OSSEOUS PROJECTILE POINTS FROM THE SWISS NEOLITHIC: TAPHONOMY, TYPOLOGY AND FUNCTION

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Abstract: Except in situations where a bone projectile point is found embedded in a human body, osseous projectile points tend to be unreliable artifacts for quantifying their relative importance as weapons in conflicts. Owing to their relatively softer raw materials, however, bone and antler points are less frequently found in direct contact or actually penetrating the victims' bone compared to lithic projectiles. This study of the typical and easily recognized projectile points from St. Blaise on the shore of Lake Neuchâtel (Western Switzerland) shows that even if these points originated from hunting weapons, most of them were perfectly suited to killing humans as well. These projectiles come from a finely excavated, water-sieved site. The role of taphonomic loss related to the way these projectiles were used is reviewed. In addition, the divergent mechanical properties of bone and antler projectile points, especially as this relates to their penetrating properties, is discussed. A certain group of points from St Blasie and elsewhere in the late Neolithic of Swizerland is characterized by a tight uniform iconic style and dimensions. This may very well reflect strong identity with an important grouping within society as opposed to fulfilling the role of social markers between groups. Thus, although the use of these points for hunting in these Neolithic societies is clear, their occasional use on humans and the degree of human conflict in this period must remain ambiguous.

Keywords: Late Neolithic Switzerland, antler and bone projectile points, penetration efficiency, taphonomy, social identity, ad hoc production

INTRODUCTION

Most remains of projectile points actually found embedded in the victims' bone tend to be made of stone. Rare finds of bone points also occur, while antler artifacts found stuck in bone tend to be least common. As for the use of such projectile points in warfare, incapacitating the enemy efficiently is a priority that explains the apparent preference for harder materials such as stone or bone. This hypothesis inspired the functional study of a major assemblage of bone and antler projectile points, as well as a number of other bone artifacts possibly used as projectiles, from the late Neolithic lacustrine settlement of St. Blaise, Bains des Dames located on the northwestern shore of Lake Neuchâtel (Western Switzerland; Horgen to Auvernier cultures; Figure 1).

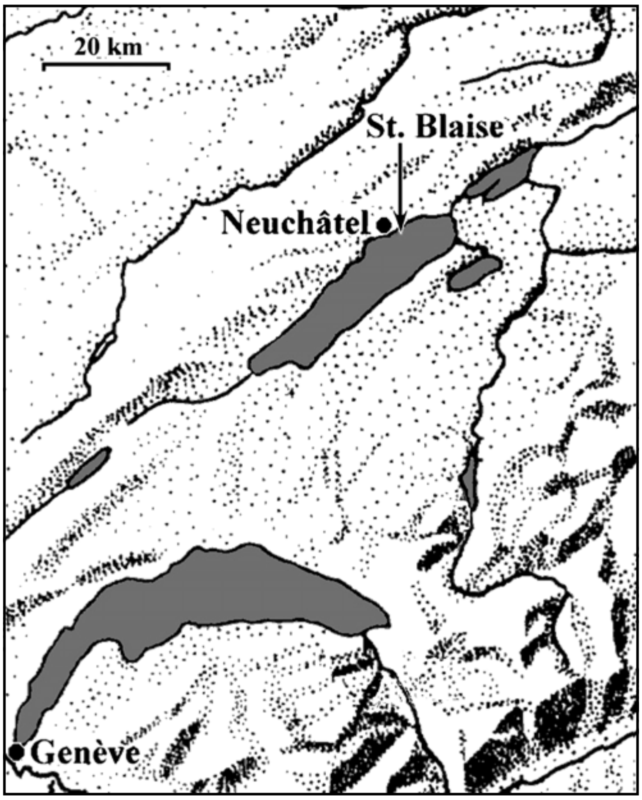

Figure 1. The location of St. Blaise–Bains des Dames along the shore of Lake Neuchâtel, Switzerland

WEAPONS OF WAR OR HUNTING GEAR?

Given the small number of bone points found embedded in either animal or human skeletal remains, and the fact that the anthropological and zoological finds are seldom discussed synthetically, typological distinctions between hunters' and warriors' projectile points have remained unreliable at most sites. Inferences, thus, must remain fundamentally indirect in nature. On the other hand, while one may speculate about whether cognitive aspects of killing humans and/or medium size game with arrows differed, the technical similarities involved are obvious.

Due to the virtual absence of human remains from the St. Blaise settlement, the primary interpretation of the projectile points under discussion here would be as parts of hunting gear, probably being used on humans only opportunistically. This coincides with the high proportion of wild animal bones in the refuse bone sample from this settlement (Figure 2). However, even if certain types of weaponry were not used in hunting, virtually all weapons made for the hunt could be turned on humans (Shepherd 1999: 223, Fig. 2) in both individual conflict and organized warfare. According to Chapman (1999: 109), the same technical qualities in [stone] arrowheads apply to warfare as to hunting. For purely technical purposes, therefore, he suggested that the 25 m

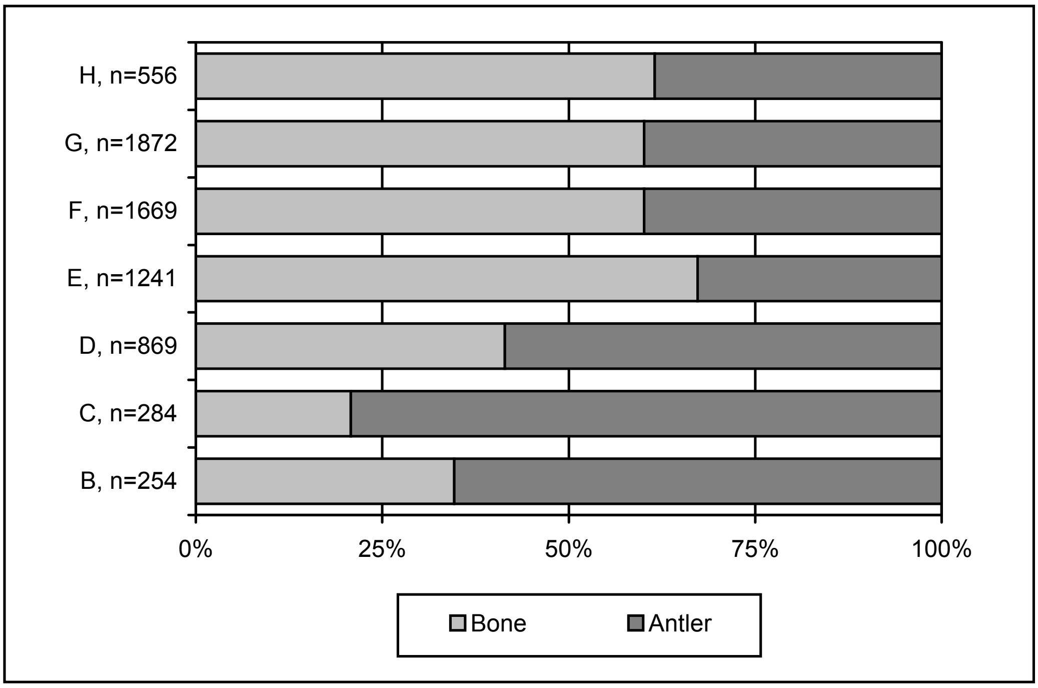

Figure 2. Diachronic increase in the proportion of bone tools

optimum hunter-prey distance established by Fischer (1985) be taken as the average for a comparable human conflict.

The two osseous raw materials under discussion here have different properties when used in hunting and warfare as was suggested by Pape (1982, 135) in his study of the more elaborate projectile points of the Late Neolithic and Bronze Age. Bone points are more destructive, while the more resilient, elastic antler (Currey 1970; MacGregor and Currey 1983; MacGregor 1985,26-28) tends to last longer. The large assemblage of worked bone and antler recovered at St. Blaise offered a unique opportunity for the appraisal of differences between bone and antler carved into projectile points.

ASSEMBLAGE COMPOSITION

The unusually rich assemblage of bone and antler artifacts from St. Blaise was collected using water sieving (mesh size= 5 mm). A total of almost 7000 artifacts, made from both materials were recovered and identified by the authors. This study concentrates on bone arrowheads (Type 3/2), two potentially relevant types of double bone points (Types 2/1, and 2/2) and antler arrowheads (Type P5d) as defined in Jörg Schibler's 1980 typology (to be discussed below).

Chronologically the site was sub-divided into sedimentological blocks B to H. The cultures present at this site included Horgen (Block B), Lüscherz (Blocks [C], D) and Auvernier (Blocks E to H). Block X contained mixed material near the top of the stratigraphic sequence. The Horgen Period occupation, dating to 3160–3100 BC, represents a small part of the original village and is located mostly in the northwestern corner of the excavated area. Layer C, contained sporadic artifacts from both the Horgen and subsequent Lüscherz stylistic groups. Lüscherz deposits at this site represent a time span between approximately 2700 and 2670 BC. Due to overlapping effects of sedimentation and erosion, Horgen and Lüscherz elements could not always be separated. Thus, the exact length of the Lüscherz occupation is difficult to determine.

