Red deer antler punches in the Terminal Mesolithic Ertebølle Culture. Use wear traces and experimental studies on worked antler tines from the site of Grube - Rosenhof LA 58 (Northern Germany)

Zwischenstücke zur Artefaktherstellung (Punches) aus Rothirschgeweih aus der spätmesolithischen Ertebølle Kultur. Gebrauchsspurenuntersuchungen und Experimente zu bearbeiteten Geweihsprossen von der Fundstelle Grube – Rosenhof LA 58 (Norddeutschland)

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Abstract - The technological concept for flint blade production by indirect percussion (punch technique) in the terminal Mesolithic Ertebølle Culture in Southern Scandinavia seems quite well understood. Several worked antler tines were detected in the bone and antler inventories from coastal sites which form parts of the flint working tool kit used by Ertebølle knappers. Experiments were carried out by Danish and Swedish modern flint knappers, but their results have not been proved on materials from northern Germany. Based on technological aspects and use wear traces this study presents a selection of worked antler tines which are interpreted as punches, conducted from the coastal site of Grube-Rosenhof LA 58 in eastern Schleswig-Holstein. It will be stated that such tools were particular common in northern Germany and opened new possibilities for shaping flint as the most important stone material used by Stone Age hunters and farmers. The recorded sample of worked antler tines clearly demonstrates that punch technique was utilized within the terminal Mesolithic of northern Germany for serial production of regular blades. The investigation and knapping experiments are part of a larger project on flint blade technology in Ertebølle Culture (and early Neolithic) where worked antler tines from other northern German coastal sites should be included.

Zusammenfassung - *Das technologische Konzept zur Klingenherstellung mittels indirekter Schlagtechnik (Punchtechnik oder Zwischenstücktechnik) in der endmesolithischen Ertebølle Kultur Südskandinaviens ist weitestgehend bekannt. Aus den Knochen- und Geweihinventaren der Küstenplätze stammen zahlreiche abgetrennte Geweihsprossen, die zum Standardrepertoire der ertebøllezeitlichen Flintschläger gehören. Versuche zur experimentellen Klingenerzeugung wurden verschiedentlich von dänischen und schwedischen Flintschlägern durchgeführt, allerdings sind ihre Ergebnisse nicht an bearbeiteten Geweihsprossen von norddeutschen Fundstellen überprüft worden. Basierend auf technologischen Merkmalen und Gebrauchsspurenanalysen wird in der vorliegenden Studie eine Auswahl von bearbeiteten Geweihsprossen von der Fundstelle Grube-Rosenhof LA 58 (Ostholstein) vorgestellt, die als Zwischenstücke zur indirekten Klingenherstellung interpretiert werden. Solche Geweihsprossen sind in den steinzeitlichen Küsteninventaren Norddeutschlands sehr zahlreich und ermöglichten den steinzeitlichen Jägern und Bauerngesellschaften eine zielgerichtete Bearbeitung ihres bevorzugtesten Rohstoffes, des Feuersteins. Das umfangreiche Ensemble von bearbeiteten Geweihsprossen verdeutlicht, dass die Zwischenstücktechnik im Endmesolithikum Norddeutschlands die gängige Methode darstellte, um regelmäßiges Klingen in Serie zu erzeugen. Die hier vorgestellte Studie und die durchgeführten Schlagexperimente sind Teil eines Gemeinschaftsprojektes zur Untersuchung der ertebøllezeitlichen und frühneolithischen Klingentechnik, in die auch bearbeitete Geweihsprossen von anderen Fundplätzen einbezogen werden.*

Keywords - Northern Germany, Terminal Mesolithic, Ertebølle, worked antler tines, punch, use wear, flint knapping experiments
Norddeutschland, Endmesolithikum, Ertebølle Kultur, bearbeitete Geweihsprossen, Geweihzwischenstücke, Gebrauchsspurenanalysen, Flintschlagexperimente

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Introduction

The site of Grube-Rosenhof LA 58 (abbreviated as Rosenhof) is located in the eastern part of Schleswig-Holstein (Fig. 1) and was discovered in 1968 and partially investigated between 1969 and 1980 by H. Schwabedissen from Cologne University (Schwabedissen 1994). During this excavation an overall area of c. 330 m² were investigated systematically. More than 100 conventional ^{14}C dates suggested that the coastal settlement was inhabited from c. 5'000 until 3'900 calBC, meaning that it covered both the preceramic and ceramic stages of the Ertebølle Culture. But some questions remained unclear, for instance at which time the first pottery was introduced and when the early Neolithic period started and pointed-base vessels and oval lamps were replaced by funnel beakers. Thus, in 2001 and 2002 some more 60 m² were investigated from the refuse area of the settlement (new excavation, Rosenhof area A) and later published by J. Goldhammer in a monograph (Goldhammer 2008).

These results have led to a reinterpretation of Schwabedissen's findings, as the earliest AMS-^{14}C dates from the basal find layers do not provide any indication of an occupation prior to 4'900/4'800 calBC (ibid. 2008). Direct sampling of antler axes and charred food remains on ceramic vessels has dated the introduction of pottery and T-shaped axes to around 4'600 calBC.

The material from the new excavation comprises approximately 320 pottery fragments which belong to thick-walled, coarsely tempered pointed-base vessels. The number of lithic artefacts totals c. 5'500 pieces,

