Bone, Tools, and Traditions
15th WBRG Meeting (Paris, 2024)
Organized by Nejma Goutas and Marianne Christensen
Paris, Société préhistorique française, 2026 (Séances de la Société préhistorique française, 24)
pp. 379–388
www.prehistoire.org
ISSN : 2263-3847 – ISBN : 978-2-9588382-2-5

Archery and quiver experiments with barbed bone and antler points

Expériences de tir à l'arc et de carquois avec des pointes en os et en bois de cerf barbelées

Merel Spithoven

Abstract: In the context of an analysis of osseous points from postglacial Doggerland, an experimental program was set-up to create a reference collection to interpret wear traces on archaeological specimen. This paper presents a basic outline of the experiments and the main insights obtained. In total, 69 points were made for which deer bone and antler was used. Three different archery experiments were conducted: deer shooting, bowfishing and replicating missed arrows. In addition, three different quivers were used to carry arrows: fallow deer (*Dama dama)* skin with hairs on the inside, fallow deer skin with hairs on the outside and birch bark. It has been assumed that smaller points were used as arrowheads and larger points as spearheads. However, the experiments show that small as well as large, barbed points are efficient arrowheads. Polish from contact with fish can be distinguished from other animal polishes, permitting the identification of hunting fish on archaeological points. A missed arrow does not necessarily result in the breakage of the point. However, when hitting a tree or branch the chances are high that the point will break. Use-wear traces on the experimental points as a result of being carried in a hide quiver are similar to use-wear traces present on the archaeological points. The high degree of wear on the non-hafted part of the archaeological points may therefore be the result of the points being used as arrowheads and carried in hide quivers.
Keywords: Doggerland, projectile point, microwear analysis, experimental archaeology, artefact biography, postglacial.

Résumé : Pendant la fin du dernier âge glaciaire et une grande partie de l'Holocène ancien, la région actuellement connue sous le nom de « mer du Nord méridionale » était constituée de terres sèches et habitables. Avec la fonte du manteau de glace due au changement climatique, le niveau de la mer a progressivement augmenté, et la steppe-toundra s'est transformée en un paysage boréal. Les chasseurs-cueilleurs qui habitaient le Doggerland ont été confrontés à un changement environnemental qui a affecté le caractère du paysage dans son ensemble, tant en ce qui concerne la couverture végétale et les populations animales que la configuration du terrain. À long terme, cela a entraîné des changements dans la disponibilité des ressources, ce qui a nécessité des adaptations technologiques pour permettre leur exploitation. De plus, ces changements à grande échelle, en plus des événements « catastrophiques » survenus au cours de la vie d'un individu, ont pu affecter les relations socioculturelles et potentiellement mener à des conflits avec d'autres groupes de personnes. Un vaste enregistrement de découvertes archéologiques et paléontologiques extraites du fond de la mer du Nord et datant de cette période de changement est disponible pour la recherche. Parmi les artefacts, les outils osseux et les déchets de production forment le groupe de découvertes le plus important et le plus informatif. Cette contribution porte sur la plus grande catégorie de ces artefacts osseux : les pointes barbelées utilisées depuis le Paléolithique supérieur jusqu'au Mésolithique final, lorsque le Doggerland a complètement disparu sous les eaux.
La plupart des pointes osseuses provenant du Doggerland sont retrouvées sur les plages de la Zuid-Holland (Hollande-Méridionale), aux Pays-Bas. Plus de mille d'entre elles ont déjà été découvertes. Ces plages sont régulièrement réapprovisionnées avec du sable extrait des sites d'extraction de sable dans la mer du Nord, à environ 10 km au large. Par conséquent, les restes archéologiques du Doggerland sont retrouvés hors du contexte de leur emplacement/de leur environnement de dépôt primaire, mais sont très informatifs en ce qui concerne les processus de production, d'utilisation, d'entretien et d'abandon. Les pointes osseuses barbelées sont des armatures d'armes de chasse de type pointes de flèche, de sagaie et de javelot, ou pourquoi pas des lances. Elles étaient fixées à des hampes en bois avec des ligatures et sans doute une matière adhésive.