The dominant stylistic group is the Auvernier culture which lasted from approximately 2550 to about 2510 BC at this settlement. This archaeological culture marks the very end of the Late Neolithic in Western Switzerland. Apparently, the excavation area exactly covered that part of the settlement abutting the water front. The unexcavated portion of the Late Neolithic settlement continued inland towards the lakeside hills beneath the railway line. The diachronic distribution of bone and antler implements by sedimentological blocks is shown in Table 1.

The percentual composition of this material shows a diachronic increase in the proportion of bone tools at the expense of worked antler (Figure 2). The number of worked pieces of bone is less than 50% in provenances associated with the Horgen and Lüscherz Periods. The Auvernier Period (as well as the probably related top layer, Block X), on the other hand, is characterized by a slight dominance of bone tools.

Using the wild/domestic dichotomy, the faunal lists of these periods (Barbara Stopp, personal communication) show a clear increase in the relative frequency of wild animal bones at the St. Blaise settlement. A consistent decline in the contribution of domestic animal bones from almost 75% (Horgen Period) to only slightly more than 50% (Auvernier H Block; Figure 5) incorporates a range below which hunting might be considered substantial within the subsistence economy (Matolcsi 1982: 77). Earlier shifts in the

Table 1. The numbers of worked bone, antler and point types discussed in this study

All worked	B	C	D	E	F	G	H	X	Total
Bone	88	59	360	835	1003	1125	342	31	3843
Antler	166	225	509	406	666	747	214	56	2989
Total	**254**	**284**	**869**	**1241**	**1669**	**1872**	**556**	**87**	**6832**
Point type									
Bone 3/2	9	5				1		2	17
Bone 2/1	3	2	5	5	12	23			50
Bone 2/2	1	1	5	6	9	10	1		33
Antler P5d	18	8	1	2				2	31
Points total	**31**	**16**	**11**	**13**	**21**	**34**	**1**	**4**	**131**

proportions between domestic to wild animal remains at many Swiss lake dwellings does not mean an absolute decline in animal keeping: it should rather be attributed to the intensification of hunting (Hüster-Plogmann and Schibler 1997).

In this sense, it is interesting that the number of bone/antler tool types clearly related to hunting activities or their degree of elaboration decreases in later periods at this site. There is also little perceivable change in variability or style in comparison with other sites of the same archaeological cultures (Horgen, Lüscherz, Auvenier; Ramseyer 1985, Winiger 1992: Abb.1-3, Fig.10-11; Wolf 1993: Tables 98/3, 122/3; Schibler 1987: Tables 21/10, 21-23). This is in contrast, for example, with the Mesolithic situation in the Upper Volga region, where the major emphasis on hunting seems to have produced a great variety of beautifully made, elegant projectile points (Zhilin 1998, 173). Such stylistic variability may be related to function as well as to the fundamental importance of hunting in the Mesolithic. Thus, hunting societies might well decide to use projectile points to mark ethnic boundaries. Sackett (1990, 33) describes this as the ‘isochrestic’ model in which a social group chooses a particular way of making or forming an object out of the many possibilities available. The cluster of choices which produce a tool style are unique to individual social groups. These choices lie as much in the schedule of manufacturing as in the formal characteristics of, in this case, projectile points.

The uniformity of the Swiss arrowheads, thus, suggests that they may have been associated with a well-defined group of hunters/warriors within the settlement. On the other hand, neither hunting nor warfare seems to have been important enough during these periods for the tools associated with these activities to be used to express differences between groups across Switzerland. Stylistic differentiation in points again appears at the very end of the Neolithic (although not at the site under discussion here) and during the Bronze Age in many places in Europe when elaborated bone points (from the late Neolthic to the middle Bronze age) appear as copies of bronze types (Pape 1982: 145).

This trend toward reduction in the typological variability of projectile points at St. Blaise is of particular interest, since it coincides with the intensification of red deer (*Cervus elaphus* L. 1758) hunting, suggesting that antler manufacturers in the earlier periods relied to a greater extent on the carving of shed antler.

Similarly strange is the fact that the percentual contribution of projectile points also decreases diachronically at St. Blaise. Relatively speaking, most such artifacts came to light from the earliest, Horgen Period provenances (Figure 3), when animal keeping seems to have been better established. It remains even more of a mystery whether they were intended for killing humans or animals?

TAPHONOMY AND THE DEGREE OF EXPLOITATION

Understanding the function and socio-cultural meaning of projectile points would be hopeless without a brief critical survey of our source material. Our perception and interpretation of these artifacts may be distorted by at least three factors.

Loss related to artifact function

As is shown by the aforementioned trend at St. Blaise, owing to the basic function of projectile points, their representation in site materials is rather unreliable. At least, these less elaborated projectile points, displaying few signs of curation, seem to have been of the ‘disposable’ kind. The finely worked, labor intensive projectile points discussed by Zhilin (1998: 163) show definite signs of having been repeatedly repaired. The St. Blaise projectiles typically belong to the category of portable artifact that is most commonly used and lost/discarded off site, often in the bodies of injured animals or humans who either escape or finally die in a completely different place.

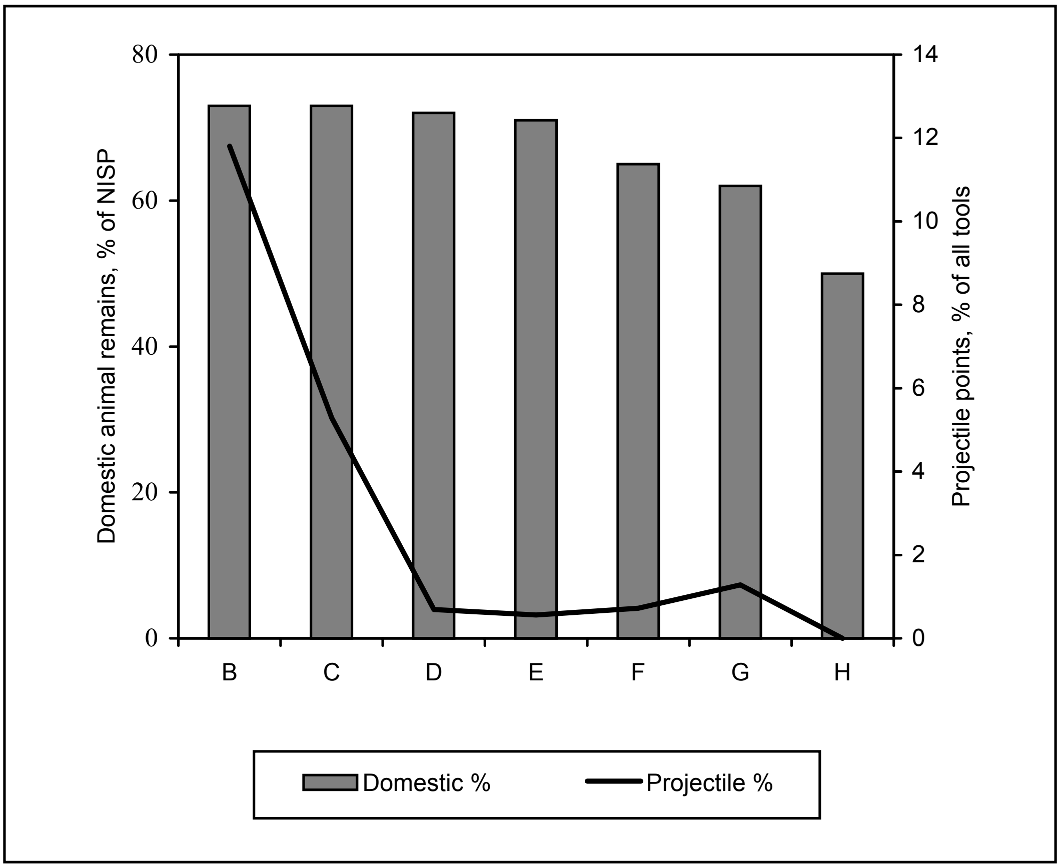

Figure 3. Diachronic decline in the exploitation of domesticates and in the presence of projectile points

Antipina (2001, 122; in press) has mentioned the possibility that elaborated projectile points from the Late Bronze Age, East European Steppe copper mining site of Gorny in the southern Urals were largely missing from the settlement material because they were exported as precious trade items.

The selectivity of evidence is also present in the discovery of specimens embedded in the victim's bone. As mentioned in our introduction, bone and antler projectile points are less commonly encountered in such contexts than are stone arrow heads, simply because they would penetrate bones only softer than themselves. In fact, to our knowledge, antler points have not yet been found in such unambiguous contact with either animal or human skeletons. The few embedded bone points penetrated skeletal parts softer than the bone points themselves. In addition to lighter and weaker human bones (at a definite taphonomic "advantage" from this purely mechanical point of view), flat bones of relatively small and usually young animals are most frequently damaged by points, typically made from splinters of the compact cortical bone of large ruminants.