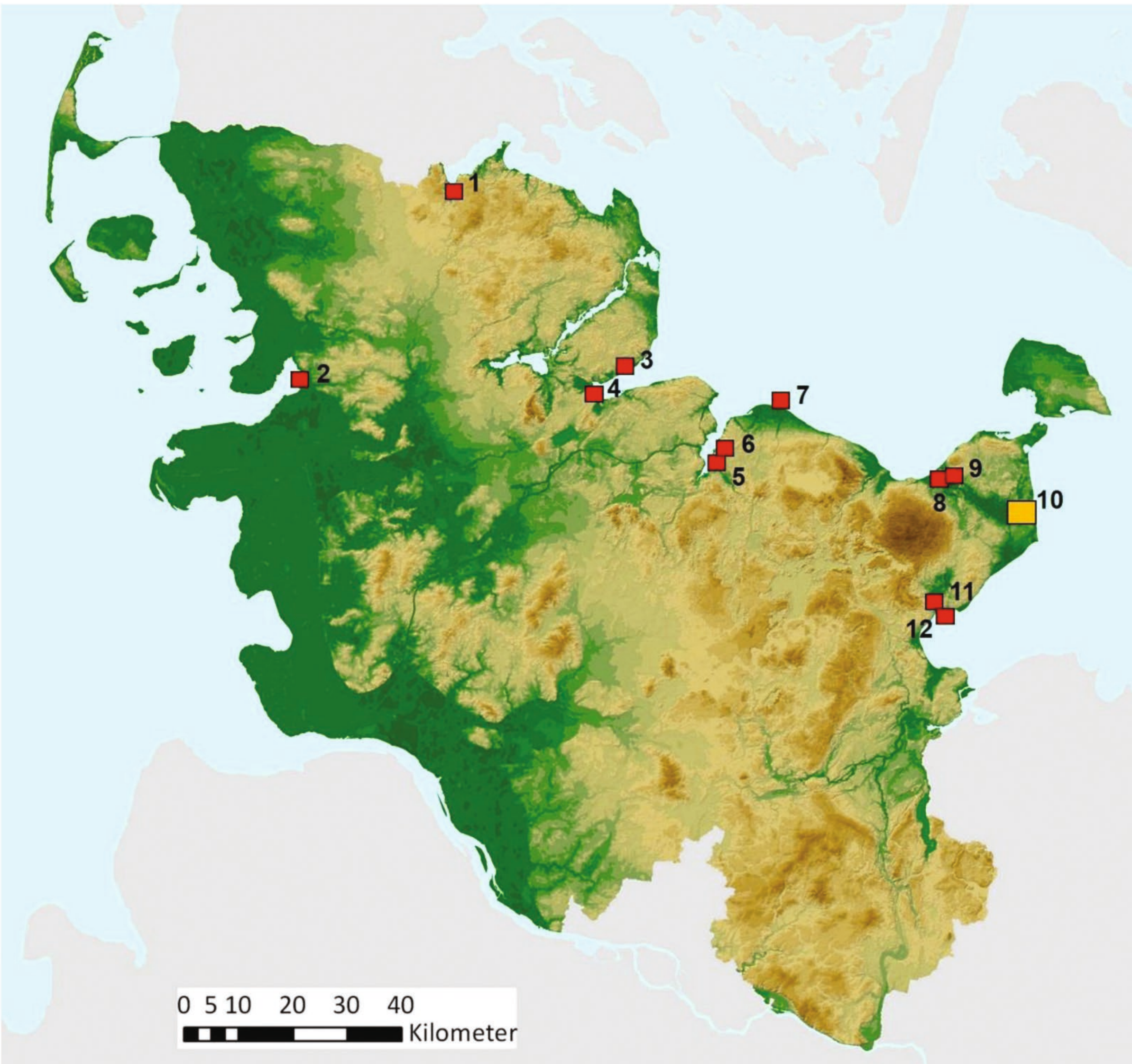

Fig. 1. Coastal sites of the Ertebølle Culture with red deer antler punches in Schleswig-Holstein. 1 - Flensburg LA 105. 2 - Husum LA 11. 3 - Karlsminde LA 86. 4 - Eckernförde LA 29. 5 - Kiel-Ellerbek LA 1. 6 - Neumühlen-Dietrichsdorf LA 1. 7 - Schönberg LA 7. 8 - Wangels LA 505. 9 - Wangels LA 223. 10 - Grube-Rosenhof LA 58. 11 - Neustadt LA 156. 12 - Neustadt LA 159.

Abb. 1. *Küstenfundstellen der Ertebølle Kultur mit Zwischenstücken (Punches) aus Rothirschgeweih in Schleswig-Holstein.*

2 % of which have been identified as tools (Goldhammer 2008) and c. 7 % are blades. Blade removals were produced by means of indirect percussion which resulted in regular, slightly curved and prismatic blades with a combination of lib and flat bulb, flat and lens shaped butts and medium lengths of 6.5-7 cm. Among the flint tools, trapezoidal, flat-trimmed flake axes/adzes are the most prominent group followed by transverse arrowheads. The remaining flint tools consist of blade scrapers, concave and straight-truncated blades, thick core borers and various edge-retouched pieces. Burins are lacking which illustrates the relative insignificance of this implement in the late Ertebølle Culture of eastern Holstein.

The excellent preservation conditions in brackish sediments led to the discovery of a number of specific tools for specific needs. Among these are wooden artefacts such as leister prongs, paddles, fragments of spears, net floats and fragments of a bow. A group of antler and bone implements completes the tool inventory. Two sharp bone points were made from bird bones, and three T- shaped axes from red deer antler. Other finds comprise a large perforated faceted antler dag with a continuous line ornament running around (Feulner & Hartz 2011) and 14 red deer antler tines with a blunt distinctive wear marks (punches). The results of the 1970s excavations (Hartz 1999), the thickness of the cultural layers, which comes up to 0.6 m, and the high frequency of blade tools and axes/adzes suggest that Rosenhof was a so-called base-camp settlement, probably inhabited throughout the year.

In the collection of antler artefacts from the 1970s excavations at Rosenhof 44 examples of evenly curved tines of red deer antler were mentioned by Vielstich (1992) as punches. The raw material comprised the second tine above the antler beam, and they were removed by circular chopping or sawing of the compact outer layer of antler to the soft spongy core and breakage after it. The outermost natural points were also cut away, and the end about 1 cm in diameter has a slightly convex or domed tip. This end displays pitting and smashing observed with a naked eye, and flat scars run along sides of the beam from the end in the direction of the butt, most often along the concave side. When regarding the general form of the tools, the shape of the working end and the type of the damage, 37 tools could be examined as punch tools (sometimes mentioned as fabricators) similar to ones identified from other sites in Northern and Eastern Europe (Larsson 1977/78; Zhilin 2001, 2012; Dellbrugge 2002; Karsten & Knarrström 2003; Andersen 2013; David 2015; Kabacinski & Terberger 2015; David & Sørensen 2016; Sørensen 2017). For the method of their use we refer to Kannegaard Nielsen (1985), Weiner (1985) and Sørensen (2006).

Methods

The tools made from red deer antler tines from Rosenhof 1970s excavations were studied with a help of stereo microscopes MBS-9 and Wild M 650. Magnification of the ocular was 10, magnification of the objective was from 0.6 to 7, which made available magnification from 6x to 70x. As our previous traceological studies of bone and antler artifacts showed (Zhilin 2012) this was sufficient for good observations of traces of manufacture and use on Mesolithic bone and antler tools. The majority of informative traces were clearly visible at magnifications from 6x to 40x, and only at some rare occasions higher magnifications were needed.

Photos of general view and macro photos were taken with the help of a Nikon D 60 camera, and micro photos were taken with the help of a camera ocular DCM-800, which was placed instead of one ocular of a microscope and connected with a computer via USB cable.

To test traceological observations a number of experiments was carried out. The aim of these experiments was to reproduce the process of removing blades from cores with the help of punches similar to original artifacts from Rosenhof (description of experiments see below) and to study formation and appearance of use wear traces on these tools. Experimental results and observations were compared with the results of traceological analyses and a hypothesis about the manufacture and use of original artifacts from Rosenhof was put forward. More than 20 punches from red deer antler of similar size and shape made and used by Harm Paulssen during last years for production of flint blades comparable to ones from sites of Ertebølle culture were also studied by the authors. Traces, similar to ones observed on two experimental and 20 archaeological pieces from Rosenhof LA 58 site were observed on these punches. The only difference is the absence of scars on sides and convex surface of H. Paulssen's old punches, because he never changed position of his punches during blade making. When a punch was not suitable for further work even after reshaping he just abandoned it. Use-wear traces similar to ones observed on H. Paulssen's punches were also observed on some red deer antler punches used for blade production by M. Sørensen during a conference in Schleswig in 2011 and a workshop in Holma in 2013, and on punches used by J. Pelegran during a workshop in Paris in 2012. M. Zhilin conducted a number of experiments in blade production using elk antler punches in 1979-2016. Damage and micro traces were also similar to ones observed on punches from Rosenhof except for damage of a concave side, because elk antler punches were straight.

Experiments

To study blade production in Ertebølle Culture of Schleswig-Holstein, observations of the behavior of punches and formation of use wear traces during blade production were the main aims of our knapping experiments. Experimental team included Harm Paulsen (punch preparation and knapping), Sonke Hartz (photo and notes), Mikhail Zhilin (punch repair, notes and observations, micro wear studies). Experiments were carried out at Gottorf Museum in Schleswig. Homogenous, grey cretaceous flint collected on the Baltic Sea coast was used as raw material. Two slightly curved tines detached from modern red deer antlers of the same size and shape as original artifacts were used (Fig. 2: 1; Fig. 5: 1) for removing blades. A short billet made from elm wood was used as a hammer.