Un programme expérimental a été mis en place pour créer une collection de référence afin d'interpréter les traces d'usure sur les pointes osseuses provenant du Doggerland postglaciaire. En tout, 69 pointes ont été fabriquées à partir d'os et de bois de cerf. Trois expérimentations de tir ont été réalisées, à l'aide d'arcs : tir sur cerf, pêche à l'arc et tirs manqués. De plus, trois types de carquois ont été utilisés pour transporter les flèches : peau de daim (*Dama dama)* avec les poils à l'intérieur, peau de daim avec les poils à l'extérieur et écorce de bouleau. Il a été supposé que les petites pointes étaient utilisées comme pointes de flèche et les plus grandes comme pointes de lance. Cependant, les expériences montrent que les petites comme les grandes pointes barbelées sont des pointes de flèche efficaces. Le polissage résultant du contact avec le poisson peut être distingué des autres polissages d'animaux, permettant ainsi l'identification de la chasse au poisson sur les pointes archéologiques. Une flèche manquée ne conduit pas nécessairement à la rupture de la pointe. Cependant, lorsqu'une flèche frappe un arbre ou une branche, les chances de briser la pointe sont élevées. Les traces d'usure sur les pointes expérimentales, résultant du transport dans un carquois en peau, sont similaires aux traces d'usure présentes sur les pointes archéologiques. Le degré élevé d'usure sur la partie non emmanchée des pointes archéologiques peut donc être le résultat de l'utilisation des pointes comme pointes de flèche et de leur transport dans des carquois en peau. Le carquois présentant les poils à l'intérieur a été considéré comme le meilleur pour protéger les flèches et produire un bruit minimal. Le carquois en écorce de bouleau a été jugé le moins adapté. Dans ce dernier, les flèches bougeaient beaucoup et produisaient beaucoup plus de bruit. Cela a également entraîné des dommages mineurs aux pointes, qui se sont détachées de leurs hampes. Aucun polissage résultant du contact avec des plantes ou de l'écorce n'a été trouvé sur les pointes archéologiques étudiées pour cette recherche. Les traces d'usure associées aux deux types de carquois en peau étaient similaires. La principale différence semblait résider dans le degré d'usure développé. Les pointes transportées dans le carquois en peau avec les poils à l'intérieur ont généralement développé un degré d'usure plus élevé que celles transportées dans le carquois avec les poils à l'extérieur.

Mots-clés : Doggerland, pointe de projectile, tracéologie, usure, archéologie expérimentale, biographie d'objet, Postglaciaire.

INTRODUCTION

During the Late Glacial and much of the Early Holocene, the area presently known as the southern North Sea consisted of dry inhabitable land, baptised "Doggerland" by archaeologist B. Coles (1998). With the melting of the ice sheet due to climate change, sea levels rose steadily, and the steppe-tundra transformed into a boreal landscape with marshes, lakes and woodlands of mainly birch, pine and hazel (Coles, 2000; Gaffney et al., 2009; Leary, 2009). The hunter-gatherers that inhabited Doggerland were confronted with environmental change, which affected the character of the landscape as a whole, both in terms of the character of vegetation cover and animal populations, as well as in the lay of the land. At the long term, this led to changes in the availability of resources, which would urge for technological adaptations to enable their exploitation. Furthermore, these large-scale changes, in addition to "catastrophic" events occurring within a person's lifetime, could have affected sociocultural relationships, and could potentially have led to conflict with other groups of people (Waddington, 2007; Gaffney et al., 2009; Leary, 2009, p. 230; Momber, 2011).

As yet, we still know little about what really happened to the Doggerland hunter-gatherers. However, a vast record of archaeological and palaeontological finds dredged from the North Sea floor and dating from this period of change is available for research (Peeters and Amkreutz, 2020). Among the artefacts, osseous tools and production waste form the major and most informative group of finds. In this contribution I will focus on the largest category of these osseous artefacts: barbed points which were used from the Late Palaeolithic all the way to the Late Mesolithic period, when Doggerland completely submerged. The research presented here is part of the author's ongoing PhD work, which focusses on human-deer relationships in particular. A pilot study of Zooarchaeology by Mass Spectrometry on Doggerland points showed that many, if not most, barbed points are made of Red Deer (*Cervus elaphus*) and some of human bone (Dekker et al., 2021). Using the concept of object biographies insight was gained into the dynamics of particular aspects of materiality. Insight in such dynamics can help to look into the effects of environmental change as they occurred in the region of Doggerland. A representative experimental collection of osseous points being used as projectiles on different targets and carried in different quivers was not sufficiently available. Therefore, an experimental program was set-up to create a reference collection of barbed points to interpret the use-wear on the archaeological specimens and to test their use as projectiles. This paper presents some first insights from the experiments. A full account of the experiments, regarding protocol and results will be published at a later stage in the author's PhD dissertation.

1. MATERIALS AND METHODS

Most osseous points from Doggerland are found on the beaches of South-Holland in the Netherlands (Spithoven, 2016). Over a thousand have been found already (fig. 1). These beaches are regularly being replenished with sand extracted from allocated sand extraction sites in the North Sea, about 10 km off the coast. Therefore, archaeological remains from Doggerland are found out of the context of their primary depositional location/environment but are highly informative regarding processes of production, use, maintenance and discard.

Fig. 1 – Doggerland points (National Museum of Antiquities, Leiden).
***Fig. 1** – Pointes de Doggerland (Musée national des Antiquités, Leiden).*

Radiocarbon dating of such objects permits to evaluate the insights into such processes within a chronological framework.

