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Preliminary Results of an Experimental Investigation of Magdalenian Antler Points

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1. Introduction

The results presented here are part of a comprehensive study (doctoral thesis) concerned with functional and technological aspects of long-range weapons and projectiles in the late Upper Paleolithic of West- and Central Europe (Stodiek, unpublished Ph. D. Thesis).

An important role in the investigation is played not only by the spearthrower, which is evidenced by "hooks", normally of reindeer antler, which were originally set in a wooden shaft (Stodiek, 1988), but also by the spears used with these. As in the case of the spearthrower no complete specimen of a spear has survived, the only archaeological demonstrable evidence for them are quite commonly found points, also made of reindeer antler.

A glance at the spectrum of types found in the Magdalenian shows that those with single- or double-bevelled base make up a large proportion of the total. Using the morphology of their base and the method of hafting, which can be quite accurately reconstructed from these data, it is possible to obtain good indications for the design of the lower part of the spear, and for a certain probability, for the total length of the shaft.

Bearing this in mind, a series of both above mentioned types of projectile points from Middle and Upper Magdalenian contexts was measured, in numbers large enough to allow statistical analyses (points with single-bevelled base: $n = 286$, points with double-bevelled base: $n = 300$). Only complete specimens and basal fragments were recorded.

The measurement of greatest interest for the reconstruction of the spear shaft, the maximum width of the base of the point, showed a normal distribution for both types of point, with a mean value around 10 mm.

Practical experiments with spear shafts of this thickness showed that they may be between 1.30 m to 2.20 m in length, according to their intended function.

2. Objectives and Organisation of the Experiment

The ballistic experiments presented here had as their objective firstly to investigate the suitability and durability of various methods of hafting, secondly to examine patterns of impact damage on projectile points and bones and, thirdly, to document possible differences in the depth of penetration by projectiles.

Particularly in the latter it was necessary to find a replacement for the spearthrower and projectile launched by the human hand and so to mechanise the procedure that projectiles could be launched repeatedly with the same controlled parameters.

A review of the relevant literature (Barton & Bergman, 1982; Bergman & Newcomer, 1983; Guthrie, 1983; Fischer *et al.*, 1984; Albarello, 1986; Odell & Cowan, 1986; Arndt & Newcomer, 1986) shows that in the majority of the ballistic experiments carried out to date the projectiles were launched using a bow, this even in the case of projectile types from archaeological contexts where the use of this weapon is highly improbable. The use of a bow in these cases was described by the authors explicitly as an expedient measure only (Guthrie, 1983: 279–280; Arndt & Newcomer, 1986: 165). The decisive factor for these experimenters was that it was thus possible to achieve higher rates of impact than with a spear launched either by hand or with a spearthrower.

The criterion for an optimal rate of successful impacts was also of importance to the author. In view of the intention of guaranteeing comparability between individual impacts, particularly with regard to their depth of penetration, the use of a bow was ruled out from the very beginning.

The degree of standardisation provided by projection from a bow, although certainly greater than that given by a spearthrower, was nevertheless judged by the author to be insufficient.

In order to achieve acceptable results a firing mechanism similar to a crossbow was designed and built. The apparatus rests on two supports which height can be adjusted and consists of a central element of steel, 1.20 m long, and a T-shaped extension at the front, to which are attached two exchangeable bow-limbs with a draw weight of 32–35 lbs (fig. 1). The triggering mechanism (fig. 2) of the firing device was set using a photoelectric beam so that a projectile measuring 1.50–1.60 m and weighing *ca* 80 g reached an initial velocity V_0 of 30 m/s. This corresponded to the average value established by high-speed photography for projectiles which were launched manually with a spearthrower by several experimenters at a target placed 25 m away.

Because of economical reasons a total of only four spears were manufactured for use in the experiment; they were constructed of pine wood, with a standard length (L = 110 cm) and diameter (D = 10 mm) and had almost the same weight (*W* = 54–57 g). All spears were fletched radially with three feathers. A hollow aluminium tube 10 cm in length was slid over the opposite end of the spear so that it still extended for half its length beyond the shaft, where it was then firmly attached. Each point was attached to a foreshaft (total length of foreshaft + point = 55 cm), which could then be inserted into the aluminium tube of one of the main shafts for each shot (fig. 3). The total weight of a complete spear varied between 78 and 88 g, with a mean value of 81 g.