Punch 1 is 15.2 cm long and 3.1 cm wide at the butt (Fig. 2: 1). It was made from a curved antler tine, a slightly convex tip about 1.3 cm in diameter was ground with a medium grained granite slab. The butt end was also ground with the same slab, whereas the side remained unworked **Core 1** was prepared in hard percussion using a hammer stone of quartzite. The core was held at the thigh and irregular flakes and blades were produced from a nucleus with an unfacetted striking platform. Before starting indirect percussion with a punch the platform edge was carefully abraded with the hammer stone. To detach the blades the working end of the punch was placed on the core platform near its edge, the convex side of the tine facing the core platform, and the concave side facing the knapper (Fig. 2: 2). After removal of the first blade the area of the tip near a convex side of the punch was slightly smashed and a small flat scar appeared at the tip near the convex side. Blade no 2 was detached with the same tool, no extra traces appeared. Before knapping the next blade, the punch was used to remove overhang from the edge of core platform, and single new scars appeared on its convex side. After abrasion and detaching two more blades overhang was again removed, and some smaller scars emerged on the tip near the convex side of the punch. After removal of blade no 10 the same traces on the tip of the tool became more pronounced. When blade no 20 was knapped the cornice was removed with the punch and some flat facets with hinge termination appeared at its end. Initial cracks emerged at the punch's tip near the convex side, transverse scars and coarse longitudinal striations running from the tip roughly parallel to the axis were visible on its convex side. After detachment of blade no 23 use wear is the same, but more pronounced (Fig. 2: 3). After removal of each series of blades the edge of the striking platform of the core was ground with a side of a hammerstone. It is remarkable that most blades were broken during removal. A massive intact blade no 34 was removed with a strong blow along the ridge between the flaking front and the rear side of the core. A deep pit occurred at the side of the punch tip near the convex side. When 41 blades were removed, the core shape became regular subconical. The core was not exhausted, and more blades could be removed. Some initial cracks appeared on the tip of the punch, and a rough platform was formed on the tip near its convex side. Transverse scars are observed at a distance up to 4 cm from the tip at the convex side.

Punch 1 was later used for blade production from **core 2** - similar to previous, but more massive. The first 8 blades were removed in the same manner. The punch was also used for making a crest on the cores front. A deep groove appeared at the end of the punch near the convex side, and a flat oblique platform was formed near the convex side. As a result the punch slipped off from the core platform when used in the same position without removing any blades. The knapper turned the punch about 90° counter-clockwise, now the portion of the tools end near one lateral side was contacting the platform (Fig. 2: 4). This position is also suitable, blades were removed, but when the knapper attempted to remove a massive crest on the core side, the end of the punch cracked. An initial chip about 8 mm wide went off. The punch still worked and 8 more blades were removed, but gradually more scars and cracks emerged at the tip (Fig. 2: 5). A flake went off from the initial crack along the side of the punch leaving a flat scar (Fig. 2: 6). The knapper changed position of the punch, and now parts of the working end near its concave side contacted the core platform. Four blades were removed but the middle of the punch end flattened and more initial cracks were formed there. At this stage the **core 2** was abandoned.

Punch 1 and **core 3** are similar to previous, but with more impurities. The large flake and a smaller one went off along a lateral side of the core leaving a long facet with hinge termination. A large crack emerged at the punch tip at the attempt to remove this defect from the core front. After the next blow a flat flake with a step termination went off along this crack from the other lateral side of the fabricator (Fig. 2: 7). The punch with facets at both lateral sides, flattened middle of the working end and more initial cracks there (Fig. 2: 8) was again turned. As a result of a strong blow a flake vent off from its concave side, and the punch was abandoned.

Use wear traces on abandoned **punch 1** (Fig. 3; Fig. 4: 1) include flat scars running from the tip along the tool axis (Fig. 4: 2-3). The tip is flattened in the middle and smashed, especially near the convex side (Fig. 4: 4-6), multiple initial cracks are visible at the tip; the edge between the tip and convex side is crudely abraded, multiple irregular pits overlap each other; crude grooves and finer striations cross the edge running from the tip towards the convex side and along it roughly parallel to the tool axis or at acute angles to it (Fig. 4: 7-8); multiple transverse marks

Fig. 2. Experimental antler punch 1. 1 - general view; 2 - standard mode of use (H. Paulsen); 3 use-wear traces on the tip after removing 23 blades; 4 - position of the punch after turning at 90°; 5 - the tip of the punch with deep initial crack; 6 - a flat scar on the lateral side of the punch end; 7 - a flat scar on the other lateral side of the punch end; 8 - the tip of the abandoned punch 1.

Abb. 2. *Experimentell hergestelltes Zwischenstück 1 (Punch 1). 1- Gesamtansicht; 2- gängiges Anwendungsprinzip (H. Paulsen); 3- Gebrauchsspuren an der Spitze nach Abschlagen von 23 Klingen; 4- Position des Zwischenstücks (Punch) nach Drehung um 90°; 5- Spitze mit tiefem Initialbruch; 6- langschmaler Abspliss am Lateralende; 7- langschmaler Abspliss am gegenüberliegenden Lateralende; 8- vollständig abgenutzte Spitze.*

Use-wear traces	Experimental punches	Rosenhof LA 58 punches
Flat scars running from the tip along the tool axis	+	+
The tip is flattened in the middle and smashed, especially near the convex side	+	+
Multiple initial cracks are visible at the tip	+	+
Multiple irregular pits overlap each other	+	+
The edge between the tip and convex side is crudely abraded	+	+
Crude grooves and finer striations cross the edge running from the tip towards the convex side and along it roughly parallel to the tool axis or at acute angles to it	+	+
Multiple transverse marks perpendicular to striations and the tool axis, resembling traces of chopping are observed at the convex side of the punch.	+	+

Fig. 3. Use-wear traces on experimental and archaeological punches.

Abb. 3. *Gebrauchsspuren auf experimentellen und archäologischen Zwischenstücken.*

perpendicular to striations and the tool axis, resembling traces of chopping are observed at the convex side of the punch.

Punch 2 is 17.2 cm long and 2.5 cm wide at the butt with a slightly convex tip about 1.3 cm in diameter (Fig 4: 1). It is similar to punch 1 and made from a curved tine of red deer antler. The sides are smoothed by longitudinal whittling with a flint blade up to 5 cm from the working end (Fig. 5: 2). The slightly convex tip was formed by short radial cuts towards its center, and finally rounded by grinding on a sandstone slab (Fig. 5: 3). It turned out to be an exact copy of the punches from Rosenhof.

The **core 4** was made from a flint nodule found at the Baltic coast and was prepared by direct hard percussion with a hammer stone, then coarse protrusions were removed with a short massive antler punch. The edge of the striking platform was smoothed by abrasion with a side of a hammer stone.

Blades no 1-5 were removed in the described manner with punch 2 (Fig. 5: 4), but they were all broken. A step on the front occurred when blade no 6 was removed. An additional striking platform was made at the base of the core. Four regular blades were removed from this platform with punch 2.

After described work use wear traces typical for punches emerged at the tip and convex side of the tool 2: transverse triangular scars, short grooves and longer scratches running from the tools end. The tip near the convex side became flat and oblique, with multiple irregular pits overlaying each other, and short grooves crossing its edge (Fig. 5: 5). Several initial cracks are observed. Thus, punch 2 became unsuitable and needed reshaping. It was ground at the same sandstone slab to make the end round and remove the cracks. Grinding removed about half of previously observed use wear traces.

After 10 blades and flakes were removed the punch 2 hit a massive ridge. A small flat scar with step termination emerged at its convex side, irregular pitting developed and initial cracks emerged at its tip (Fig. 5: 6). However, punch 2 was still suitable. More blades were removed from the main platform, the other one was used only to restore the front (remove steps, extra thickness and curves). Most massive steps were removed with a heavy red deer antler hammer by direct percussion. After removing 3 more blades from the main platform the punch end again became oblique and flat near the convex side (Fig. 5: 7) and was restored to original shape by grinding on the same sandstone slab (Fig. 5: 8). Most use wear traces at the tip and initial part of the scar were removed. After a strong blow to reshape the core front two more small flat scars emerged at the punch side near the first one. Again the tools end was reshaped by grinding. Now the punch end became 15 mm in diameter and was reshaped to initial 10 mm in diameter by longitudinal whittling with a flint blade, the point ground to initial shape. The punch became much better, and five more blades were removed.

