, diagonal striations formed on the sides of the needle, sometimes crossing each other. Along the perforation, wide, short striations are present, running in a transversal and diagonal direction, possibly caused by a relatively coarse thread that passed through the perforation.

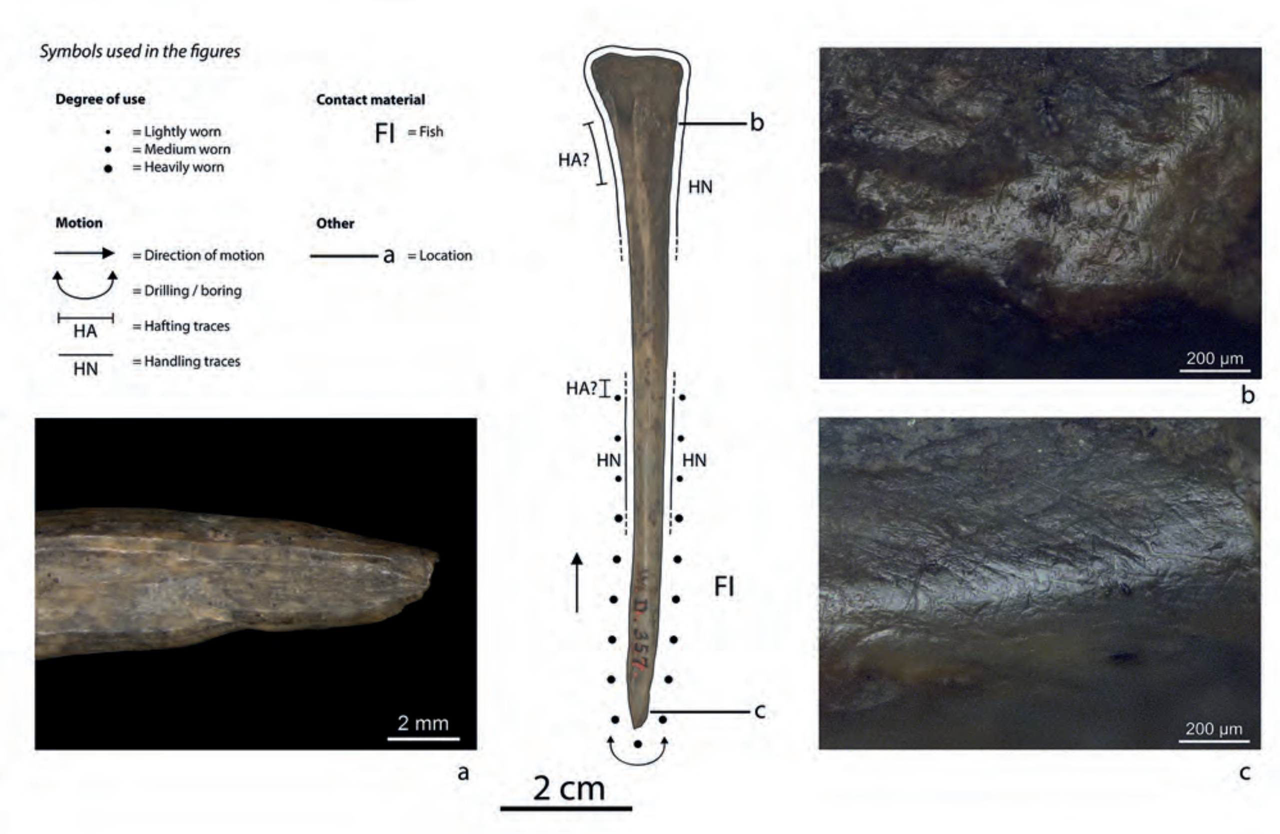

Fig. 4 – Use-wear traces on a bone pin from Dorestad (National Museum of Antiquities, Leiden, inv No. WD357). a) Tip of bone pin WD357 with broken end and dents on one side; b) Handling traces with broad transversal striations on the right side of the image (possibly hafting or binding traces); c) The tip has a rough, greasy polish with a domed topography and some spots of bright polish.