Recovery bias

Fortunately, the points under discussion here are uniformly longer than 20 mm, the critical size threshold below which bone splinters are missed with great probability when finds are collected only by hand (Bartosiewicz 1988). The number of projectile points, however, still seems relatively low in the St. Blaise assemblage, in spite of 100% water-sieving.

A somewhat arbitrary parallel was used to help elucidating this potential taphonomic bias. Worked bone assemblages from Meso- and Neolithic sites in the Iron Gates Gorge of the Danube between Romania and Yugoslavia have recently been tabulated by Radovanovic (1996: 253-261). Sites in the Iron Gates region seem to contain a greater number of projectile points per worked bone unit than the Swiss collection under discussion here (Figure 4). The relationship between the number of worked bones (x) and projectile points (y) at St. Blaise and in the Iron Gates may be described by the regression equations in Table 2.

Superficially, the fact that almost ten times more projectile points per worked bone unit were identified in the Iron Gates (0.188/0.020; i. e. almost every fifth specimen, as opposed to every fiftieth at St. Blaise) may be interpreted either as a sign of the indubitably greater importance of hunting during the Mesolithic or, perhaps, a more violent way of life than at the lakeshore settlement of St. Blaise.

It must be emphasized, however, that the water-sieved collection from St. Blaise obviously contained many more small types of other bone artifacts than hand-collected assemblages in the Iron Gates region.[*] In light of this difference, the presence or absence of bone projectile points in and of itself should be considered a poor indicator of either the importance of hunting or even warfare.

[*] Of the Iron Gates sites, systematic water-sieving has been carried out during recent excavations at Schela Cladovei, not included in these calculations.

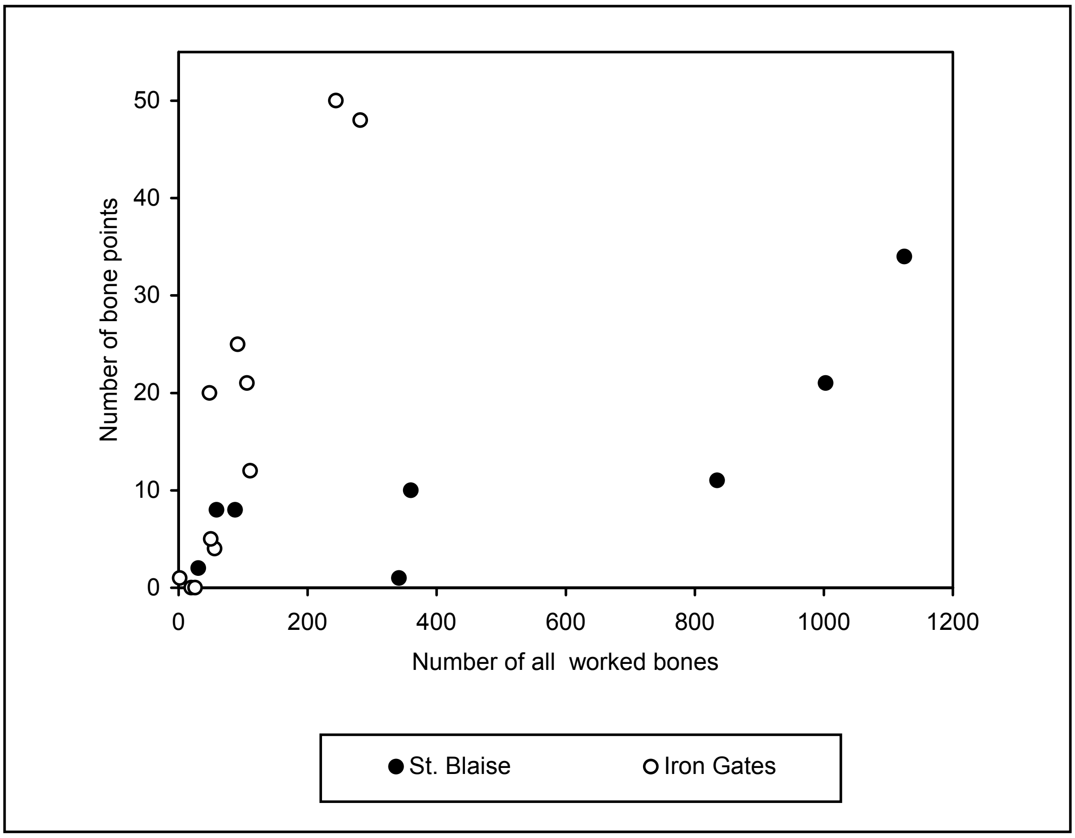

Figure 4. The relationship between bone tool assemblage size and the number of bone projectile points

Table 2. Contributions of projectile points to the worked bone assemblage in two regions

Site/Region	No. of assemblages	Regression equation	Correlation
St. Blaise	8	y = 0.020x + 2.124	r = 0.832***
Iron Gates	10	y = 0.188x - 0.832	r = 0.938***

Fragmentation and attrition

At St. Blaise, Type 3/2 bone points are characterized by tip polish and only moderate use wear relative to the degree of manufacture their production takes. As mentioned previously, more used and damaged pieces may have been lost or discarded off site. Wear traces evidenced on stone arrowheads from the Danish Mesolithic studied by Fischer (1985) suggested that most of them had not yet been used. The lack of reworking on bone projectile points from the site under discussion here seems to indicate that these planned artifacts were relatively unused or too small for any secondary use once they had became blunt or broken. This, once again, suggests that they were used in a context away from the settlement.

Type 2/1 double points were defined on the basis of purely morphological characteristics but almost certainly were used in a greater variety of ways. These may also have differed in terms of their hafting modes which could not be directly reconstructed in any of the cases under discussion here.

Type 2/2 double rib points were made from the compact outer surfaces of ribs. Smaller size, less intensive manufacturing and overall handling polish on two of the Type 2/2 rib double points is indicative of a more limited use than was the case with long bone double points. At the same time, the greater homogeneity of this type suggests that it might have provided substitutes for smaller, less carefully crafted long bone double points which may or may not have served as casual projectile points.

Even the heterogeneous types of long bone and rib double points (Types 2/1 and 2/2) are characterized by a low intensity of use relative to the degree of labor investment required by their manufacturing.

TYPE DESCRIPTIONS

Bone arrow heads (Type 3/2)

The broadly defined Type 3/2 ("*Pfeilspitzen varia*") from Schibler's typology (1980: 47) represented by a rather uniform pointed and elongated form with smoothed edges, the only kind recognized at St. Blaise settlement. Tar remains occurring regularly on the basis and stem of these objects (12 of 17 specimens) as well as fortunate finds of shafted

Table 3. The distribution of raw materials within Type 3/2

	Cattle	Red deer	Large ungulate	Small ungulate
Rib			1	
Radius	1			
Metapodium		2	10	
long bone				1

projectile points confirm their morphological analogy to modern-day arrow heads.

With one exception, they were produced using long bone diaphysis splinters of large Ruminants (both cattle and red deer could be identified in one case each). As far as skeletal parts are concerned, straight metapodium fragments were clearly preferred, although usually no distinctions between metacarpus and metatarsus are possible. In the St. Blaise assemblage, a few other long bones and a rib point were found as well (Table 3).

Metapodium projectile points were produced using the ”groove and split” technique. Plain carving with flint and grinding on abrasive materials such as sandstone were typical ways of finishing these artifacts, resulting in a high level of modification. Both tip and basis were carefully executed in most cases. The base was usually also sharpened, and even has a small crest left on it. The mode of shafting makes the pointed or crested basis of such arrow heads *de facto* “barbed”: once inserted, the point can only be torn out of the wound causing further pain and damage.

Projectile points recovered from this site have almost uniformly symmetric long shouldered tips (Form 3 in Schibler 1981: 16, Abb. 3) although other broad symmetric forms (Forms 2, 5) are represented as well.

With the exception of two rectangular (Form 4) and a trapezoid (Form 8) cross-section (all stemming from the natural shape of bone splinters), tips were ground into a round cross-section. The only trapezoid tip was formed on a small Ruminant bone, which would have been probably too thin to produce a perfectly round cross-section.

This artifact type was recovered most commonly (with only two exceptional Lüscherz and one Auvernier specimens) from the Horgen and mixed Block C layers of St. Blaise. Its exclusive contribution to that chronological subsample at this site makes it suitable for typo-chronological distinctions. Projectile points of this type, together with their antler counterparts discussed below, may be considered common in the Horgen culture.

Long bone double point (Type 2/1)

According to Schibler’s typology (1981: 42) this group includes exclusively long bone points. It is important to note, however, that lower pig incisor double points, potentially grouped with this type (Schibler 1980: 34), do not occur in the St. Blaise material. In fact, long bone double points, so characteristic of the Cortaillod material from Twann (Schibler 1981), seem to have lost most of their importance at this late Neolithic site in comparison with other small point types.