The core was reshaped to a more conical form with a granite hammer stone. Blades became more regular, but most of them were still broken. After detaching 36 blades the core and fabricator were abandoned.

Use wear traces on abandoned **punch 2** (Fig. 3; Fig. 6: 1-2) are similar to observations on punch 1. But because tool 2 was less heavily used and its tip was regularly reshaped by grinding only some small facets are observed on its convex side near the tip (Fig. 6: 3-5), the working end is less smashed and the number of initial cracks is much smaller. Intense pitting, deep transversal marks and grooves subparallel to tool axis are clearly visible at the tool's end and its nearby area (Fig. 6: 5-6). But multiple grooves, coarse and fine striations running from the tip parallel to the tool axis and at acute angles to it, crossing each other accompanied by transverse marks perpendicular to striations and the tool axis, resembling traces of chopping (Fig. 6: 7-8) are much better pronounced at the convex side of punch 2 at a distance of 1 cm from the tip and even at 5 cm from it.

Both variants of use wear traces described above were observed on antler tine tools from Rosenhof.

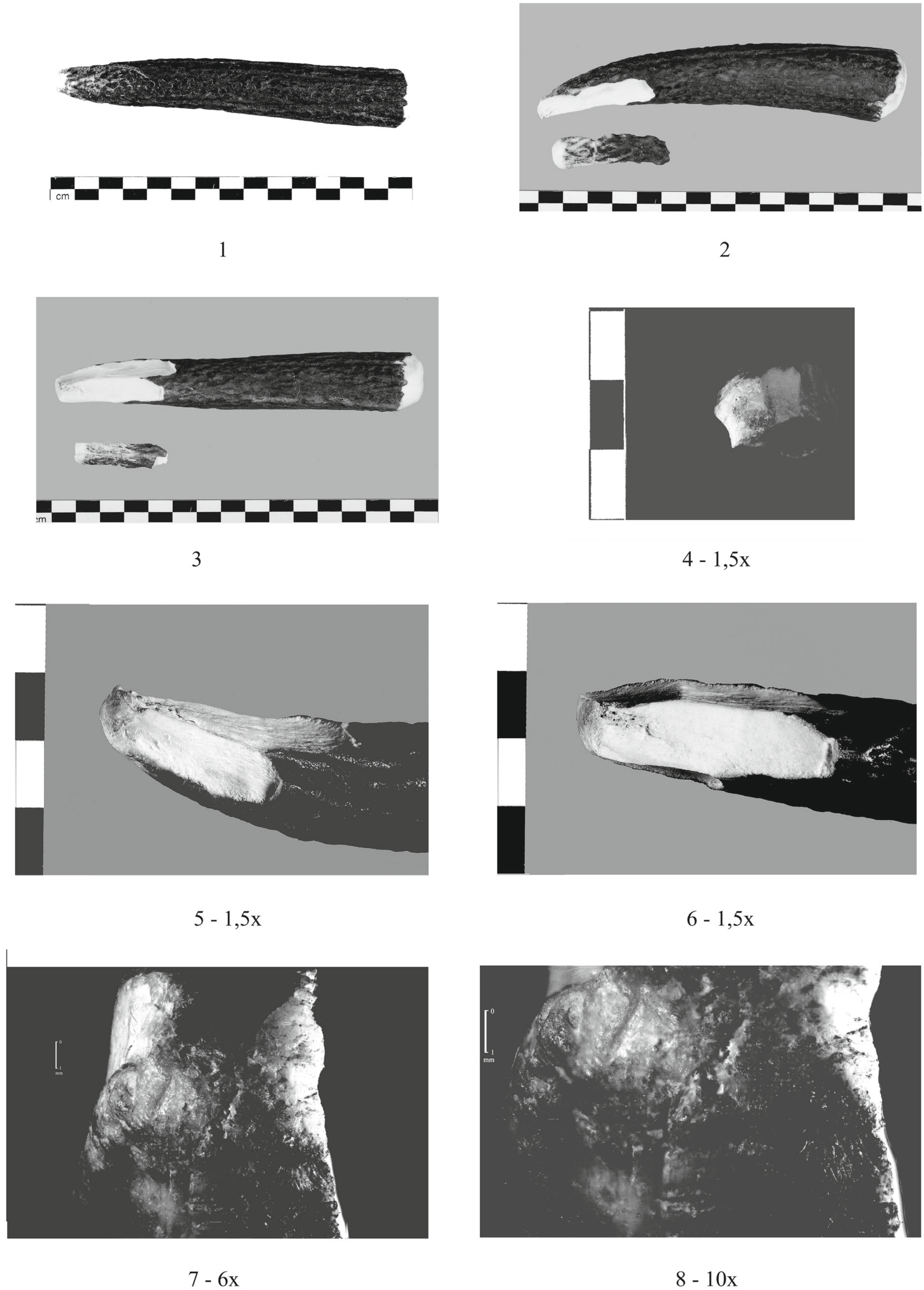

Fig. 4. Experimental antler punch 1, use-wear traces. 1 - convex side; 2 - left lateral side after a long flake vent off; 3 - concave side after another long flake vent off; 4-6- working end and adjacent area of the convex side; 7-8 - the edge of the working end.

***Abb. 4.** Gebrauchsspuren am experimentell hergestellten Zwischenstück 1 (Punch 1). 1- konvexe Seite; 2- linke Lateralseite nach Abgang eines langschmalen Absplisses; 3- konkave Seite nach Abgang eines weiteren langschmalen Absplisses; 4-6 Arbeitsende und umgebende Fläche an der konvexen Seite; 7-8 Spitzeansicht des Arbeitsendes.*

Fig. 5. Experimental antler punch 2. 1 - general view; 2 - shaping the working end by whittling with a flint blade; 3 - shaping the tip by grinding on a fine grained abrasive slab; 4 - standard mode of use by H. Paulsen); 5 - use-wear traces on the tip after removing 6 blades; 6 - use-wear after removing 10 more blades; 7 - further use-wear after removing 3 more blades; 8 - reshaping of the tip by grinding.

Abb. 5. *Experimentell hergestelltes Zwischenstück 2 (Punch 2). 1- Gesamtansicht; 2- Anschärfen der Spitze mit eine Flintklinge; 3- polieren der Spitze durch Reiben auf einer feinkörnigen Sandsteinplatte; 4- gängiges Anwendungsprinzip (H. Paulsen); 5- Gebrauchsspuren an der Spitze nach Abschlagen von 6 Klingen; 6- Gebrauchsspuren nach Abschlagen von 10 weiteren Klingen; 7- Gebrauchsspuren nach Abschlagen von 3 weiteren Klingen; 8- Nachschärfen der Spitze durch Reiben auf der Sandsteinplatte.*