***Fig. 4** – Traces d’usure sur une épingle en os de Dorestad (musée national des Antiquités, Leiden, inv No. WD357) : a) pointe de la tige osseuse WD357 avec une extrémité cassée et des endommagements fonctionnels en forme d’indentations sur un côté ; b) traces de manipulation avec de larges stries transversales sur le côté droit de l’image (possiblement des traces d’emmanchement ou de ligature) ; c) la pointe a un poli rugueux et gras avec une topographie en forme de dôme et quelques spots de poli brillant.*

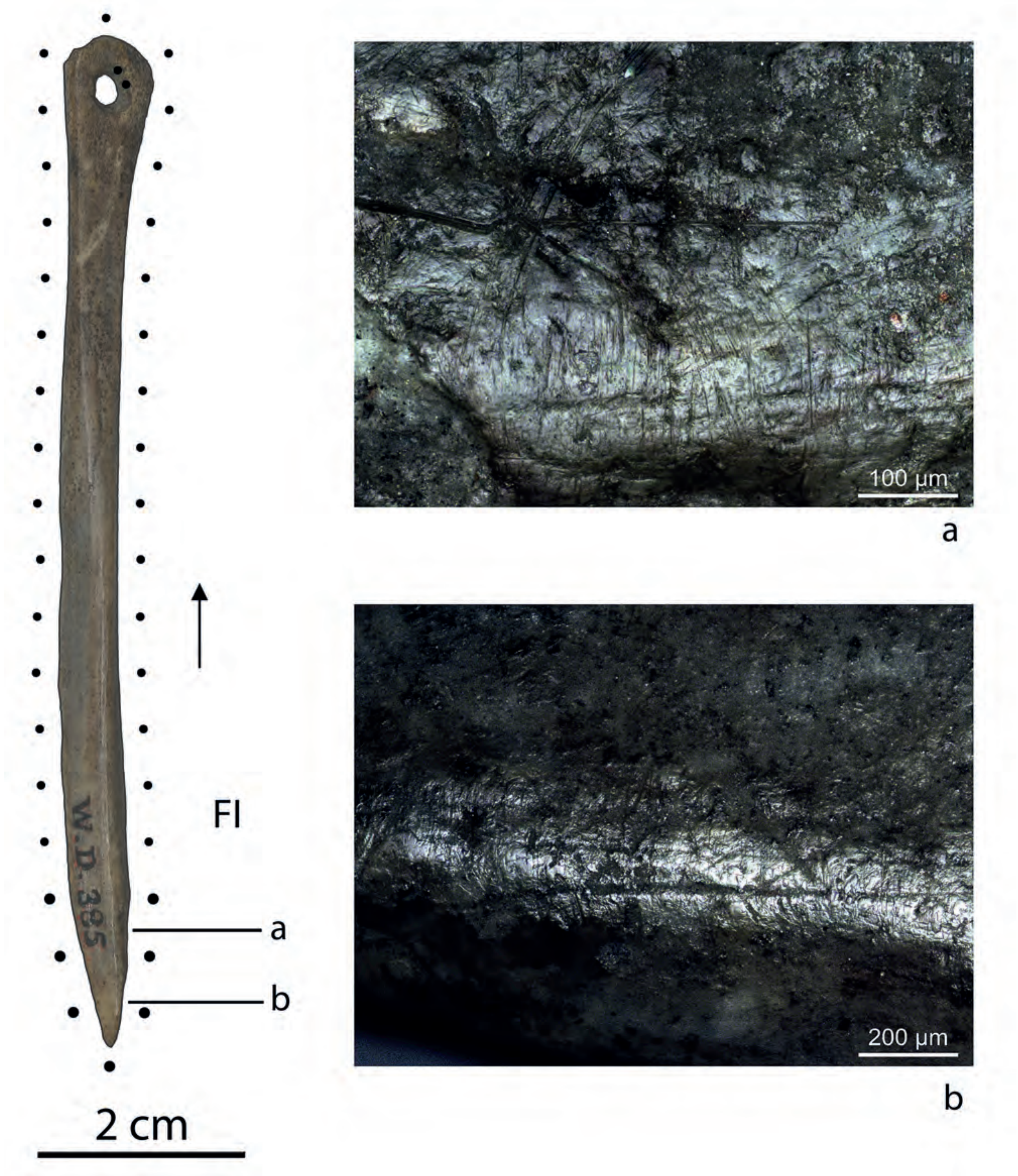

Fig. 5 – Use-wear traces on a bone needle from Dorestad (National Museum of Antiquities, Leiden, inv. No. WD385): a.) Some clusters of transversal striations in a close and parallel alignment; b. Note the rough, greasy polish with spots of bright, smooth polish, the domed topography and the short, parallel transversal striations.

***Fig. 5** – Traces d'usure sur une aiguille en os de Dorestad (musée national des Antiquités, Leiden, inv. no. WD385) : a) quelques groupes de stries transversales dans un alignement étroit et parallèle ; b) le poli rugueux et gras avec des spots d'un poli brillant et lisse, la topographie en forme de dôme et les stries transversales courtes et parallèles.*

3. DISCUSSION

The microwear traces on the experimental bone tools that came into contact with fish remains are characterised by a rough and greasy polish. The smooth, bright polish on the higher parts of the topography is quite similar to plant polish (compare figure 3c to figures 1, 2, 3a and 3b; e.g. Griffitts, 2006, p. 184; Van Gijn, 2007, pp. 84–85; Buc, 2011; Bradfield, 2015, p. 6). The corrugated character of the traces is characteristic of contact with fish, which develops more when working with fresh fish (see also Van Gijn, 1986). The combination of these traces is typical for fish as a contact material. Differences between the three experiments concern the distribution, arrangement and morphology of the striations. Contact with tanned fish skin produces a relatively dense cluster of parallel striations. These striations are long and fine with a longitudinal direction. The bone tool that was in contact with wet, fresh skin resulted in relatively shallow and more dispersed striations. This has also been observed in another experimental study (Buc, 2011, p. 554). Finally, contact with fish skin, scales, flesh and bone creates a more varied pattern of relatively wide, short striations and clusters of closely spaced, parallel striations.