This type is made of long bone diaphysis splinters of Artiodactyl bones. Small and large ungulates seem to have contributed almost equal numbers to the assemblage under discussion here, although a more precise identification of these heavily modified splinters is usually hopeless. Of the better recognizable specimens, remains of red deer, roe deer and Caprines (all metapodia) and one cattle radius were recognized.

As for skeletal parts, metapodium splinters again dominate. One third of the material, however, could only be described by the generic term “long bone diaphysis fragment”. In this latter broad category, however, highly modified flat bone and especially rib splinters may have been included as well, although there is no way to ascertain this theoretical possibility (Table 4).

These points were produced by intensive carving with flint tools such as burins and scrapers and grinding with abrasive

Table 4. The distribution of raw materials within Type 2/1

	Cattle	Caprine	Red deer	Roe deer	Large ungulate	Small ungulate
radius	1					
metacarpus				1		
metatarsus			1			
stylopodium					4	1
metapodium		2	2	2	4	10
long bone					14	12

materials affecting most of the tools' surface. In spite of the high contribution of metapodia to the pool of raw materials for double points, marks of the groove and split technique could be recognized only in two (!) cases, probably because subsequent manufacturing obliterated the marks of primary flint scraping.

The refined typology developed by Schibler for these artifacts on the basis of their mid cross-sections (Schibler 1981: 42) to a great extent may be linked with the choice of raw materials as well as the intensity of manufacturing. While no long bones were turned into "tubular" double points (sub-type "f" by Schibler), lenticular and bean-shaped mid cross-sections (sub-types "b" and "e") were observed on less modified small Ruminant bone points, while rectangular mid cross-sections (sub-type "a") were more characteristic of large Ruminant metapodium double points.

Round mid cross-section (sub-type "c") was typical of heavily worked specimens in both size categories. It was characteristic of almost two thirds of metapodium (58.2 %) and one third of non-metapodium (32.4 %) double points. This round shape was achieved with more work on metapodium than on other, non-metapodium fragments.

Although both ends of these artifacts were sharpened into tips, only one of these served as an actual working end. In other cases, the presence of a "pointed base" may be recognized in the form of more cutmarks than manufacturing polish related to sharpening, and higher use wear on the working tip. One of the Horgen points even has tar remains around the base, which is, in most cases, regarded as evidence of hafting, as illustrated by Winiger (1992).

Among the working tips symmetric broad (Form 2) and sharp (Form 1) shapes were most common. Some shouldered (Form 3) and dull (Form 5) specimens occurred as well. The contribution of these latter two, however, is less than 15 %.

Cross-sections of the working tip are most typically round (Form 1) or lenticular (Form 2), although in this case a greater variability may be observed. The presence of rectangular (Form 4) and triangular (Form 10) tip cross-sections is particularly remarkable on points characterized by a relatively low intensity of manufacture.

In relative terms, this artifact type was recovered most commonly from the Horgen and C layers of the St. Blaise site. At the same time, its percentual contribution increases more-or-less consistently from the Lüscherz Period onwards.

Rib double point (Type 2/2)

This artifact type is defined using an morphological feature in addition to its raw material. A somewhat greater proportion were made on rib splinters of large Ruminants. In one case, a Horgen Period red deer rib double point could be identified. Since, however, all these points were made from the *substantia compacta* fragments of ribs, they are sometimes even difficult to assign to animal size categories.

Table 5. The distribution of raw materials within Type 2/2

	Red deer	Large ungulate	Small ungulate
Rib	1	17	15

With one exception, when grooving and splitting could be detected, all these points were produced by carving with flint tools and subsequent grinding on sandstone or other abrasive materials. The intensity of surface modification, however, falls well below that found on long bone double points. This is indirectly shown by the fact that many such points could be identified on the basis of spongiosa remains on the tools' mid-shaft.

Symmetric, sharp (Form 1) and broad (Form 2) tip shapes are equally common in this type. The only exception is a small Ruminant rib double point with a sabre-shaped (12) working tip: due to the small bone used as raw material, the tool retained some of the bone's original form. Cross-sections of the working tip are more variable with frequent occurrences of all flattish shapes (Forms 2, 5, 12, 13). Six round (Form 1) and four triangular (Form 10) tips were recorded as well.

This artifact type was recovered in comparable proportions from all major layers of the St. Blaise site. Its small numbers and homogeneous contribution to chronological subsamples make them unsuitable for defining developmental trends in themselves.

Antler projectile point (P5d)

Such slender projectile points (made either of bone or antler) are without question a tool type of the Horgen culture. They are usually about 60 mm long. One end has a round symmetrically pointed tip, while the other is trimmed into a thinned tang, ending in a raised barb to enhance attachment to the shaft. A great deal of care and energy was invested into manufacturing such projectile points. Many of the specimens have traces of tar and twine on their surfaces from the attachment to the arrow shaft.

Only about 10 mm of the tip is always left free (Plate I, middle). At St. Blaise, one of these antler points (Inv. No. 793) was found still attached to its hazelwood (*Corylus avelana* L. 1758) shaft.

Antler projectile points were evidently extracted from the thicker *substantia compacta* in the lower beam of the red deer antler rack. While antler seems to have been the preferred raw material for this tool type, numerous bone specimens (discussed previously under Type 3/2) were found.

First, a long slim strip of soaked antler was procured by grooving two parallel lines 60-70 mm long into the softened compact external layer of the beam. The strip was forced out and the rough shape was carved using a flint tool such as a burin. However, characteristically for all the more heavily worked, refined antler and bone objects at St. Blaise, the

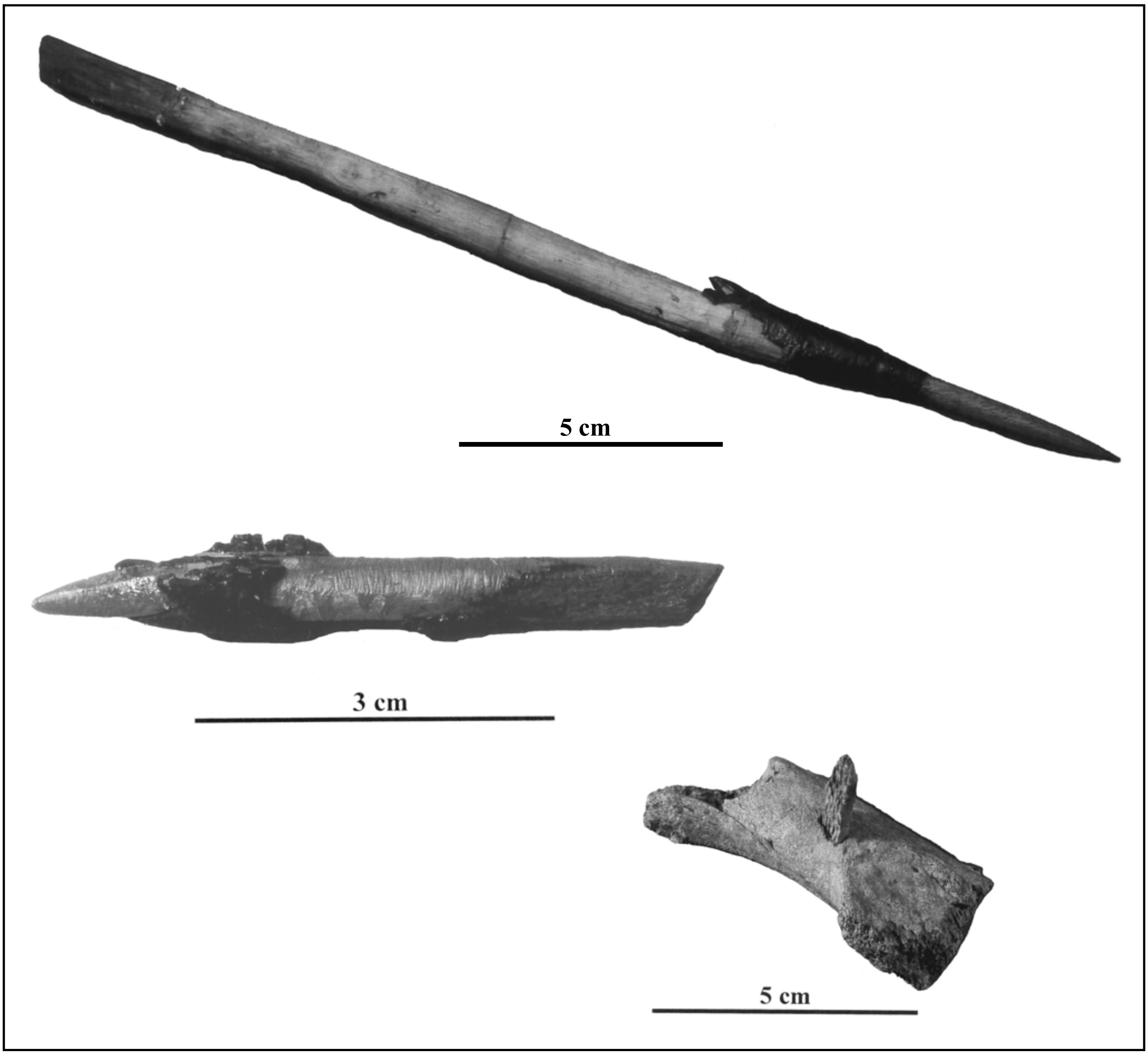

Plate I. Top: Type 3/2 bone projectile point with foreshaft (?) from the Horgen Period of St. Blaise
Middle: Type P5d projectile point with tar remains from the Horgen Period of St. Blaise
Bottom: Rib projectile point embedded in the pelvis of young pig from 15th century Vác, Hungary

final shaping was done by grinding on an abrasive surface, probably once the antler had begun to harden as it dried out. The thin tang of the projectile point was then laid against the wooden shaft or an extra piece at the end of the shaft. Cord made from sinew or bast was wrapped around it and the whole thing firmly fixed by a birch tar coating. The tips of these points are elongated and remarkably round in cross-section (Form 1) showing how easily this raw material can be worked in a softened state.