The author manufactured some 40 projectile points of medium size of both of the aforementioned types from several relativity fresh shed antlers of male reindeer. Two opposing rows of backed bladelets were attached with adhesive to 5 of them. For purposes of comparison replicas of lithic points of Hamburgian type (n = 5) and Upper Solutrean type (n = 3) were also incorporated in the experiment.

After a long phase of planning, during which a suitable target of the approximate size of a reindeer had been unsuccessfully sought, a possibility was finally found at the beginning of 1990 in the form of a 10 year old female fallow deer. As parts of the carcass were intended for human consumption, it was necessary on veterinary grounds to gut the animal before

Fig. 1 — The firing apparatus used in the experiments spanned and ready for us (Photographs by the author).

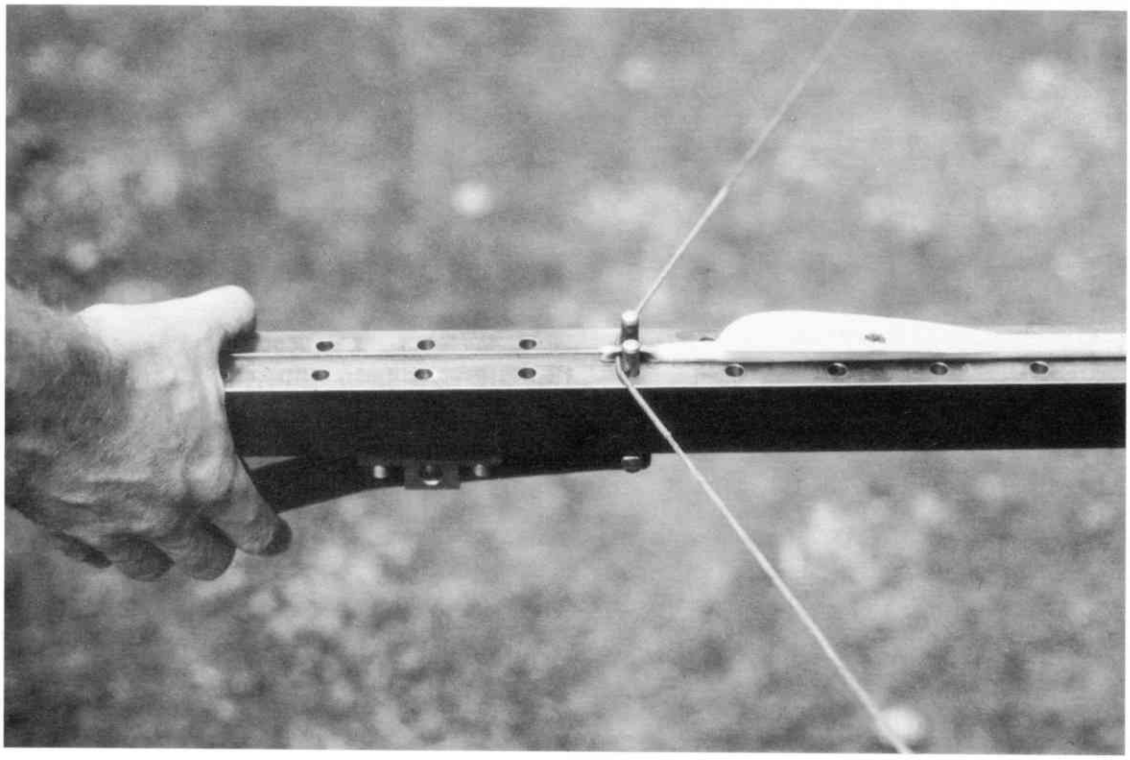


Fig. 2 — Detailed view of the triggering mechanism. Pulling the lever visible on the lower face of the central frame moves the two pins downwards, and releases the bow-string with the projectile (Photographs by the author).