The microwear traces on the archaeological bone tools are very similar to those on the experimental fish bone tools. They also have a rough, corrugated polish and the topography is domed. The polish can be greasy, but also very bright and smooth on the higher parts of the topography. As in the experiments with fresh fish, wide striations are visible on the surface of the archaeological bone pin (National Museum of Antiquities, Leiden, inv. No. WD357). Based on these characteristics, it is likely that the archaeological bone needle and bone pin were in contact with fresh, whole fish. As observed during the experiment with fresh fish, piercing through layers of scales, skin, flesh and bone proved to be a difficult task and the ad hoc bone tool turned out to be relatively ineffective. However, in a more realistic setting, parts of the fish that were easier to pierce would have been used. Perhaps as a solution to the difficulties of piercing fresh fish, the archaeological bone pin (National Museum of Antiquities, Leiden, inv. No. WD357) may have been hafted or been covered with some other material to protect the hands, leaving binding traces on the middle and upper parts of the artefact. Traces of hand contact are visible on the head of the pin. The indentation on one side of the tip may be caused by the pressure applied during use. The archaeological bone needle (National Museum of Antiquities, Leiden, inv. No. WD385) was involved in a mainly longitudinal and transversal activity. The short transversal striations can occur in a close and parallel alignment. These transversal striations are somewhat similar to the traces found on an experimental spatula that was used for scaling fish (Arrighi et al., 2016, p. 154). The intersecting diagonal striations at the edge of the needle can also be explained by contact with fish scales (Van Gijn, 1986, p. 15). Given that a coarse thread probably passed through the perforation, it is possible that the needle was used to string fish (Kristjánsson, 1985, pp. 148–149, 484).