The P5 or P5d projectile points occur almost exclusively in the B (Horgen) and C (mixed Horgen and Lüscherz) sedimentological Blocks. There is one specimen from a pure Lüscherz deposit at St. Blaise, two from an uncertain context and two from the Auvernier sedimentological Block E. It is even possible that artifacts from the underlying strata, disturbed by a particularly deeply driven pile, were brought up into the Auvernier level.

THE RECONSTRUCTION OF FUNCTION

In addition to formal analogies of tool typomorphology, composite finds as well as ethnographic parallels must be briefly reviewed.

Bone point 3/2 and antler point P5d

Thanks to the good preservation of organic materials in the water-logged layers of St. Blaise, wooden shafts recovered with arrowheads make the identification of 3/2 bone and P5d antler points as such implements unambiguous. One open question, relevant to the actual use of such projectile points, is the possible use of foreshafts.

Ethnographic examples suggest that during use, less of an attempt may have been made to recover the points themselves than the shaft. High quality raw materials for bows (yew wood; *Taxus baccata* L. 1758) and arrow shafts (e. g. hazelwood or wayfaring tree: *Viburnum lantana* L. 1758) identified at other Swiss Neolithic sites (Gross et al. 1990: 90) also support this hypothesis.

When discussing a 230 mm long guelder rose (*Viburnum opulus* L. 1758) Neolithic arrow fragment found at Blackhillock Bog (Aberdeenshire, Scotland), Mercer (1999: 147, Fig. 2) referred to composite arrow shafts. These are made of a foreshaft that remained in the victim, while the back-shaft broke away, making its recovery easier. Foreshafts made from less special wood such as pine (*Pinus* sp.: Bokelmann 1999: 78; Guthrie 1983: 289) would also be indicative of the difference between the values of arrow shafts and projectile points.

A Yanomami bone double point studied by the authors was mounted on such a 228 mm long foreshaft. The butt end of a bone-tipped arrow fragment of similar length (c. a. 20 cm) from St. Blaise shows dark discoloration, a possible indication of attachment as a foreshaft (Plate I, top).

Even in the absence of wooden components, most projectile points brought to light at St. Blaise seem to have been directly attached to obliquely sharpened pieces of wood recovered from the waterlogged sediment. The 9-11 mm diameters of the prehistoric wooden shafts recovered, more-or-less, correspond to the 10-12 mm diameter of the main arrow shafts that belong to the aforementioned Amazonian point and foreshaft.

Foreshafts may have been especially advantageous in hunting when it was sufficient for arrows to cause pain, bleeding and subsequent exhaustion, thus, preparing large game to be killed by other means (Møhl 1978: 21). A "shoot to kill" policy, however, may have been preferred in warfare as part of self-defense, in the face of equal adversaries.

In the absence of wooden components, tar remains may also offer evidence of shafting that, together with characteristic size and shape, is of help in identifying projectile points. Chemical analyses showed that the tar used on the stone arrow heads in the *Iceman*'s quiver was produced by carbonizing either the wood or bark of birch (*Betula* sp.) in a reducing atmosphere. The asphalt-like tar thus obtained hardens as it cools (Spindler 1993:162). Birch tar, produced experimentally, was successfully used in shafting arrows (Neubauer-Saurer 1997: 43).

Bone points 2/1 and 2/2

Some of the Type 2/1 artifacts brought to light at St. Blaise may also have served as projectile points. Two Horgen Period and an Auvernier Block G double point from this settlement offer some indirect evidence of this. They have an overall shape very similar to that of P5d type antler projectile points, more-or-less exclusive to the Horgen layers. Another double point is covered with tar remains on the bone's original outer surface, while the inner side corresponding to the *cavum medullare* remained clean as a possible attachment surface for an arrow shaft.

Such forms appeared in the Horgen layers of the Twann settlement as well (Furger 1981: 60). Most importantly, a Neolithic specimen found near the Lake of Biel was embedded in the ventral surface of the sacral bone from a red deer (Jörg Schibler, personal communication).

A remarkably different, alternative use for double points, fishing (Schlenker 1994: 45), deserves particular attention. At least two symmetric Auvernier Period (Blocks F and G) double points had equal size tips and showed minor transversal indentations in the middle which may be indicative of their use as fish gorges. It is also remarkable that a stratum within the Auvernier layer with two fish hooks contained three long bone double points and four rib double points without signs of hafting. The symmetric specimen with attachment marks in the middle was found in the proximity of this deposit as well. Many double bone points from the Paleolithic to the recent past have been used as fish gorges (Riek 1959; Vilsteren 1987: 31). Some were used in catching both fish and waterfowl in the area of Lake Konstanz (von Tröltsch 1902).

The great size variability in fish gorges is clearly illustrated by typologically identical, 100-130 mm long Medieval wooden cod gorges (Szabó et al. 1985; Heinrich 1986: 52), as well as expedient modern "gorges" for small fish made from matchsticks in southwestern France (Cleyet-Merle 1990: 85). Bone double points from St. Blaise represent the lower range of this broad size interval. The mean length of 77 double points (Types 2/1 and 2/2 combined) was only 54.2 mm. Several Auvernier specimens (Blocks F and G) were as long as 60-80 mm, while the largest double point recovered from Block G measured 106.9 mm.

An unique early Mesolithic find assemblage from Federsee – Forschner (Torke 1993: Abb. 5) contained a 67 mm long pointed bone object in association with a score of pike bones (*Esox lucius* L. 1758) and remains of a large tench (*Tinca tinca* L. 1758). This latter, with the gorge hidden inside, may have been the bait used in catching the 4-5 kg pike. The indentation in the middle of that artifact even displayed polish wear left by the fishing line.

METRIC PROPERTIES AND EFFICIENCY

Neolithic archery developed into a highly sophisticated technique that permitted kills to be made from a distance from 5 to 50 m (Stodiek and Paulsen 1996: 15), thereby reducing the imminent risk involved in warfare and hunting dangerous game. The characteristics of the ideal flint projectile listed by Fischer (1985: 37) are valid for its bone and antler counterparts.

These qualities are reviewed in light of a metric analysis and experimental results published in the literature.

Longitudinal symmetry, directional stability

From this point of view, long and slender bone/antler points are unquestionably superior to most lithic projectiles. Given the great deal of uniformity in this respect, rather than overall shape, sizes of the four types under discussion here may be of interest.

In order to appraise homogeneity within the set of artifacts tentatively identified as projectile points in this study, Student's t-tests were carried out to identify statistically significant differences between types. The measurements compared included the three greatest dimensions of each point (length, breadth and depth) and two tip measurements: length (SPI) and diameter measured at a distance of 5 mm from the tip (GSB).

Bone double points show the greatest degree of heterogeneity. They even differ significantly by their raw material: rib double points (Type 2/2) are on average half the weight, significantly thinner and their tips are also shorter. Of these, the more numerous group, long bone double points (Type 2/1), was compared to that of Type 3/2 arrowheads. In this case, double points were significantly thinner with shorter tips. Most importantly, no significant metric differences could be established between the morphologically similar Type 3/2 bone and P5d antler projectile points.

Of the values listed in this table, the mean weights of 0.8-2.4 are of special interest. What is significant is the concept of a relatively light, pointed armature (<10 g and in practice usually <2g; Fischer 1985). A heavier tip would have unbalanced the arrow. Owing to the smaller specific weights of bone and antler (1.5 to 1.8; Fábián 1973) than stone, they could be used in making longer arrowheads with better directional stability. The most "professional" points could thus, on average, weigh slightly over 2 g. The lengths of individual points in the four types are plotted against their respective weights in Figure 5. According to this graph, Type 3/2 and P5d points tend to be stouter than double points above the 2 g weight limit.