1.1. Doggerland points

Barbed osseous points are weapon tips of hunting gear, such as arrowheads and spearheads. They were attached to wooden shafts with bindings and possibly tar. Barbed points can be found all over north-western Europe during the Late Palaeolithic to Mesolithic period. What makes the Doggerland points unique is their relatively short length and the intensity of use (Spithoven, 2018; Amkreutz and Spithoven, 2020). Most Doggerland points are shorter than 88,5 mm and have a high degree of wear (Spithoven, 2016). Use-wear on the points mainly consists of rounding and smoothening of the surface in combination with a polish from use. One of the indications that these wear traces are not (solely) caused by post-depositional processes is the fact that the hafted part of the points shows different degrees and types of wear than the non-hafted part.

1.2. Experimental points

An experimental program was set-up to create a reference collection to interpret wear traces on the archaeological points. In total, 69 points were made for which deer bone and antler was used. Blanks were shaped with a combination of scraping with flint and grinding on stone with sand and water. The average measurements and most common design for small and large Doggerland points were used to make the experimental specimens, based on data of over 900 Doggerland points. Small ones were made 50 mm in length, 10 mm in width and 5 mm in thickness. Large points were made 120 mm in length, 12 mm in width and 6 mm in thickness. The lateral barbs side was narrowed. Three barbs were cut into the small points with an oblique incision. Five barbs were cut into the large points in the shape of crosses. Production traces left by shaping the blank on stone are recognizable as longitudinal parallel grooves. The grooves are "empty" in contrast to grooves from shaping the blank with flint. The latter are wide with thin parallel striations inside of the grooves.

On the archaeological points clear borders are microscopically visible between the part which was hafted with bindings to a wooden shaft and the part that functioned as a weapon tip. On the hafted part polishes from contact with bindings developed. Different hafting methods were used to attach the experimental points to shafts to test if it is possible to infer which hafting method was used based on the wear traces present (fig. 2). About half of the points was attached using the bevelled hafting method, sawing off half of the end of the wooden shaft and attaching the point to the remaining half. The other points were attached to the shafts with the inserted method, sawing a slot into the end of the wooden shaft compatible with the thickness of the point. Two types of binding materials were used for binding the points to the shafts: nettle and sinew. Plant fibres, possibly nettle, were preserved on one of the archaeological points (Spithoven, 2018, p. 78). Sinew was assumed to have been used for hafting as well based on archaeological finds (Junkmanns et al., 2019, p. 307).

Fig. 2 – Bevelled hafting method (top) and inserted hafting method (bottom).
***Fig. 2** – Méthode de fixation biseautée (en haut) et méthode de fixation insérée (en bas).*

At last, birch tar was used during the hafting process for most experimental points, before or after the bindings were applied. Both methods can be seen ethnographically and archaeologically (Clark, 1954; Vahur et al., 2011; Zhilin, 2015, p. 47; Junkmanns et al., 2019, pp. 306–307). All experimental points were cleaned with soap after use (without abrasives).

2. ARCHERY EXPERIMENTS

The high degree of wear on the archaeological points suggests they were heavily curated weapon tips (Spithoven, 2018). This could be caused by the points being shot many times without breaking off the top part where most use-wear polish developed. Experiments with points being used as weapon tips have been conducted before (e.g. Buc, 2011; Bradfield and Brand, 2015; Spithoven, 2018; Pétillon and Cattelain, 2022). For this experimental program the focus lay on archery due to the small size of most Doggerland points. Three archery experiments have been conducted on different types of targets: deer, fish and replicating missed arrows. Making it a total of five experiments.

2.1. Hunting land mammals

A complete deer carcass, without intestines was hung on rope in a wooden frame (fig. 3). Unfortunately, it was not possible to obtain a carcass with the organs still remaining, due to legal regulations regarding hygiene, which would have been more representative for use-wear results (Pétillon et al., 2016). Twenty arrows in total were shot in the deer with a wooden longbow of 45 pounds at 26.5 inch draw length and wooden laminate from back to belly made of bamboo, robinia, ipe, and yellow lapacho. The distance between the archer and the target was about 6 m ensuring that no arrows would miss the target. Half of the arrowheads were made of bone, the other half of antler. Four arrowheads were large (about 12 cm), the others were small (about 5 cm). The shafts were made of pine wood, about 8 mm thick and 80 cm long. These measurements were based on the arrows with which the modern-day sports archer normally shoots, to make the shooting with the experimental arrows easier.