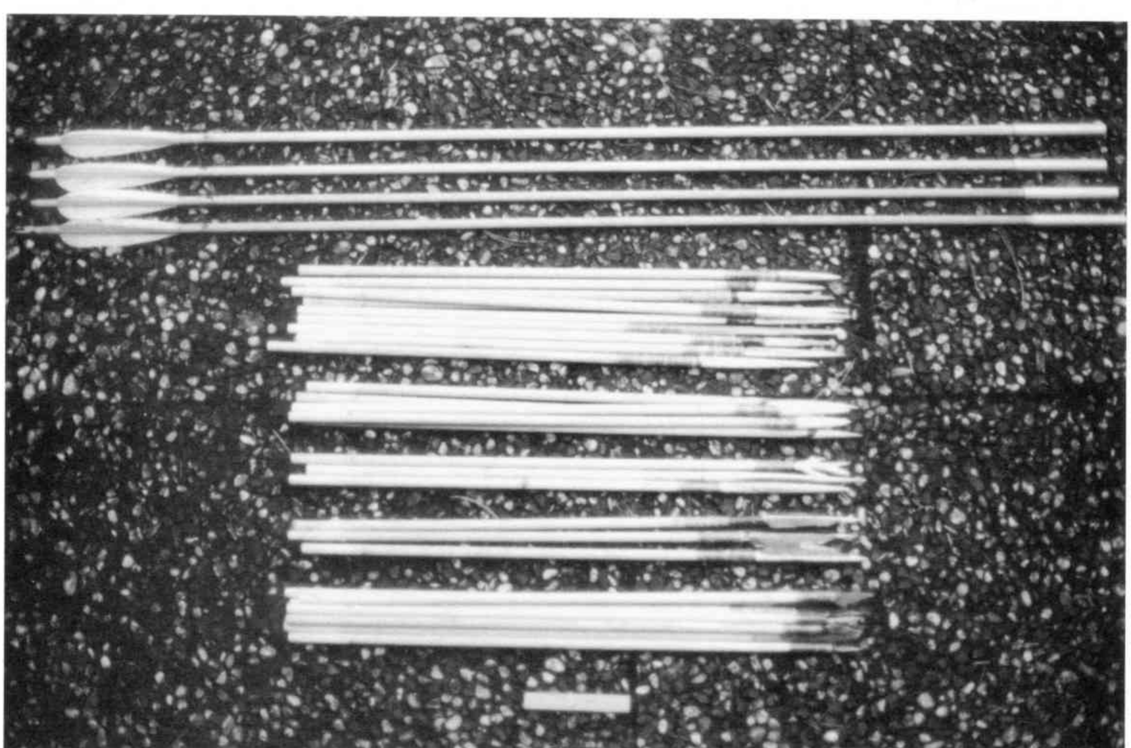


Fig. 3 — The main shafts used in the experiments, together with the fore-shaft inserts, with attached projectile points (Photographs by the author).