During experiments with stone projectile points (Rozoy 1985: 18), *ca*. 90 cm arrows (shaft diameter 1 cm) were fitted with 0.5-2 g points to produce a total weight of *ca*. 20-30 g. Such arrows can be best used in shooting medium to large sized game (comparable to a human being in terms of physical makeup), which it would pass through completely. Such weapons could be generally used over distances of 20 to 50 m, whose lower limit corresponds to Chapman's (1999: 109) aforementioned average range for prehistoric armed conflict.

Table 6. Pairwise metric differences between the four point types (measurements in mm)

Measurement, mm	n	Mean value	Standard Deviation	n	Mean value	Standard Deviation	t-value	df	p-value
Type		2/1			2/2				
W, g	**51**	**1.6**	**1.2**	**28**	**0.8**	**0.6**	**3.209**	**77**	**0.002**
Greatest length	48	55.6	18.3	29	51.9	18.4	0.846	75	0.400
Greatest breadth	56	6.4	2.0	32	5.8	2.3	1.243	86	0.217
Greatest depth	**57**	**4.2**	**1.2**	**33**	**3.1**	**1.0**	**4.401**	**88**	**0.000**
SPI	48	29.4	10.3	28	30.1	13.1	-0.265	74	0.792
GSB	**50**	**3.2**	**1.1**	**30**	**2.4**	**0.5**	**3.618**	**78**	**0.001**
Type		2/1			3/2				
W, g	51	1.6	1.2	9	2.4	1.4	-1.980	58	0.052
GL	48	55.6	18.3	9	55.0	14.6	0.090	55	0.929
GB	56	6.4	2.0	9	6.7	1.8	-0.441	63	0.661
GD	**57**	**4.2**	**1.2**	**9**	**5.9**	**1.6**	**-3.821**	**64**	**0.000**
SPI	**48**	**29.4**	**10.3**	**9**	**38.5**	**17.3**	**-2.170**	**55**	**0.034**
GSB	50	3.2	1.1	9	3.2	1.3	-0.091	57	0.928
Type		3/2			P5d				
W, g	9	2.4	1.4	22	2.6	1.2	-0.333	29	0.742
GL	9	55.0	14.6	27	63.2	14.7	-1.462	34	0.153
GB	9	6.7	1.8	28	6.8	1.0	-0.258	35	0.798
GD	9	5.9	1.6	27	6.4	2.0	-0.691	34	0.494
SPI	9	38.5	17.3	17	38.3	19.6	0.021	24	0.984
GSB	9	3.2	1.3	24	3.2	0.8	0.158	31	0.876

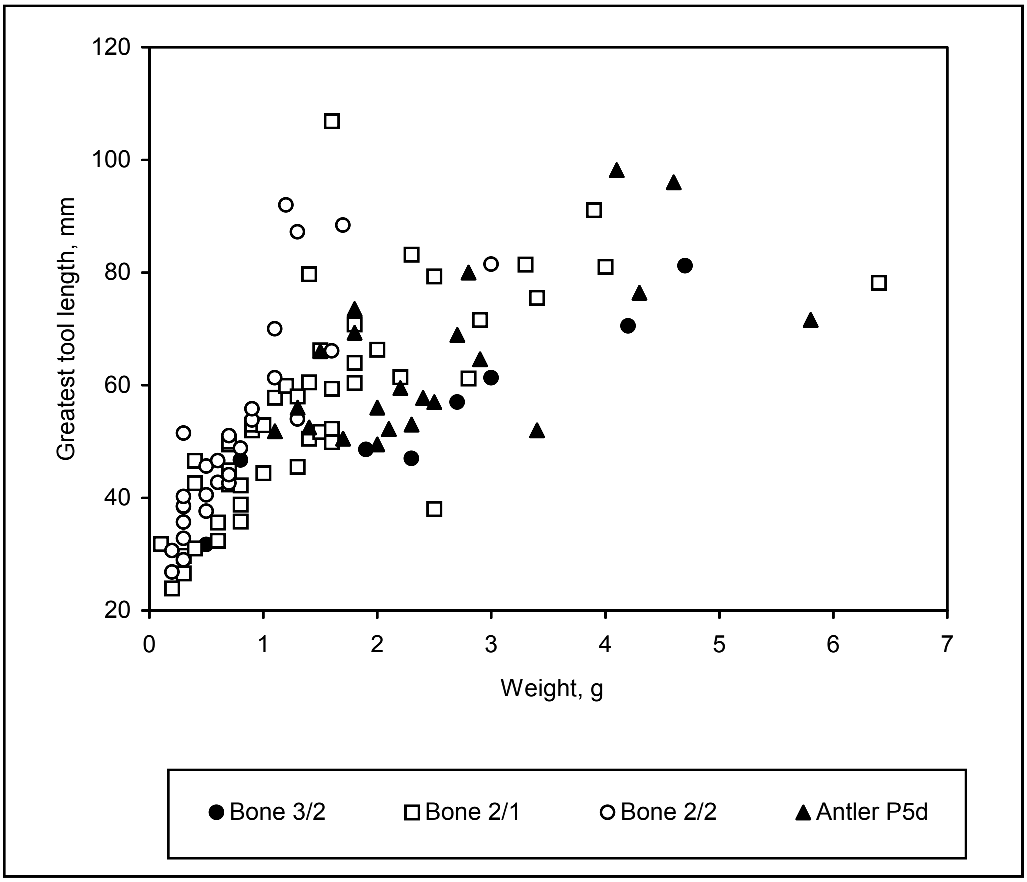

Figure 5. Weight/length relations in the four types of points in the assemblage from St. Blaise

Optimum penetrating qualities

Experimental work, testing the penetration parameters of projectile points has been limited to animal carcasses. Live prey would make the standardization of technical parameters difficult. From the large number of shootings at whole and still warm animals, it can be concluded that Stone Age [stone-tipped] arrows had extremely good qualities of penetration, often forcing their way through the ribs of a sheep and even of a full-grown boar (Fischer 1985: 36-37). While recently, human corpses were reputedly used in a blockbuster war movie to better imitate shot wounds, a similar practice would be ethically unacceptable in experimental archaeology.

The analogy of what are termed medium size mammals (preferably killed prior to target shooting) should indeed be perfectly sufficient for simulating the effects of projectile points, even in human conflict. An experiment in the Duisburg Zoo has shown that antler projectiles shot into a dead fallow deer (*Dama dama* L. 1758) penetrated, on average, 20 cm into the animal, while the mean penetration depth was 32 cm for stone arrow heads. Even antler points may have proven lethal in this case, although when hitting bone, they sometimes chipped (Stodiek and Paulsen 1996: 35, Abb. 34 and 35). In general, however, their life span surpassed those of more brittle stone projectile points used in the same experiment.

On the other hand, experimental work by Lowrey (1999) among native Americans of the Pacific Northwest Coast (see Roksandic this volume) showed that bone projectiles of both the spindle and the triangular types had better penetrating value than either stone or iron points, and required less pull. These seemingly contradictory results may be dependent on how the different experiments were conducted and what their aims were.

Evidently the ribs of the large game provide some protection against arrows, but hits inbetween or behind them offer a good chance of killing a red deer, an elk (=moose, *Alces alces* L. 1758) or even an aurochs (*Bos primigenius* Boj. 1827) with a single shot. Perforated and sometimes healed red deer scapulae also bear witness to the power of some of these shots (Noe-Nygaard 1974, 1975).

Experiments on elk carcasses carried out by Guthrie (1983: 284, Fig. 5) suggest that points with diameters of <10-11 mm all penetrated to 20 cm or beyond into the animal. Thicker points had a smaller mean penetration depth, below 20 cm. The shaggy hair and thick skin of a dead European bison (*Bison bonasus* L. 1758) used in another experiment in the Duisburg zoo prevented any projectile points from penetrating deeper than 120 mm. Antler points, potentially lethal when used on smaller creatures, proved remarkably ineffective in this experiment (Stodiek and Paulsen 1996: 34, Abb. 29). One must remember, however, that the same meager performance would have been more damaging to a smaller, thin-skinned human torso. Bundles of prehistoric clothing or even some sort of a leather armor would have withstood the impact of the same projectile points a lot less efficiently than the bison's natural defenses.