The highest number of times shot with one arrow was eight. However, most arrows were only shot a couple of times, mainly due to the shafts breaking on impact. Both hafting methods and binding materials worked well. Bindings with tar added prolonged the use-life of the arrows. The arrowhead would stay in place even though some bindings would break. The most common reason for having to stop shooting with an arrow was the shaft breaking, not the point itself. From the 16 arrows with small, barbed points, six shafts broke on impact. Four arrowheads were hafted with the inserted method bound with sinew or nettle and two with the bevelled method bound with nettle. From the four arrows with large, barbed points, all shafts broke after one or two shots. The breaking of the shafts on impact is related to several aspects. The amount of impact a shaft can withstand can be positively influenced by making the shafts thicker. Furthermore, the material from which the shafts were made influences the toughness as well. In general, branches are tougher because they still have all grow rings intact, whereas with pine wood the grow rings are cut through. Lastly, the distance between the archer and the target influences the breaking of shafts as well. When the archer stands further away from the target, the arrow will fly straighter, creating less tension on the shaft.

Furthermore, small, barbed antler points were more durable than small, barbed bone points. On average, the antler points could be shot 4.4 times, and the bone points 2.5 times. Since antler is more elastic and more impact resistant, this was to be expected. Breakages of bone points are easier and faster to repair than the breakages on the antler points. This is because bone breaks more in flakes, and antler tips more often completely broke off. Most points could have been repaired or rejuvenated to be used again after breakages.

Experimental points shot at the deer carcass have developed use-wear traces mainly consisting of rounding, smoothing and polish (fig. 4). The degree of wear is highest on the tip of the point and decreases down to the hafting border. Use-polishes as a result of penetrating the deer carcass consist of a greasy, semi-smooth polish from the point hitting meat, a similar more rough polish of the point hitting hide, a more greasy and bright polish with fine striations due to hitting hairs and a bright, smooth polish from hitting bone. The polish often has a longitudinal direction and is best developed on the tip of the point down to the first barb, and sometimes down to the second barb. Polish(es) from hitting the deer carcass develops after one shot in the deer carcass.

2.2. Bowfishing

For the bowfishing experiment a fresh complete salmon, without organs, was hung on ropes on a wooden frame. In this set-up only fish would be hit, resulting in use-wear from hitting fish with a projectile, which can be used to interpret use-wear traces on the archaeological points. Unfortunately, it was not possible to obtain with the organs still inside due to legal regulations. Twelve arrows in total were shot in the salmon with a yew longbow of 46 pounds at 27.5 inch draw length. The distance between the archer and the target was about 5 m, ensuring that as less arrows as possible would miss the target. Half of the arrowheads were made of bone, the other half of antler. Four arrowheads were large, the others were small. All

Fig. 3 – Set-up of deer shooting (top) and bowfishing (bottom) experiments.
Fig. 3 – *Configuration des expériences de tir sur cerf (en haut) et de pêche à l’arc (en bas).*

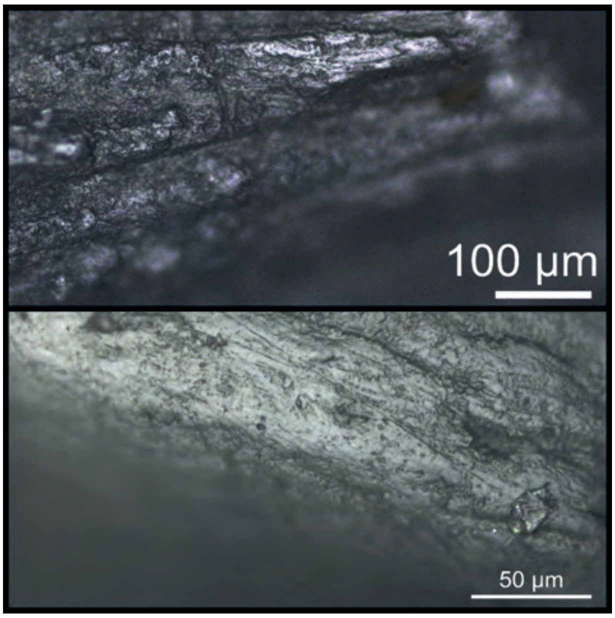

Fig. 4 – Polish on experimental bone points from contact with the deer carcass (top) and salmon (bottom).
Fig. 4 – *Poli sur les pointes en os expérimentales, dû au contact avec la carcasse de cerf (en haut) et avec le saumon (en bas).*

arrows, except one, went through the salmon on both sides. One experimental point got detached from the shaft during the first shot and got stuck in the salmon. For this bowfishing experiment the hafting method and type of binding materials did not make a difference for the durability of the arrows. The impact on the arrows was lower in comparison to the deer shooting experiment which led to less damage to the arrowhead, bindings and shaft. However, when the ground would be hit when bowfishing in nature, this could be more destructive for the points, depending on the type of sediment. Generally, shooting with an arrow was discontinued due to bindings loosening or the wooden shaft breaking. In contrary to the deer shooting experiment, the small, barbed points were as durable as the large, barbed points. Furthermore, the difference between bone or antler as a raw material did not seem to make a difference either. The highest number of times shot with one arrow was 20. All points could have been used again without reparations to the arrowhead.