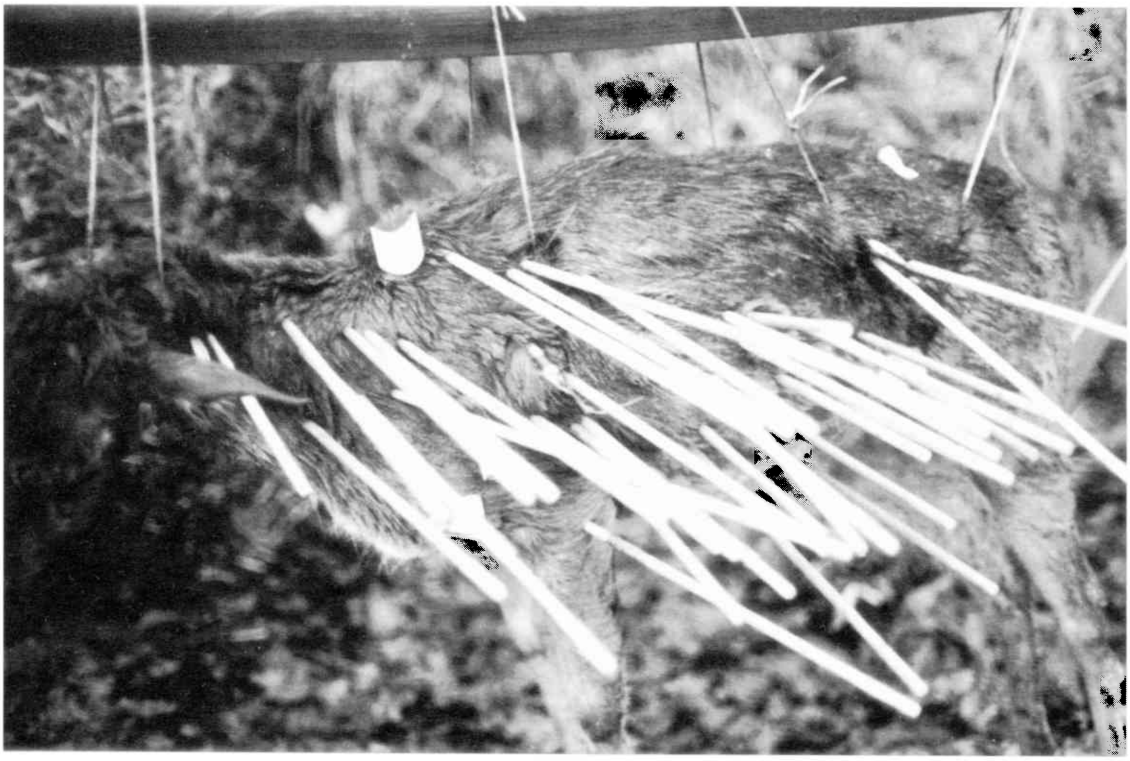


Fig. 4 — The carcass, suspended from a framework in a lifelike position, is towards the end of the experiment pierced by a large number of foreshafts (Photographs by the author).

beginning the experiment. Gutted, the animal still weighed 45 kg.

In contrast to the majority of previously carried out experiments listed above, which, in order to increase the rate of impact, were carried out over exceptionally short ranges, normally under 10 m, sometimes under 5 m or less, the present experiments were carried out at a range of 15 m. According to occasional references in ethnohistorical reports about the Aborigines of Australia, who are certainly the most important recent users of the spearthrower in the present context, this can be regarded as the average distance for hunting episodes (vid. e.g., synthesis in Cundy, 1989: 17).

The experiment took place on 25.1.1990, in comparatively unfavourable weather conditions (rain, gusts of wind, 5 °C). The carcass was suspended from a framework in a lifelike position oblique to the firing direction.

3. Results

Of a total of 45 projectiles fired, 8 were of either no, or only partial value for the analyses, the former being due to misses due to gusts of wind leading to irreparable damage to the point or foreshaft, the latter as a result of the form of hafting without additional binding (see below). The majority of the remaining 37 impacts ($n = 27$) were in the region of the abdominal and thoracic cavities—the most vulnerable target in hunting—; the remaining 15 hits were placed along the backbone in both neck and the rump, and around the shoulder blade, in order to obtain impact on bone.

3.1. Hafting

In the case of a double-bevelled point, which was attached to the shaft solely with an adhesive mixture of pine resin and beeswax (in a proportion of 2 : 1), the shock of impact split and broke the end of the shaft (fig. 5 : 1). The point only penetrated the target to a depth of a few cm, the greater part of energy expended caused the shot literally to backfire and forced the base of the point into the shaft like a wedge. This theoretically predictable result demonstrates convincingly in practice the impracticability of this form of hafting (and vid. Arndt & Newcomer, 1986: 166).