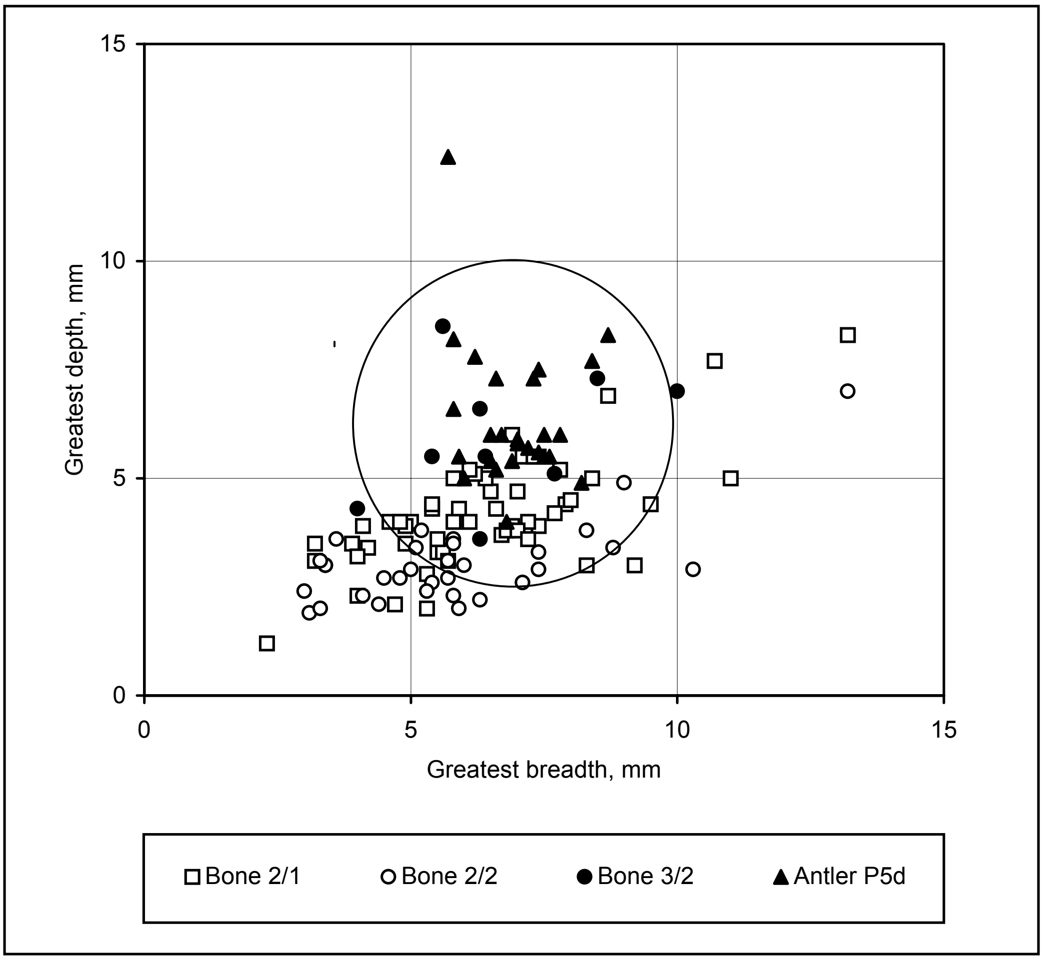

Figure 6. The greatest transversal dimensions of point types. Groups within the circle are of optimal penetration capacity

As for the points recovered from St. Blaise, their greatest transversal diameters were plotted against each other in Figure 6, in order to appraise penetration capacity. Most Type 3/2 and P5d points falling below the 10 mm upper limit of 200 mm penetration into elk, therefore could have served as a most potent missile against humans [as well]. Some of the double points also fall within these limits, however, their small and variable thickness may have been a disadvantage, reducing the life span of such points when used as projectiles.

The capacity to produce the sharpest cut possible

This trait of the projectile points is related to heavy bleeding. The functionally decisive mean thickness (greatest breadth = 6.7 mm, greatest depth = 6.4 mm) of these bone points, however, is below the 7-8 mm range at which a sharp decline in durability was measured in archery experiments (Guthrie 1983: 285). Since, however, Guthrie used longer points on a robust game animal, fracturing was probably more of a problem than in the case of the smaller St. Blaise specimens, possibly used on smaller prey.

The small projectile points with a thinned, slightly hooked base represent a tool type which is emphatically characteristic of the Lüscherz and, even more, the Horgen settlement materials. Similarly to the projectile points from Yvonand (Voruz 1984), the Lüscherz specimens are more elongated compared to the short dense Horgen points. Comparable small points occur in the Horgen levels from the nearby Twann settlement but not in the Middle Neolithic Cortaillod levels either here or, for example, at the Cortaillod Period site of Burgäschisee-Süd (Bleuer 1988). These all may have been equally dangerous for small game or fellow human beings.

CONCLUSIONS

Osseous projectile points tend to be unreliable artifacts for quantifying their relative importance as weapons in conflicts. Owing to the fundamental taphonomic nature of projectile points, their relative frequency in settlement assemblages (uneven spatial distribution related to use, chancy recovery) is a poor, although piquant, indicator of prehistoric violence. Shafted specimens or those embedded in the victims' flesh or bones offer rare but convincing evidence of the mode of use. Owing to their relatively softer raw materials, however, bone and antler points are less frequently found in direct contact or actually penetrating the victims' bone than lithic projectiles.

Although the function of the most typical projectile points from St. Blaise may be relatively easily recognized, in the absence of external evidence, the prospective victims of these arrowheads could not be precisely identified. Metric analyses have shown, however, that even if these points originated from hunting weapons, most of them were perfectly suited to killing humans as well.

Some Type 3/2 bone points show such a striking similarity to P5d antler projectile points that distinguishing between the raw material of these two highly worked types was sometimes difficult. According to experimental evidence, however, more brittle bone points would have a 1/6 shorter mean life expectancy than their antler counterparts of the same size. At the same time, the mean penetration of corresponding antler points was only 80% of those of bone projectile points (Guthrie 1983: 288). Less lacerating/lethal [antler] arrowheads therefore may have been more suitable for hunting than combat. Efficiency, availability and labor investment (manufacturing and possible curation) together may have influenced the designed function of these projectile points.

The Type 3/2 and P5d projectile points, most characteristic of the late Neolithic Horgen settlement at this site, were probably used by men and boys, widely presumed to have been the warriors or hunters in this Late Neolithic society. But, does this explain why here they have such a tight uniform iconic style and dimensions? Stylistic similarity beyond functional necessity, is a mirror of social comparison. The choice of strong emulation may reflect strong identity with an important social grouping. Although this class of artifacts cannot be said to be decorative, the uniformity in style argues for a deliberate adherence to a very particular form and may be described as a kind of active communication about social identification.

Type 3/2 bone and P5d antler projectile points are carefully planned, finely worked and standardized in size. They represent the "high end" of the so-called manufacturing continuum (Choyke 1997). A notably greater variability of forms and raw materials is evident among the two types of double points under discussion here, many of which may still have been used as projectile points.

Rib double points (Type 2/2), which may also have been used as projectiles, represent the far less sophisticated "expedient" or Class II end of the manufacturing continuum. A curious example of a much later specimen may serve here as the juxtaposition against which the warrior/hunter image of better made arrowheads can be better appreciated. A small ungulate rib projectile point, distinctly expedient in nature, was found embedded in the ventral side of an ilium fragment from a young pig (Plate I, bottom) at a late medieval (13th-15th century) site in Vác, Hungary (Bartosiewicz 1995: 178, Plate 18). This specimen dates to a time by which prehistoric bone manufacturing was long forgotten in Hungary. A low status person, such as a poacher or a child, however, may have improvised this "primitive" weapon for killing the pig, whose wild or domestic status could not be established, owing to the animal's young age. Found outside this context, however, the haphazardly carved rib splinter probably would not have been recognized as a projectile point. Bone projectile points, intended as a vital part of "serious" weaponry designed for warfare, must have been a lot more carefully planned and executed in prehistoric times.

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References

ANTIPINA Ye. 1999. Kostnye ostatki zhivotnykh s poseleniya Gorny (biologicheskiye i arkeologicheskiye aspekty issledovaniya). *Rossiiskaya Arkeologiya* 1, Moskva: 103-116.

BARTOSIEWICZ, L. 1988. Water-sieving experiment at Örménykút, Site 54. In Járó, M. and Költö, L. eds.: *Archaeometrical research in Hungary*. National Centre of Museums, Budapest: 267-274.

BARTOSIEWICZ, L. 1995. *Animals in the urban landscape in the wake of the Middle Ages*. BAR International Series 609, Oxford.

BLEUER, E. 1988. Die Knochen- und Geweihartefakte der Siedlung Seeberg, Burgöschisee-Süd. *Acta Bernensia II, Seeberg, Burgäschisee-Süd* Teil 7, Verlag Stämpfli & Cie AG, Bern.

BOKELMANN, K. 1999. Eine Stielspitze mit Schäftungspech der Ahrensburger Kultur aus Stellmoor. In E. Cziesla, Th. Kersting and St. Pratsch eds. *Den Bogen spannen... Teil 1. Festschrift für Bernhard Gramsch zum 65. Geburtstag*. Beier & Beran, Archäologische Fachliteratur, Weissbach: 77-81.

CHAPMAN, J. 1999. The origins of warfare in the prehistory of Central and Eastern Europe. In J. Carman and A. Harding eds.: *Ancient warfare. Archaeological perspectives*. Sutton Publishing, Stroud: 101-142.