Under the stereomicroscope the points have become rounded to different degrees on the non-hafted part, especially the tip down to the top barb incision. For example, one experimental bone point was shot most times of all points (20×) and its entire non-hafted part became rounded. Furthermore, the tip of this point down to the top barb incision became partly translucent after use. The translucency has occurred in lower degrees on other points from the bowfishing experiment as well. This is the result of rounding, eroding away some of the surface of the bone or antler with each shot. Damage to the points was minor. A low degree of pitting seems to be associated with the polish as well. When only a few shots were made, the polish from contact with fish was more difficult to distinguish from polish from contact with meat. The polish from contact with fish developed mainly on the higher ridges and to a lower degree in between the ridges as well. The polish could be observed under the metallographic microscope using magnifications of 20× to 500×. It generally displays a greasy appearance which is probably due to the fattiness of the salmon. It should be noted that the difference in fat percentage between different types of fish would result in a higher or lower degree of greasiness of the polishes. Furthermore, the polish is semi-bright, quite smooth, irregular and has a moderately undulating surface relief with usually a lack of direction and no degree of linkage. To observe the polish, distribution magnifications of 100× were used under the metallographic microscope. The structure of the polish is similar to what for fish polish on flint is called “corrugated” (Van Gijn, 1986). When the fish polish does have direction, it is longitudinal and/or perpendicular. The perpendicular direction of fish polish is related to the spinning of the arrow. In contrary to the deer carcass, the salmon did not stop the arrow as quickly or not at all, resulting in the arrow still spinning when going through (part of) the salmon, creating the perpendicular direction of the polish.

2.3. Missed arrow shots

To differentiate between use-wear development because of hitting prey, a quiver or the environment, missed arrow shots were replicated. Six small, barbed arrowheads were made, half of them of antler, three of bone. All points were hafted with the inserted method and bound with sinew. Three scenarios of missed arrows were replicated for this experiment: 1) missing a land mammal on a grass field, 2) hitting a tree and 3) shooting through a bush. Furthermore, when an arrow would be missed during bowfishing it would presumably hit a more clay river ground and possibly rocks. This experiment was conducted priorly (Spithoven, 2018).

Under the stereomicroscope all points have become rounded, in different degrees, on the non-hafted part. The antler points were again shown to be more durable. The bone point shot over the grass field resulted in the uttermost tip of the point breaking off. On the points shot over the grass field the entire non-hafted part developed heavy rounding, smoothness and polish making the hafting border clearly visible. Both the bone and antler point developed a high degree of wear on the non-hafted part consisting of rounding and smoothening of the surface. The non-hafted part of the antler point, which was used twice as long as the bone point, even reduced in thickness from the heavy degree of wear. The non-hafted part of the points developed a polish from contact with grass and the ground. It is a bright and rough polish similar to plant-polish, with longitudinal striations. Shooting arrows through a bush led to breakage of the points, probably due to hitting multiple branches in a perpendicular angle. The non-hafted part of the bone point had developed a polish from contact with the ground like the ones shot over the grass field. The antler point was lost and could not be found again. Use-wear on the entire non-hafted part developed on the points shot over the grass field and through the bush. The bone point shot into a tree broke off from the tip down to the second barb incision. The tip of this point became rounded and developed a longitudinal polish from hitting the tree. The non-hafted part of the antler point became rounded, smoothened and developed a polish from hitting the tree as well. The polish from contact with wood has a (partly) longitudinal direction on the antler point. The polish is less well-developed on the bone point. On the points shot in the tree use-wear developed mainly on the uttermost tip and in lesser degree on the remaining non-hafted part which penetrated the tree.

3. QUIVER EXPERIMENTS

Another possibility for the well-developed wear traces on the archaeological points is the use of a quiver to carry the arrows. To the knowledge of the author, no experiments with prehistoric arrows with osseous points in quivers have been conducted before. For the quiver experiments, three different quivers were used to carry arrows with osseous points while walking (fig. 5). The first quiver was made of fallow deer (*Dama dama)* skin and based on the Neolithic quiver made of roe deer (*Caprolus capreolus*) skin found with Ötzi (Egg and Spindler, 2009, p. 104; Junkmanns, 2013*,* pp. 228–230; Klek, 2022). Some tufts of hair were found on the quiver of Ötzi on the outside of the quiver on the transverse flap as well as the body of the quiver (Egg and Spindler, 2009, p. 104). However, since we do not know if hairs were always on the outside of hide quivers, it is interesting to look at both possibilities.