A similar result was shown in all cases by 3 single-bevelled points, which had been attached to the shaft in similar fashion using only the described adhesive. Impact caused

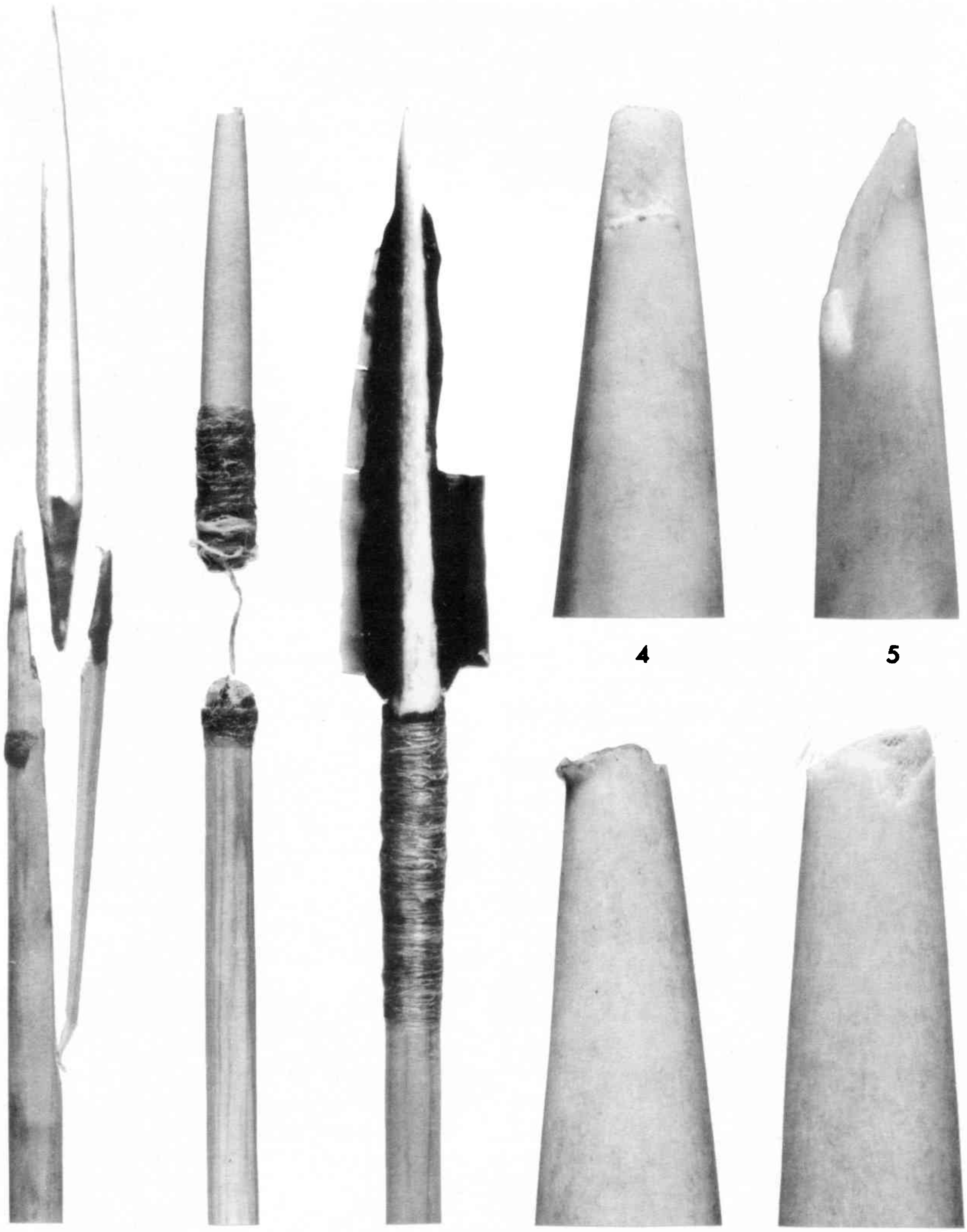


Fig. 5 — Damage to projectile points and shafts. **1**: Projectile point with a double-bevelled base, which was attached by adhesive only and which, upon impact, has split the shaf; **2**: Point with a single-bevelled base, the shaft of which has broken at the contact between point and shaft upon impact with a compact bone. There is also damage to the tip of the point (vid. N. 7); **3**: Projectile point armed with two opposing rows of backed bladelets. Two bladelets became detached upon contact with cartilage in the region of the thoracic cavit; **4–5**: Examples of oblique breakage with formation of a lip at their low margin, caused by impact upon the process of a thoracic vertebra (4) and between two vertebrae (5) respectively; **6–7**: Transverse breakage with "mushrooming" of the break surface, caused by impact upon compact bone. Scale of plates 1–3: 1:1, scale of plates 4–7: 4:1 (Photographs by the author).