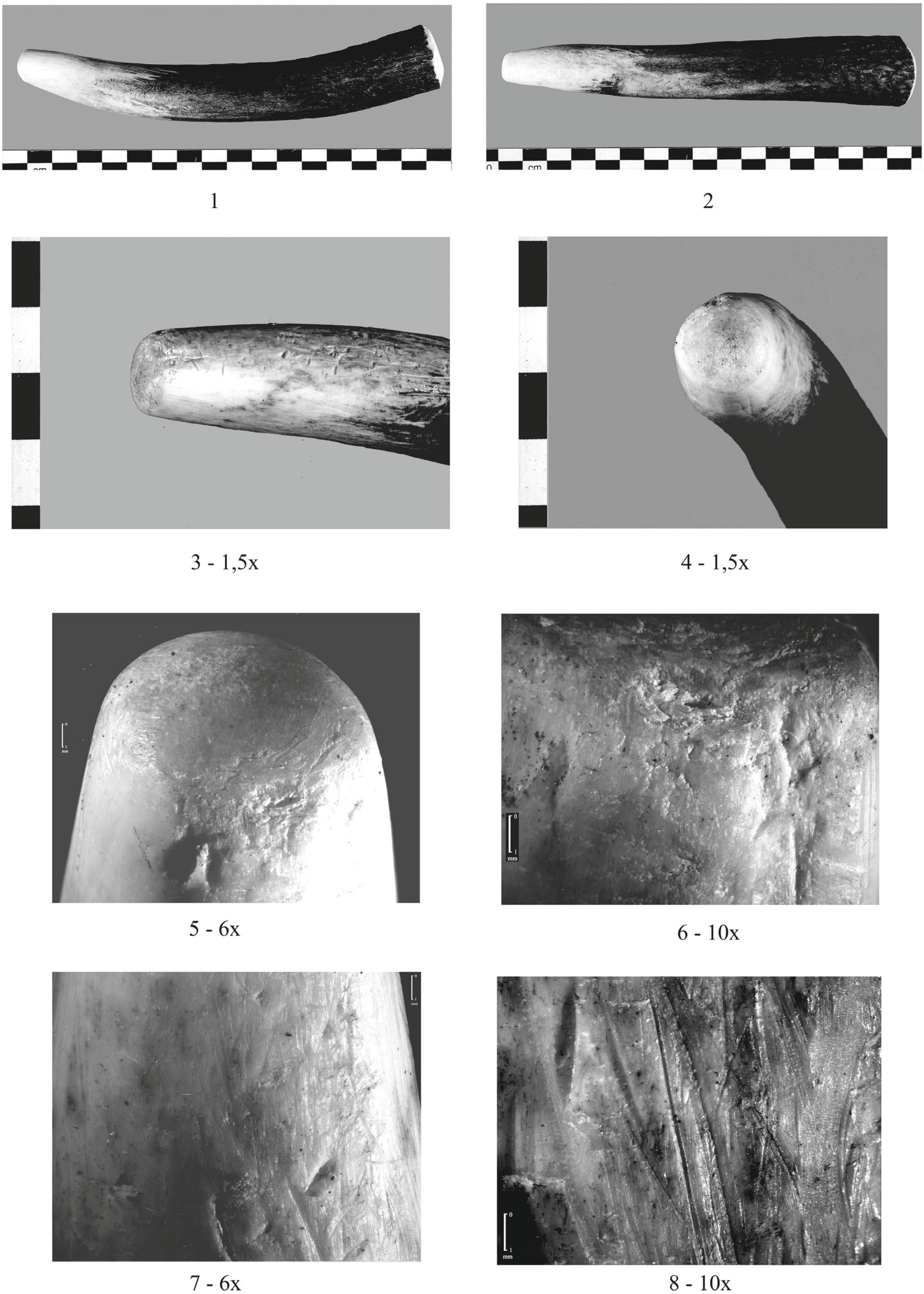

Fig. 6. Experimental antler punch 2, use-wear traces. 1 - right lateral side; 2 - convex side; 3-5 working end and adjacent area of the convex side; 6 - the edge of the working end ; 7 - convex side, 1 cm from the tip; 8 - convex side, 5 cm from the tip.

Abb. 6. *Gebrauchsspuren am experimentell hergestellten Zwischenstück 2 (Punch 2). 1- rechte Lateralseite; 2- konvexe Seite; 3-5 Arbeitsende und umgebende Fläche an der konvexen Seite; 7- konvexe Seite, 1 cm unterhalb der Spitze; 8- konvexe Seite, 5 cm unterhalb der Spitze.*

Results

All 37 worked red deer tines were studied with the help of a microscope. Surface of 20 of them was satisfactory for use-wear analysis with well-preserved micro topography and a full set of traces of manufacture and use including edge and surface mechanical damage, polishes and linear traces. Two were preserved extremely well as if recently abandoned. Preservation of 15 was rather poor due to chemical erosion of their surface. Micro topography was leveled, surface is scaly or pitted, no polishes or linear traces visible, only macro traces such as various scars are preserved.

Technology of the manufacture of Rosenhof punches

Various traces of manufacture and use were observed. The basal (butt) ends of 14 tines showed traces of simple breakage after circular grooves were made by sawing through the compact outer layer (Fig. 10: 2-3). Two more were broken along circular grooves made by chopping. A wide shallow transverse groove running along tine perimeter of another one displays very flat scars with step termination, at a very acute angle to antler surface, without striations, normally left by flint tools. Our experiments showed that such flat scars emerge when worked antler is intensively softened.

One more tine was broken along transverse groove, the butt end of this tool was smoothed by grinding after breakage. Similar smoothing of breakage end is observed on four tines which were simply broken off, and two others were broken off along circular grooves (Fig. 9: 1; Fig. 10: 1-3). Pointed ends of tines were cut off, and tips were shaped blunt and slightly convex with the help of grinding. Sides near the working edge were smoothed by longitudinal whittling or scraping, visible at five tools, and by polishing with a fine grained abrasive slab (Figs. 11-12). Longitudinal whittling was also used combined with grinding of the tip for renewal of working ends damaged during work when the working edge became irregular and grew thicker than needed. Besides smoothing of the tip it was necessary to keep the diameter of the working end about 1 cm as we see at the majority of tools. At some tools whittling or scraping traces partially remove damage scars at their sides (Fig. 10: 6).

Thus, we can reconstruct the following operation sequence (*chaîne opératoire*) for the production of the Rosenhof antler tine tools: 1) detachment of a tine; 2) smoothing of the breakage at the butt end; 3) removing of the tine point and formation of a tip by whittling/scraping and grinding; 4) shaping of sides by whittling/scraping and/or grinding. Not all stages were obligatory, for instance 14 tools show no traces of smoothing at the butt end. Shaping of sides of working end by whittling/scraping and/or fine grinding was not found at the majority of tools. The simplest basic variant of tool manufacture included only the detachment of a tine and formation of a tip by grinding.

Use wear traces on antler tines from Rosenhof

Butt ends of most tools do not display any pronounced use wear traces, which indicates the use of a wooden hammer. This observation is also typical for experimental punches made from red deer antler tines which were used with a wooden hammer for a rather long period of time. But two tools in our collection display smashing and flat scars running from the edge of the butt end. Such traces are typical for punches used with a hard hammer (hammerstone). Their formation was repeatedly observed during our experiments on blade production in the Upper Volga (Zhilin 2012).

Working ends show a combination of macro and micro wear traces (Fig. 3). The first include flat scars with a feather or (more often) hinge termination, running from the tip along sides of a tool. Such scars were observed on studied tools from Rosenhof (Figs. 7-12): on the convex side of two tines; on the

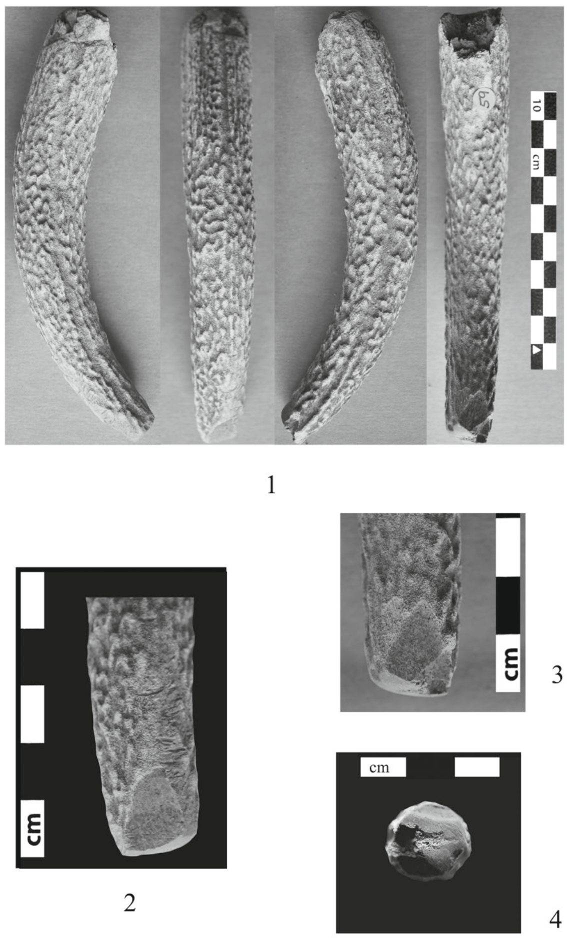

Fig. 7. Punch from Rosenhof (Ros 1970.30, 59). 1 - general view; 2 - tip from convex side; 3 - tip from concave side; 4 - tip from above.