Conceivably, the bone needle and pin from Dorestad were part of a fish preservation process, such as smoking and drying whole fish. There are ethnohistoric examples from 19th century Orkney and Shetland of both fish hanging by domestic fires and fish hanging outside in large numbers to dry (Fenton, 1978, pp. 528, 530). Despite being a nutritious food, fish played only a minor role in the food supply of Dorestad (see introduction). It provided variety in the diet and could be eaten during religious fasting periods that occurred 130 days a year (Prummel, 1983, pp. 248, 254–257; Hoffmann, 2004, p. 23). Fish need to be preserved before decay sets in within 1 to 7 hours of death, or within a few days in cold conditions. The preservation method affects the duration of preservation and the flavour of the end product. The extent to which fish can be dried successfully depends on the weather conditions (including the absence of black flies) and the dimensions and quality of the fish (Locker, 2000, pp. 51–53, 59). Drying in the Dutch climate can be done if a fish is thin and small enough. A suitable marine species would be flatfish, of which the flounder (*Platichthys flesus* L.), plaice (*Pleuronectes platessa* L.) and turbot (*Scophthalmus maximus* L.) were found in Dorestad (Prummel, 1983, pp. 90, 94, 108; Kerklaan, 2021, p. 367). Research has shown that flatfish were already caught for consumption in the North Sea in the early medieval period, before the “marine fish event horizon” (10th–11th c. AD), when the economic exploitation of fish has shifted from freshwater to marine fish. The settlements involved were all part of a trading network and it has been suggested that they were linked by the exploitation of flatfish (Dierickx et al., 2024, pp. 818–819). In the late medieval period, the site of Raversijde (Belgium) was known for its large-scale processing of flatfish (Pieters et al., 1995; Van Neer and Pieters, 1997; Tys and Pieters, 2009). A wide variety of fish were found during the excavations in Dorestad, including smaller species such as roach (*Scophthalmus maximus* L.) that could have been suitable for smoking (Prummel, 1983, pp. 108, 236). However, smoking fish without first drying or salting it, means it will have a significantly shorter storage life. For subsistence storage, smoking has long been practiced using a domestic, household fire, often combined with other methods such as drying (Locker, 2000, p. 57). Irrespective of whether the pointed objects were used for smoking and/or drying fish, their presence can be regarded as an indication that fish was not only part of the food economy, but that fish processing also took place in the settlement. Based on these two bone tools alone, it cannot be determined whether the production of preserved fish was intended for personal consumption or whether it was related to a surplus for the manorial estate, ecclesiastical institutions or trade.

PRELIMINARY CONCLUSIONS

Preliminary results show that formal the types of bone needle and pin, typically associated with hair adornment or fibre working, can also be associated with fish processing. Three experiments were carried out for this research project: piercing a piece of fresh salmon from the skin to the bones, piercing fresh salmon skin and piercing tanned salmon skin. Typical traces on experiments with fresh fish include a rough, greasy polish with spots of smooth, bright polish and the corrugated character of the traces. The bone pin (National Museum of Antiquities, Leiden, inv. No. WD357) was possibly hafted or covered with a material to protect the hands during use. The bone needle (National Museum of Antiquities, Leiden, inv. No. WD385) may have been used to string fish. For future research, experiments involving multiple activities with different fish species, such as flatfish and roach, will be undertaken to gain further insight into the use of these two artefacts and possibly other artefacts from the Dorestad bone tool assemblage. Although research on these two bone tools indicate that pointed bone tools formed part of the subsistence strategy of the inhabitants of Dorestad, further research into the bone and antler tools will further illuminate this.

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NOTES

1. Personal communication A. Willemsen.
2. Kromotaroeno, forthcoming.
3. See https://hdl.handle.net/21.12126/152730.
4. See https://hdl.handle.net/21.12126/152959.

Cynthia Lucie Satinem Kromotaroeno
Leiden, The Netherlands
clskarcheologie@gmail.com

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