the point to sheer from the shaft and as in the previous case penetration of the target was practically next to nul.

In the author's opinion it can be assumed that hafting of this type would have been just as inefficient in the Upper Paleolithic. As could be further demonstrated, an additional binding of plant fibres or sinew was sufficient to provide adequate stability. It was found that sinew which had been soaked for several hours and then beaten out into its separate fibres was especially suitable for this purpose. The fibres were wrapped tightly around the joint while still wet. In drying they shrank and thus bound together the components into a stable unit.

In certain cases in which a hard (more compact) bone was struck obliquely by a projectile, damage not only occurred to the tip of the projectile point (see below) but also the shaft broke close to the binding with the point (fig. 5:2).

3.2. Depth of Penetration

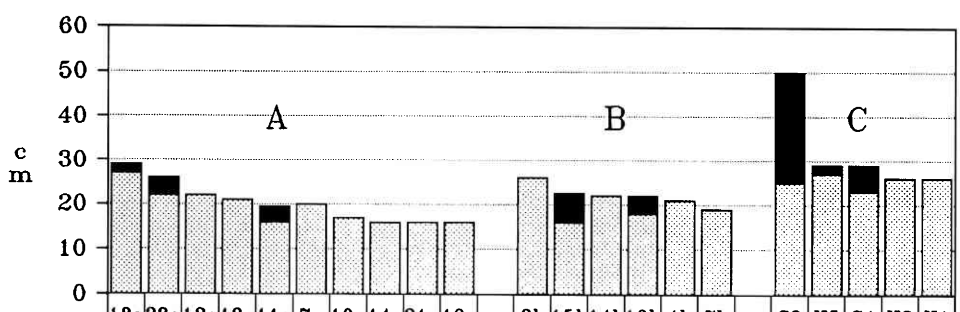
Depth of penetration was measured exclusively for those hits placed within the most vulnerable target area, i.e., the region of the abdominal and thoracic cavities, and which showed no recognisable traces of contact with bone (fig. 6).

These conditions were met by a total of 21 projectiles: 10 points with double-bevelled base, 6 points with single-bevelled base and 5 flint points (3 shouldered Hamburgian points and 2 Upper Solutrean types).

The average depth of penetration was approximately 20 cm, which would always have been sufficient to have reached one of the vital organs within the body cavity.[1] The small number of projectiles armed with flint points penetrated on average some 5–10 cm further into the body, certainly due to the cutting action of their edges. Whereas in the case of the antler points skin and tissue were merely pushed aside, the flint points cut a genuine entry wound.

Of all 5 antler points with attached backed bladelets, which might in principal have been expected to behave in a similar fashion, only 3 were included in the above group of points with impact in the region of the abdominal and thoracic cavities. The two specimens with double-bevelled base (N. 10a and 18a, vid. fig. 6) and the single specimen with single-bevelled base (N. 15b, vid. fig. 6) however did not give uniform results of further regarding the depth of penetration. Here it will certainly be necessary to wait for more results of further

[1] The fact that the carcass was used as a target in a gutted state must certainly be borne in mind in considering the depths of achieved penetration. The presence of the internal organs would certainly have acted to slow down the projectiles, but in the view of the author this effect would not have been very great.