Abb. 7. *Zwischenstück (Punch) von Rosenhof (Ros 1970.30,59). 1- Gesamtansicht; 2- Spitzenansicht der konvexen Seite; 3- Spitzenansicht von der konkaven Seite; 4- Spitzenansicht von oben.*

concave side of ten others; on convex and concave sides of eight more; on concave and lateral sides of three others; and on convex plus concave plus lateral sides of another two.

Pronounced edge damage in the form of smashing, cracks, pitting, coarse long scratches and grooves, transverse marks is observed at working ends of described antler tine tools. Smashed parts of the tip are observed near a side of a tine, and cracks usually initiate from this part (Fig. 10: 8-10), as well as coarse striations, running from the tip along the tool axis or at acute angle to it. On the contrary, thin or triangular transversal marks are situated at some distance from the tip (Fig. 7: 2; Fig. 11: 6). Comparison with punches used in blade production experiments shows that such traces originate from contacts of the tip with the edge of a flint core platform when the punch slides along it after removal of a blade. These are use wear traces typical for antler punches used for flint knapping. Besides general description of observed use wear traces it is worth to give a description of some most prominent traces observed at punches from Rosenhof. Rosenhof 1970, area 1, no 59 (Fig. 7: 1). The tine was broken off from the beam. The tip of the working end is flat (Fig. 7: 4). Transverse thin and shallow multiple scars on the convex side near the end are partly removed by a flat facet with feather termination, running from the end along convex side (Fig. 7: 2). Similar facet is on the concave side. Initial parts of both facets are removed by grinding of the end with fine grained abrasive slab (Fig. 7: 2-3). Similar thin transverse scars which emerged after reshaping of the tip are visible on the surface of the facet on the convex side near the tip. Two facets with step termination start from the tip partly removing a flat scar on the concave side and smashing the tip (Fig. 7: 3-4).

- Rosenhof 1970, area 1, no 30 (Fig. 8). The surface is eroded and the tine was broken off from the beam. The working end is smoothed by grinding, the tip is rounded at the sides and flat in the middle (Fig. 8: 2-4). A groove runs around the end at a distance 1 cm from the tip (Fig. 8: 1). A flat scar with hinge termination running from the tip along one lateral side of the tool is accompanied by a long deep double scratch starting at 2 mm from the tip and running along lateral side about 4 cm (Fig. 8: 2). Pitting is observed at sides of the tip, an initial crack starts on the concave side (Fig. 8: 3-4). Multiple deep grooves run from the tip crossing each other along concave side (Fig. 8: 3 & 5-6).

- Rosenhof 1980, area XIX, no 94 (Fig. 9). The surface is slightly eroded and a transverse groove was made on the butt end along which it was broken off from the beam (Fig. 9: 1). Elevated parts of the breakage are smoothed by grinding. Two short flat facets with step termination run from the butt end indicating the use of a hard hammer (antler or stone). The tip is rounded by grinding (Fig. 9: 3) which destroyed initial part of typical wear traces running from the tip along its convex side (Fig. 9: 4-6). A flat facet with step termination runs from the tip smashing it along concave side and destroying the tool (Fig. 9: 2). Coarse striations run from the tip along the tool axis (Fig. 9: 4-6).

- Rosenhof 1980; area XIX, no 92 (Fig. 10). A circular groove was made with the help of sawing at the butt end, which was broken off from the beam along it (Fig. 10: 3). Traces of circular chopping (Fig. 10: 2) probably indicate a previous unsuccessful attempt to make a groove. The working end is carefully smoothed along its perimeter by longitudinal whittling (Fig. 10: 5) and scraping. The tip is shaped by transversal grinding with fine grained abrasive slab (Fig. 10: 4). Remains of a flat facet on a lateral side of the tool are smoothed by scraping and grinding (Fig. 10: 6). A small facet with step termination runs from the tip along convex side, initial part removed by careful grinding of the convex tip. A short deep facet with step termination runs from the tip (Fig. 6), which is split at this place with a deep crack (Fig. 10: 4-5). A flat scar with feather termination runs along the concave side of tool, smashing its tip (Fig. 10: 7). The tip is compressed and flattened, and multiple cracks are observed at the tip of the tool accompanied by typical linear traces and marks along its sides (Fig. 10: 5-10). Deep scars and pitting on the convex side at a distance of 2 cm from the tip indicate secondary use of the tool (Fig. 10: 11-13). This punch was additionally used as a pressure flaker for retouching flint, probably after it was abandoned as a punch.

- Rosenhof 1980; area XIX, no 75 (Fig. 11). The surface is slightly eroded and the tine was broken off from the beam (Fig. 11: 1). Several small short flat facets with step termination run from elevation of compact layer of antler on the butt end along the convex side of a tool (Fig. 11: 2). The end is carefully smoothed along its perimeter by transverse grinding with fine grained abrasive slab. The tip was round, carefully ground with fine abrasive slab (Fig. 11: 3-4). Typical punch traces are preserved on the convex and lateral sides of the tool, including smashing of the edge of the tip, pitting, multiple crossing grooves and scratches running from the tip and transverse scars left by core platform (Fig. 11: 6-8). Two scars with step termination run along the concave side of tool, smashing its tip (Fig. 11: 4-5).

- Rosenhof 1980; area XIX, no 56 (square 327h) (Fig. 12). The surface lightly eroded and the tine was broken off from the beam (Fig. 12: 1). The