Therefore, the experimental quiver was first used with hairs on the inside and afterwards with hairs on the outside, conducting two separate experiments with each ten arrows with small, barbed points, half of them made of bone and the other half made of antler.

The other quiver was made of birch bark based on the Neolithic bow case from Schnidejoch (Hafner, 2012, p. 198; Junkmanns et al., 2021). Each quiver was carried for about 150 km and the arrows were taken out of the quiver and put back in a few times. The points came in contact with the inside of the quiver and each other. The hide quivers were attached to a wooden shaft with lime bark fibres. A leather strap was attached to this shaft to be able to carry the quiver over one shoulder, on the back. The birch bark quiver was made from two pieces of birch bark bent into the right shape and shoved over each other partly overlapping. The bottom was tied together and the sides were attached to each other using a piece of wood. The hide quivers were less wide than the birch bark quiver because it was harder to make the birch bark bend further to make the quiver more compact. The birch bark quiver was worn the same way as the hide quivers.

During the experiment with the birch bark quiver it became clear that carrying this quiver made a lot more noise than the hide quivers. The arrows in the birch bark quiver moved more, especially in an up and down movement. This was due to the design of the quiver which gave the arrows more space to move. The hide quivers were flatter, holding the arrows better in place. In addition, the arrows in the birch bark quiver made more noise because they were hitting a harder material.

Most points seem to have developed some degree of wear from being carried in a quiver. The degree of wear differs between the points. First of all, the antler points developed a lower degree of wear than the bone points. In addition, there is a difference between individual points. This could have been caused by the position of the arrows in the quiver, where points in the middle had less contact with the quiver. Furthermore, taking the arrows out of the quiver probably created use-wear as well. Three different types of polishes have developed which can be linked to the material of the quiver. Most of the tips of the points which were carried in the quiver made of fallow deer skin with the hairs on the inside developed a bit of rounding. One point developed a greasy polish with fine striations inside it caused by the hairs of the quiver. The tips and edges of most points from the experiment with the fallow deer quiver with the hairs on the outside have developed a greasy polish which can be inferred as animal polish due to contact with the hide. One point developed a patch

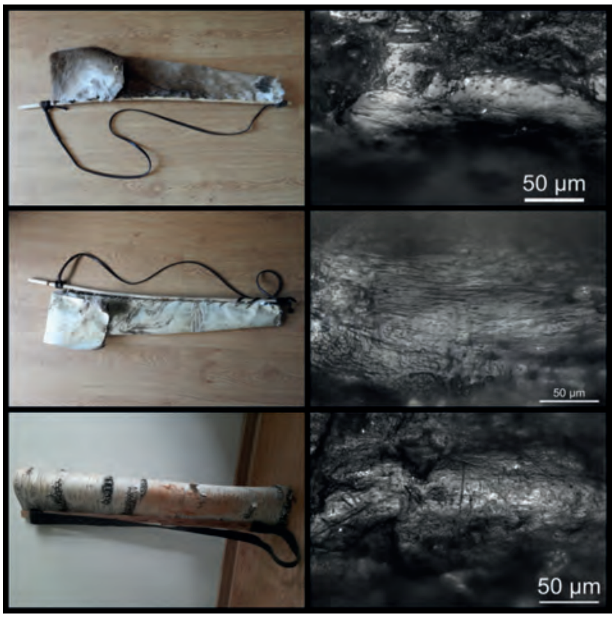

Fig. 5 – Three different quivers were used for the experiments: a hide quiver with hairs on the outside (top left) resulting in polish from contact with hide (top right), a hide quiver with hairs on the inside (middle left) resulting in polish from contact with hairs (middle right) and a birch bark quiver (bottom left), resulting in polish from contact with bark (bottom right).

Fig. 5 *– Trois carquois ont été utilisés pour les expériences : un carquois en peau avec des poils à l'extérieur (en haut à gauche), entraînant un poli dû au contact avec la peau (en haut à droite) ; un carquois en peau avec des poils à l'intérieur (au milieu à gauche), entraînant un poli dû au contact avec les poils (au milieu à droite) ; et un carquois en écorce de bouleau (en bas à gauche), entraînant un poli dû au contact avec l'écorce (en bas à droite).*

of bright polish which was probably caused by hitting another point in the quiver. Furthermore, production polish has become less visible on most points carried in the hide quivers, which looks like a dull polish. The experimental points carried in the birch bark quiver developed a bright, rough polish on their tips, comparable to polishes on other experimental tools used on bark. Furthermore, the tips and edges are slightly damaged from being carried in the birch bark quiver.