CHOYKE, A. M. 1997. The bone manufacturing continuum. *Anthropozoologica* 25-26: 65-72.

CLEYET-MERLE, J.-J. 1990. *La prehistoire de la peche*. Collection des Hesperides. Editions Errance, Paris.

CURREY, J.D. 1970. *Animal Skeletons*. Studies in Biology 22, London.

FÁBIÁN, Gy. 1973. *Állattan* (Zoology). Mezõgazdasági Kiadó, Budapest.

FISCHER, A. 1985. Hunting with flint-tipped arrows: Results and experiences from practical experiments. In C. Bonsall ed.: *The Mesolithic in Europe*. Edinburgh, John Donalds Publishing Ltd. 29-39.

FURGER, A. R. 1981. *Die Kleinfunde aus den Horgener Schichten. Die neolitischen Ufersiedlungen von Twann*. Band 13. Staatlicher Lehrmittelverlag, Bern.

GROSS, E., JACOMET, S. and SCHIBLER, J. 1990. Stand und Ziele der Wirtschaftsarchäologischen Forschung an Neolithischen Ufer- und Inselsiedlungen im unteren Zürichseeraum (Kt. Zürich, Schweiz). In Jörg Schibler, J. Sedlmeier & H.-P. Spycher eds.: *Festschrift für Hans R. Stampfli. Beiträge zur Archäozoologie, Archäologie, Anthropologie, Geologie und Paläontologie*. Helbing & Lichtenhahn, Basel, 76-100.

GUTHRIE, R. D. 1983. Osseous projectile points: biological Considerations affecting raw material selection and design among Paleolithic and Paleoindian peoples. In C. Grigson and J. Clutton-Brock eds.: *Animals in archaeology: 1. Hunters and their Prey*. BAR International Series 163, 273-294.

HEINRICH, D. 1986. Fishing and consumption of cod (Gadus morhua Linnaeus, 1758) in the Middle Ages. In: Dick C. Brinkhuizen and Anneke T. Clason eds.: *Fish and archaeology*. BAR International Series 294: 42-52.

HÜSTER-PLOGMANN, H. and SCHIBLER, J. 1997. Archäozoologie. In J. Schibler et al. eds. *Ökonomie und Ökologie neolitischer und bronzezeitlicher Ufersiedlungen am Zürichsee. Band A: Text*. Monographien der Kantonsarchäologie Zürich 20. Zürich und Egg: 40-121.

LOWREY, N.S. 1999. An Ethnoarchaeological Inquiry into the Functional Relationship Between Projectile Point and Armor Technologies of the Northwest Coast. *North American Archaeologist*, 20(1): 47-73.

MACGREGOR, A. 1985. *Bone, Antler, Ivory and Horn: The Technology of Skeletal materials Since the Roman Period*. Croom Helm, London.

MACGREGOR, A. and CURREY, J.D. 1983. Mechanical Properties as conditioning factors in the bone and antler industriy of the 3rd to the 13th century AD, *Journal of Archaeological Science* 10: 71-77.

MATOLCSI, J. 1982. *Állattartás õseink korában* (Animal keeping in the time of our ancestors). Budapest: Gondolat Kiadó.

MERCER, R. J. 1999. The origins of warfare in the British Isles. In J. Carman and A. Harding eds.: *Ancient warfare. Archaeological perspectives*. Stroud Sutton Publishing: 101-142.

MØHL, U. 1978. Elsdyrskeletterne fra Skottemarke og Favrbo. Arbøger for Nordisk Oldkyndighed og Historie, 1978: 5-32.

NEUBAUER-SAURER, D. 1997. Birkenpechproduktion im Neolithikum (Ein mögliches Verfahren). In W. Brzeziczki and W. Piotrowski eds.: *Proceedings of the First International Symposium on Wood Tar and Pitch*. Biskupin, Poland 1993: 41-44.

NOE-NYGAARD, N. 1974. Mesolithic hunting in Denmark illustrated by bone injuries caused by human weapons. *Journal of Archaeological Science* 1: 217-248.

NOE-NYGAARD, N. 1975. Bone injuries caused by human weapons in Mesolithic Denmark. In A. T. Clason ed.: *Archaeozoological studies*. North Holland and American Elsevier, Amsterdam – New York.

PAPE, W. 1982. Au sujet de quelques pointes de flèches en os. In H. Camps-Fabre ed. *Industrie de l'Os Neolithique et de l'Age des Metaux 2*, C.N.R.S., 135-172.

RADOVANOVIC, I. 1996. *The Iron Gates Mesolithic*. International Monographs in Prehistory, Archaeological Series 11, Ann Arbor, Michigan.

RAMSEYER, D. 1985. Pieces emmanchee en os et en bois decervides. Decovertes Neolithiques Recentes du Canton de Fribourg, Suisse Occidentale. In H. Camps-Fabre ed.: *Industrie de l'Os Neolithique et de l'Age des Metaux 3*, C.N.R.S., 194-211.

RIEK, G. 1959. Das Federmesser führende Magdalénien der Burkhardtshöhle bei Westerheim im Kreis Münsingen (Schvöbische Alb). *Fundberichte aus Schwaben*, NF 15, 9-29.

ROZOY, J-G. The revolution of bowmen in Europe. In C. Bonsall ed.: *The Mesolithic in Europe*. Edinburgh, John Donalds Publishing Ltd. 13-28.

SACKETT, J. 1990. Style and ethnicity in archaeology: the case for isachrestism. In M. Conkey and C. Hastorf eds.: *The Uses of Style in Archaeology*. Cambridge University Press, Cambridge, 32-43.

SCHIBLER, J. 1980. *Osteologische Untersuchung der cortaillodzeitlichen Knochenartefakte. Die neolithischen Ufersiedlungen von Twann*. Band 8. Schriftenreihe der Erziehungsdirektion des Kantons Bern, herausgegeben vom Archäologischen Dienst des Kantons Bern, Staatlicher Lehrmittelverlag, Bern.

SCHIBLER, J. 1981. *Typologische Untersuchungen der cortaillodzeitlichen Knochenartefakte. Die neolithischen Ufersiedlungen von Twann*. Band 17. Schriftenreihe der Erziehungsdirektion des Kantons Bern, herausgegeben vom Archäologischen Dienst des Kantons Bern, Staatlicher Lehrmittelverlag, Bern.

SCHIBLER, J. 1987. Die Hirschgeweihartefakte and Die Knochenartefakte. In E. Gross et al. eds.: *Zürich "Mozartstrasse", Neolithische und bronezeitliche Ufersiedlungen*. Orell Füssli Verlag, Zürich: 156-176.

SCHLENKER, B. 1994. Knochen- und Geweihgerät in der Jungsteinzeit. In M. Kokabi, B. Schlenker and J. Wahl. eds. *Knochenarbeit*. Stuttgart: Landesdenkmalamt Baden-Württemberg: 41-56.

SHEPHERD, D. 1999. The elusive warrior maiden tradition: bearing weapons in Anglo-Saxon society. In J. Carman and A. Harding eds.: *Ancient warfare. Archaeological perspectives*. Stroud Sutton Publishing: 219-243.

SPINDLER, K. 1993. *Der Mann im Eis*. Wilhelm Goldmann Verlag, München.

SZABÓ, M., GRENADER-NYBERG, G. and MYRDAL, J. 1985: Die Holzfunde aus der frühgeschichlicher Wurt Elisenhof. Studien zur Küstenarchäologie Schleswig-Holsteins. Ser. A. Vol. 5. Frankfurt-Main – Bern – Las Vegas.

STODIEK, U. and PAULSEN, H. 1996. *Mit dem Pfeil, dem Bogen...* Isensee Verlag, Oldenburg.

TORKE, W. 1993. Die Fischerei am pröhistorischen Federsee. *Archäologisches Korrespondenzblatt* 23, 49-66.

von TRÖLTSCH, E. 1902. *Die Pfahlbauten des Bodenseegebietes*. Verlag Ferdinand Enke, Stuttgart.

Van VILSTEREN V. T. 1987. *Het benen tijdperk. Gebruiksvoorwerpen van been, gewei en ivoor 10.000 jaar geleden tot heden*. Drents Museum.

VORUZ, J.-L. 1984. Outillages osseux et dynamisme industriel dans le Néolithique jurassien. *Cahiers d'archéologie Romande* No. 29, Lausanne.

WINIGER, J. 1992. Beinerne Doppelspitzen aus dem Bielersee. *Jahrbuch der Schweizerischen Gesellschaft für Ur- und Frühgeschichte* 75: 65.

WOLF, C. 1993. *Die Seeufersiedlung Yverdon, Avenue des Sports (Kanton Waadt)*. Cahiers d'archéologie romande 59, Lausanne.

ZHILIN, M. 1998. Technology of the manufacture of Mesolithic arrowheads on the Upper Volga. *European Journal of Archaeology* Vol.1/2: 149-176.