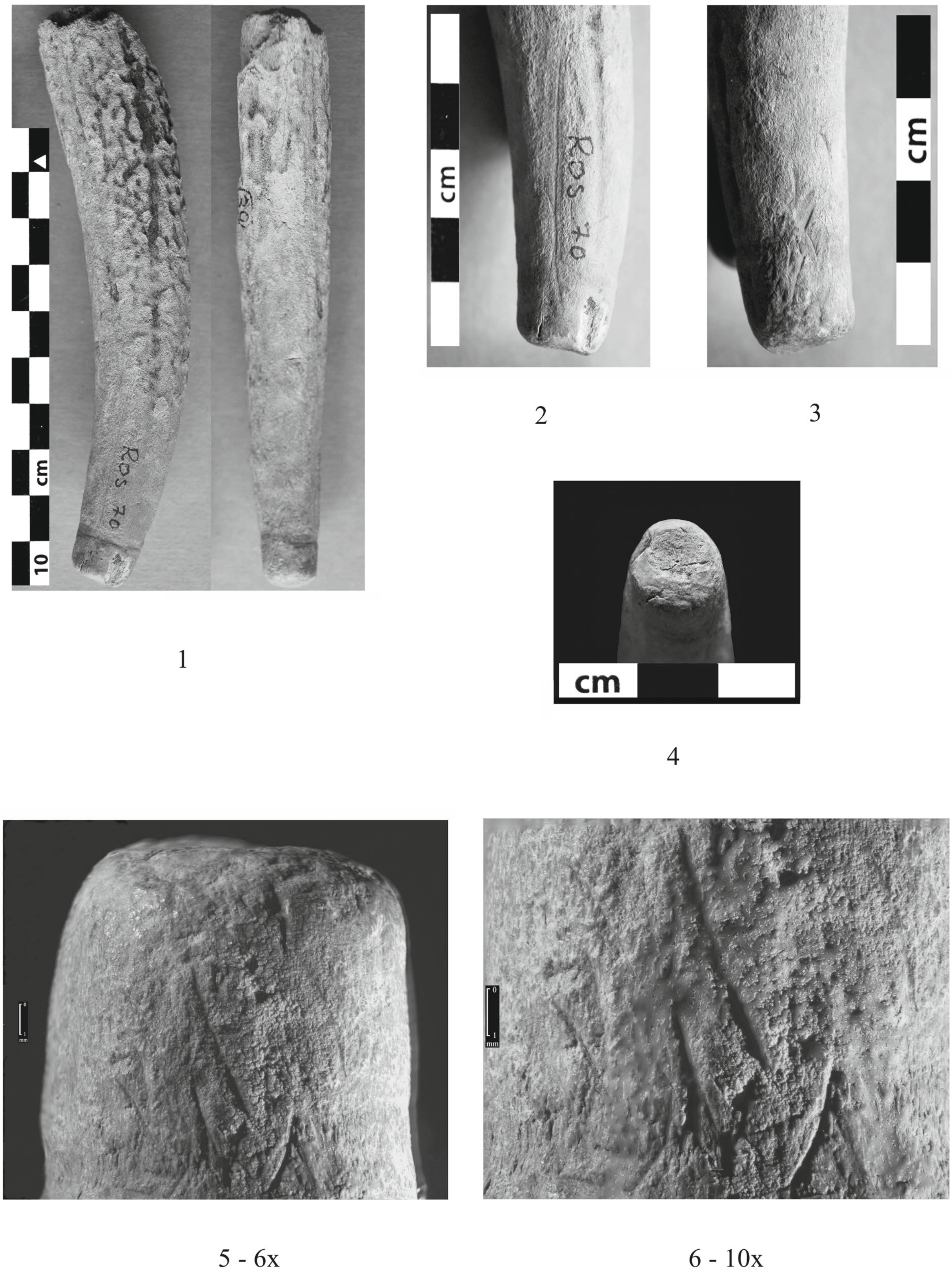

Fig. 8. Punch from Rosenhof (Ros 1970.30). 1 - general view; 2 - tip from convex side; 3 - tip from concave side; 4 - tip from above; 5-6 - use-wear traces on the tip and adjacent areas (5 - 6x, 6 - 10x).

Abb. 8. *Zwischenstück (Punch) von Rosenhof (Ros 1970.30). 1- Gesamtansicht; 2- Spitzenansicht der konvexen Seite; 3- Spitzenansicht von der konkaven Seite; 4- Spitzenansicht von oben; 5-6- Gebrauchsspuren an der Spitze und der umgebenden Fläche.*

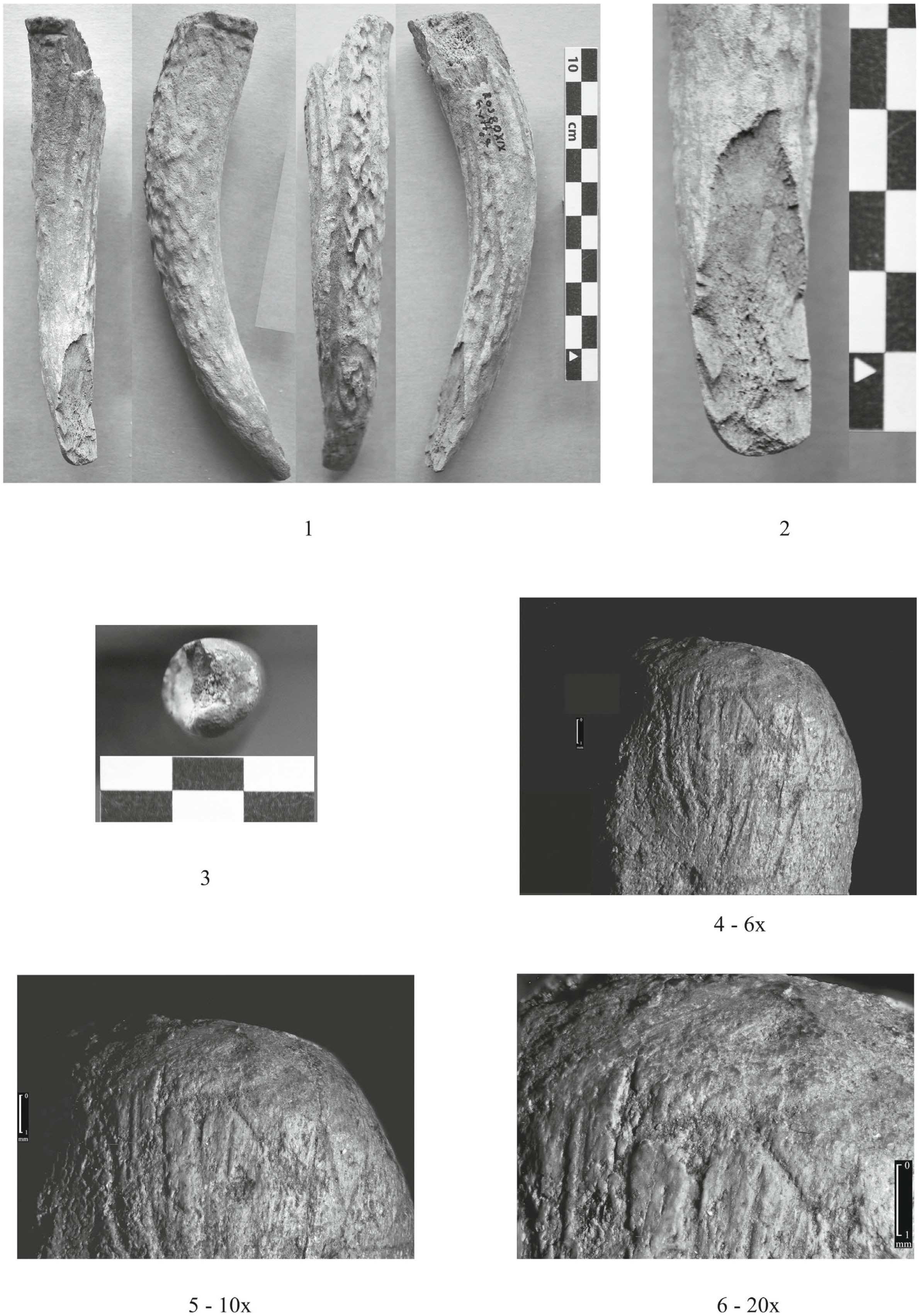

Fig. 9. Punch from Rosenhof (Ros 1980, XIX, 94). 1 - general view; 2 - facet on concave side of the tip; 3 - tip from above; 4-6 - use-wear traces on the tip in various magnifications.