CONCLUSION

It has been assumed that small points (<88,5 mm) were used as arrowheads and large points (>88,5 mm) as spearheads (Verhart, 1986; Spithoven, 2016, p. 43). However, the archery experiments conducted showed that small as well as large, barbed points are efficient arrowheads. They were both able to penetrate deep enough to hit the heart and/or lungs of the deer and were even able to penetrate through ribs. Generally, the arrowheads did not last more than a few shots. Afterwards, most of them could easily be repaired or rejuvenated to be used again as arrowhead. Arrowheads made of antler are more durable when shooting land mammals. During the shooting experiment at the deer carcass, many arrow shafts broke. It seems likely that in the past thicker shafts were used and the distance from the target would certainly have been longer. The longer distance to the target would most likely have resulted in a larger number of shafts breaking. Especially the large, barbed points created too much impact on the shafts because of their size. It is important to note that bowfishing had a lower impact on the arrow, which led to less shafts breaking. This is because fish is easier to penetrate than deer. Osseous points were very durable when bowfishing and applying tar over the bindings would make them even more durable because it would keep the bindings in place and waterproof. Polish from contact with fish can be distinguished from other animal polishes on experimental points, making it possible to infer if archaeological points were used for hunting fish when displaying the same use-wear traces. The perpendicular direction of the use-polish could also be an indication for the use as projectile point (on fish).

Breakage of points occurred due to arrowheads hitting a tree, branch or rock. Contact with these hard materials often resulted in breakage, generally breaking on a barb incision. A missed arrow does not necessarily result in the breakage of the point. However, when hitting a tree or branch the chances are high that the point, or shaft, will break. The points would be more durable without barbs since the incisions were the weak spots resulting in breakages. On the other hand, the points are relatively durable when only ending up in a grass field.

On the archaeological points no evidence was found for points hitting a grass field, tree or bush. However, some points show a thinner non-hafted part from use which could be related to missing the target. The point ending in the ground on multiple occasions would lead to a faster wear and tear of the point in comparison to it hitting an animal.

Use-wear traces on the experimental points as a result of being carried in a hide quiver display a strong similarity to the use-wear traces present on the archaeological points. The high degree of wear on the non-hafted part of the archaeological point may therefore be the result of the points being used as arrowheads and carried in hide quivers. The quiver with hairs on the inside was found to best protect arrows and make minimal sound. The birch bark quiver was found the least suitable. In the birch quiver the arrows moved around a lot and made a lot more noise. In addition, this also led to the points getting slightly damaged and detached from their shafts. Use-polish from contact with plant or bark was not found on any archaeological point studied for this research. Use-wear traces as a result of the two different hide quivers were similar to each other. The main difference seems to be the degree of wear developed. Points which have been carried in the hide quiver with hairs on the inside have generally developed a higher degree of wear than the points carried in the hide quiver with the hairs on the outside.

Acknowledgements: I would like to thank everyone who contributed to the experimental program and loaned archaeological points for analysis. In particular, I would like to thank J. ter Brugge for granting access to Masamuda education centre for conducting the archery experiments and T.H. Stikkelorum for assisting with the experiments. Use-wear analysis was conducted at the Laboratory for Material Culture Studies at Leiden University. I would like to thank A. Verbaas and Prof. dr. A.L. van Gijn for discussions behind the microscope. This work was funded by the Dutch Research Council (NWO) as part of the project Resurfacing Doggerland (file number AIB.19.009). Furthermore, I would like to thank the reviewers for their constructive comments.

Merel Spithoven
Groningen University in collaboration with
Leiden University, the Netherlands
m.spithoven@rug.nl.

REFERENCES

AMKREUTZ L, SPITHOVEN M. (2020) – Hunting beneath the waves. Bone and antler points from North Sea Doggerland off the Dutch Coast, in D. Groß, H. Lübke, J. Meadows and D. Jantzen (eds.), *Working at the sharp end: From bone and antler to Early Mesolithic life in Northern Europe,* Kiel/Hamburg, Wachholtz Verlag, pp. 383–404.

BRADFIELD J. B., BRAND T. (2015) – Further tests of the macrofracture method: Results of utilitarian and accidental breakage experiments on bone points, *Journal of Anthropological and Archaeological Science,* 7, pp. 27–38.

BUC N. (2011) – Experimental series and use-wear in bone tools, *Journal of Archaeological Science,* 38, pp. 546–557.

CLARK J. G. D. (1954) – *Excavations at Star Carr,* Cambridge, Cambridge University Press.

COLES B. J. (1998) – Doggerland: A speculative survey, *Proceedings of the Prehistoric Society,* 64, pp. 45–82.

COLES B. J. (2000) – Doggerland: The cultural dynamics of a shifting coastline, in K. Pye and J. R. L. Allen (eds.), *Coastal and estuarine environments: sedimentology, geomorphology and geoarchaeology*, London, The Geological Society of London, pp. 393–401.