	18a	23a	12a	13a	11a	7a	10a	14a	21a	19a	3b	15b	14b	10b	4b	7b	S3	H5	S4	H2	H1
b	2	4			3,5							6,5		4			25	2	6		
a	27	22	22	21	16	20	17	16	16	16	26	16	22	18	21	19	25	27	23	26	26

a b

a : Depth of shaft penetration inside the carcass
b : Projection of the shaft beyond the exit wound
a + b : Total depth of penetration by the projectile shaft

Fig. 6 — Depth of penetration of the abdominal and thoracic cavities by hits without bone contac; **A**: antler points with double-bevelled bas; **B**: antler points with single-bevelled bas; **C**: lithic points (Sn = Upper Solutrean shouldered point, Hn = Hamburgian shouldered point).

experiments involving larger series to ensure statistical validity.

3.3. Rates of Damage

An equally interesting result was observed with regard to the rates of damage to the points, in this case all 37 registered impacts with the carcass being evaluated. Whereas of the points made of antler (n = 28) only 7.1 % (n = 2) were in an irreparable and unusable state, this proportion for the flint projectiles (n = 9) was over 50 % (n = 5). In the case of the antler points it was, with the exception of two specimens, not difficult to re-sharpen the broken tip. In the case of the less heavily damaged pieces this was done by grinding with a suitable piece of sandstone, for more heavily damaged pieces it proved more practical to first carry out the preliminary preparation by chopping with a large blade or flake, and only then to finish the operation by grinding.

Unfortunately the small numbers of antler-, and especially flint-points, mean that these results too should only be treated with caution and as revealing trends.

3.4. Damage to antler points

A further point of interest is the damage to antler projectiles caused by impact on bone, especially that occurring at the tip, where in principal only two forms could be recognised. In addition to a regular compression of the tip ("mushrooming"), which occurs both in the presence and absence of previous transverse fracture of the piece (fig. 5:6–7), projectiles which did not hit the target at a right angle show regular oblique fractures, often with the formation of a recognisable lip at their lower end (fig. 5:4–5). Both forms of damage, which were already described by S. Arndt and M. H. Newcomer (1986: 167), correspond closely to features observed on the archaeological material.

3.5. Stability of the backed bladelet armatures

The rows of backed bladelet, whose attachment with an adhesive mixture of pine resin and beeswax has already been described, were very easily detached from the projectile point by contacts with more resistant materials such as bone and cartilage (fig. 5:3). By contrast, in the case of hits which only penetrated soft (muscle) tissue they remained totally undamaged.

3.6. Impact damage to bone

In the case of thinner bones, such as the upper part of the shoulder blade, the projectile normally penetrated completely, leaving a hole which was always somewhat larger than the thickest part of the antler point, or the shaft respectively (fig. 7:1).

Somewhat thicker bones, such as the relatively long processes of thoracic vertebrae, were often partially penetrated and showed associated splintering away of the bone (fig. 7:2). The latter feature is doubtless due to the conical form of the projectile points, which acts as a wedge upon the struck bone.

In two cases the bone surrounding the spinal marrow was hit (fig. 7:3). The point penetrated in both cases to a depth of some 2 cm before being halted, the perforation being exactly the same size as the diameter of the antler point at its position of greatest penetration. The energy of impact was in this case only just sufficient to cause fine cracks in the bone around the impact hole, but not enough to fracture the bone.

4. Conclusion

The results briefly summarised here form a pilot project for the author, for which for various reasons certain reservations must be made.

Since the investigation formed part of a thesis, the large investment of time and energy necessary for the manufacture, hafting and documentation of antler points meant that their number was limited for statistical purposes to a relatively small series. For this reason, as has been pointed out above, most of the presented results should only be seen as demonstrating trends.

The firing mechanism, the design and construction of which were equally time consuming, proved to be very valuable during this first trial. Due to its several positive properties such as, great accuracy, automation of the firing process, gradual adjustment of the initial projectile's velocity, and therefore providing comparable data, the author believes that the apparatus is suitable for a wide range of ballistic experiments, several of which, partly as a continuation of those described here, have already reached a certain stage of planning.