DEKKER J., SINET-MATHIOT V., SPITHOVEN M., SMIT B., WILCKE A., WELKER F., VERPOORTE A., SORESSI M. (2021) – Human and cervid osseous materials used for barbed point manufacture in Mesolithic Doggerland, *Journal of Archaeological Science: Reports*, 35, 102678.

EGG M., SPINDLER K. (2009) – *Kleidung und Ausrüstung der kupferzeitlichen Gletschermumie aus den Ötztaler Alpen*, Mainz, Verlag des Römisch-Germanischen Zentralmuseums (Monographien des RGZM Band, 77).

GAFFNEY V., FITCH S., SMITH D. (2009) – *Europe's lost world: The rediscovery of Doggerland*, York, Council for British Archaeology.

HAFNER A. (2012) – Archaeological discoveries on Schnidejoch and at other ice sites in the European Alps, *Arctic,* 65, Supplement 1: The Archaeology and Paleoecology of Alpine Ice Patches, pp. 189–202.

JUNKMANNS J. (2013) – *Pfeil und Bogen: Von der Altsteinzeit bis zum Mittelalter,* Angelika Hörnig, Ludwigshafen.

JUNKMANNS J., KLÜGL J., SCHOCH W., DI PIETRO G., HAFNER A. (2019) – Neolithic and Bronze Age archery equipment from Alpine ice-patches: a review on components, construction techniques and functionality, *Journal of Neolithic Archaeology,* 21, pp. 283–314.

JUNKMANNS J., KLÜGL J., DI PIETRO G., HAFNER A. (2021) – The Neolithic bow case from Lenk, Schnidejoch. A technological and cultural analysis, *Journal of Glacial Archaeology,* 5, pp. 5–50.

KLEK M. (2022) – The arrow quiver of the Iceman reconstruction attempts and the special significance of the fur material. *EXARC Journal*, 3.

LEARY J. (2009) – Perceptions of and responses to the Holocene flooding of the North Sea Lowlands, *Oxford Journal of Archaeology* 28, 3, pp. 227–237.

MOMBER G. (2011) – Submerged landscape excavations in the Solent, southern Britain: climate change and cultural development, in J. Benjamin, C. Bonsall, C. Pickard and A. Fischer (eds.), *Submerged prehistory,* Oxford, Oxbow Books, pp. 85–98.

PEETERS H., AMKREUTZ L. (2020) – The Netherlands: Probing into the submerged prehistoric archaeology, landscapes and palaeontology of the Dutch continental shelf, in G. Bailey, N. Galanidou, H. Jöns, H. Peeters and M. Mennenga (eds.), *The archaeology of Europe's drowned landscapes,* Cham, Springer (Coastal Research Library, 35), pp. 157–174.

PÉTILLON J. M., PLISSON H., CATTELAIN P. (2016) – Thirty years of experimental research on the breakage patterns of stone age osseous points. overview, methodological problems and current perspectives, in R. Lovita and K. Sano (eds), *Multidisciplinary approaches to the study of Stone Age weaponry* (Vertebrate paleobiology and paleoanthropology), Dordrecht, Springer, pp. 47–63.

PÉTILLON J.-M., CATTELAIN P. (2022) – Experimental evidence of spear-thrower usage in the Late Upper Palaeolithic (Upper Magdalenian) from the Isturitz Cave Site, Pyrénées-Atlantiques, France, *Arheologia*, 2, pp. 5–18.

SPITHOVEN M. (2016) – *Spitsen van been en gewei uit Zuid-Holland, Nederland: een typologische intra-site vergelijking*, Leiden, Leiden University, pp. 105.

SPITHOVEN M. (2018) – *Mesolithic Doggerland, where the points are small: a functional analysis of the small barbed bone points*, Leiden, Leiden University, p. 207.

VAHUR S., KRIISKA A., LEITO I. (2011) – Investigation of the adhesive residue on the flint insert and the adhesive lump found from the Pulli Early Mesolithic settlement site (Estonia) by MICRO-ATR-FT-IR spectroscopy, *Estonian Journal of Archaeology,* 15, 1, pp. 3–17.

VAN GIJN A. L. (1986) – Fish polish, fact and fiction, *Early Man News, Newsletter of Human Palaeoecology,* 9/10/11, pp. 13–28.

VERHART L. B. M. (1986) – *Een beschrijving van mesolithische benen artefacten uit Europoort en een typo-chronologische vergelijking met noordwest europees materiaal*, Leiden, Leiden University.

WADDINGTON C. (2007) – *Mesolithic settlement in the North Sea basin. A case study from Howick, North-East England,* Oxford, Oxbow Books.

ZHILIN M. (2015) – Early Mesolithic bone arrowheads from the Volga-Oka interfluves, Central Russia, *Fennoscandia* archaeologica, 32, pp. 35–54.