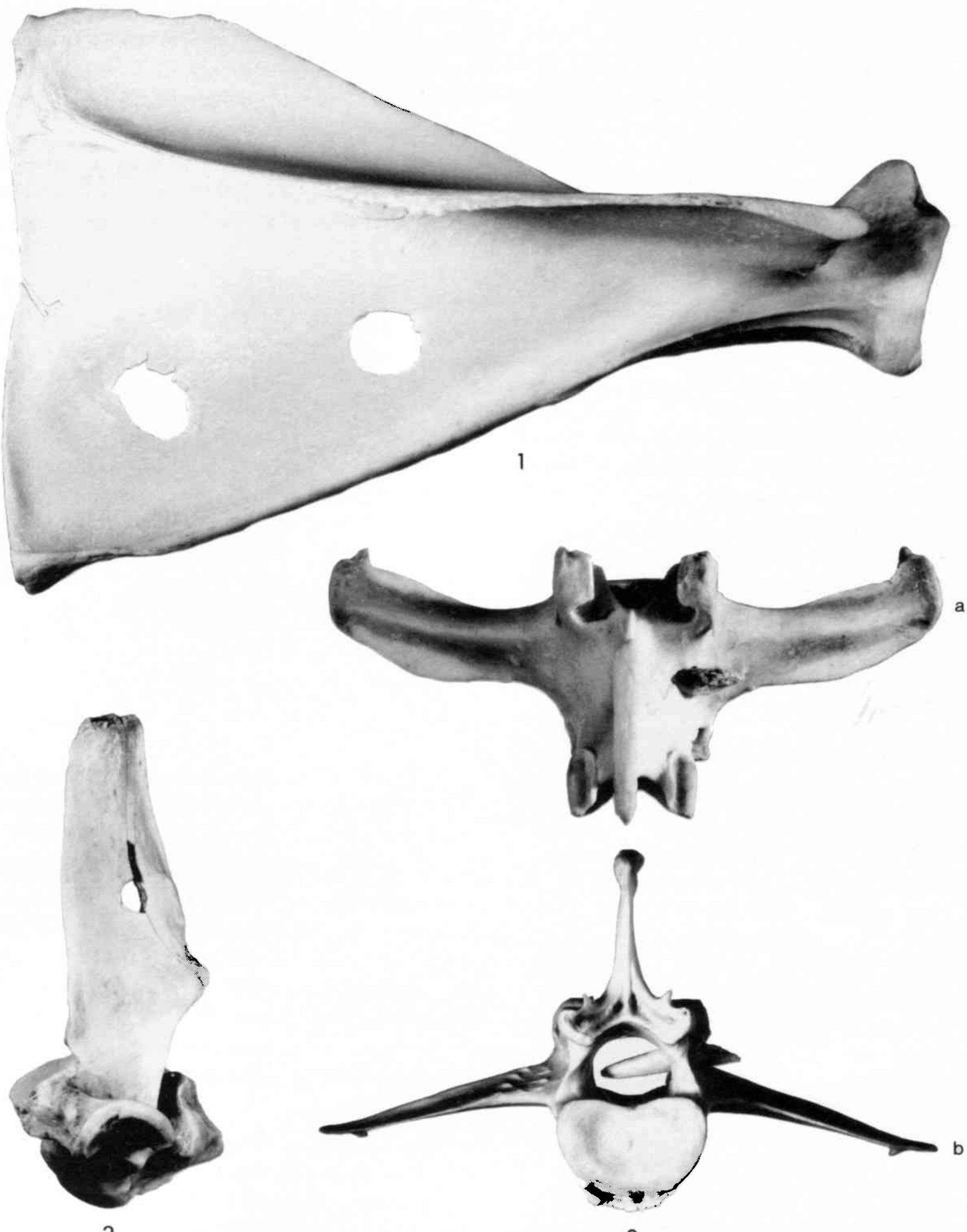


Fig. 7 — Impact damage to bone. **1**: Shoulder blade with two perforation; **2**: Thoracic vertebra with impact hole in the dorsal process. The conical form of the projectile point broke off parts of the process, which have here been replace; **3**: Thoracic vertebra with an impacted fragment of projectile point. Scale of all illustrations: 1 : 1. (Photographs by the author).

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