Abb. 9. *Zwischenstück (Punch) von Rosenhof (Ros 1980, XIX, 94). 1- Gesamtansicht; 2- Bruchfacette an der konkaven Seite der Spitze; 3- Spitzenansicht von oben; 4-6- Gebrauchsspuren an der Spitze in unterschiedlichen Vergrößerungen.*

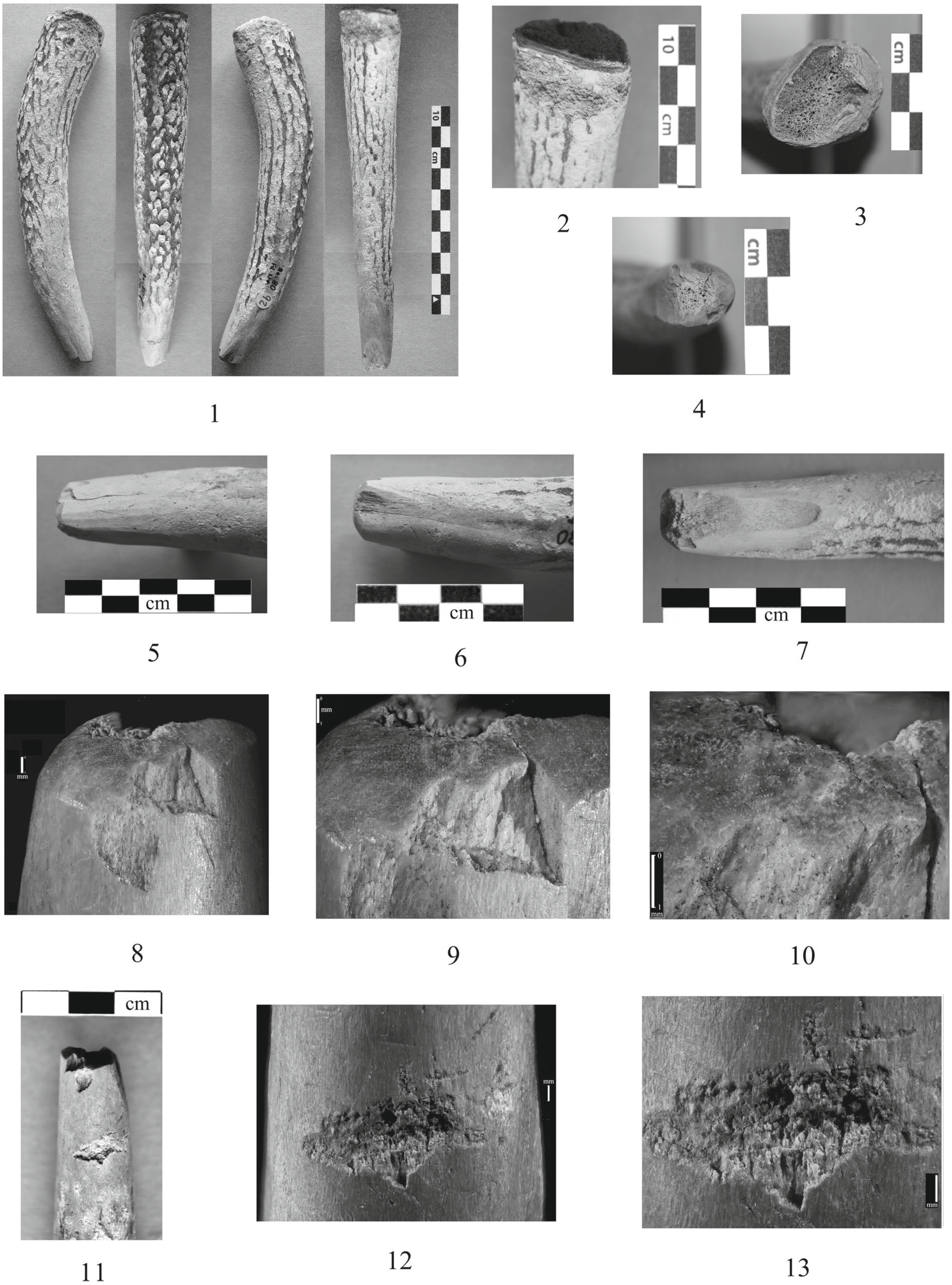

Fig. 10. Punch from Rosenhof (Ros 1980, 92). 1 - general view; 2-3 - butt end; 4 - tip from above; 5-7 - tip from various sides; 8-10 - use-wear traces on the tip in various magnifications; 11-13 - secondary use-wear traces on one side of the working end.

***Abb. 10.** Zwischenstück (Punch) von Rosenhof (Ros 1980, 92). 1- Gesamtansicht; 2-3 abgetrenntes Basalende; 4- Spitzenansicht von oben; 5-7 Spitzenansicht von verschiedenen Seiten; 8-10- Gebrauchsspuren an der Spitze in unterschiedlichen Vergrößerungen; 11-13- sekundäre Gebrauchsspuren an einer Seite des Arbeitsendes.*

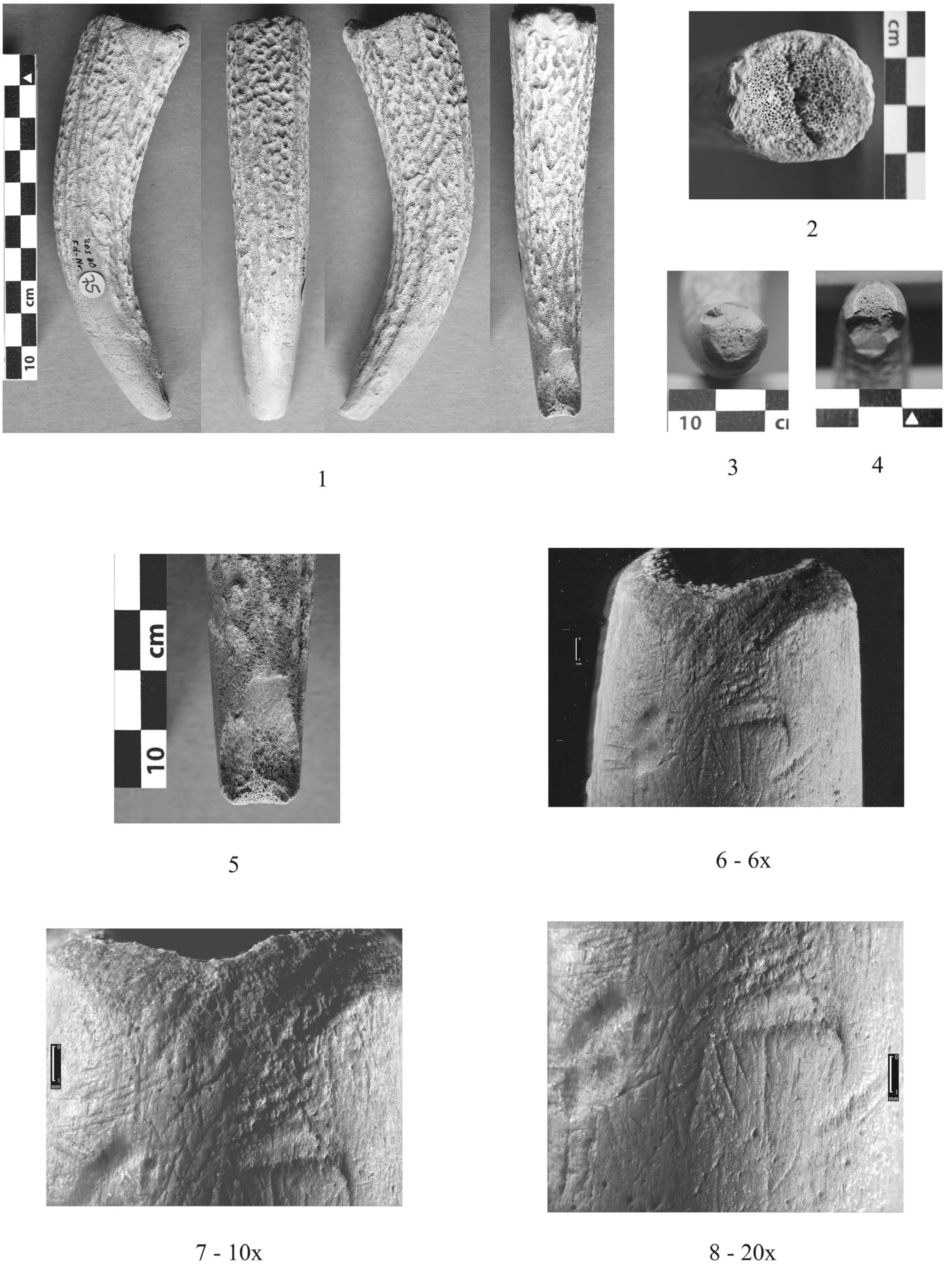

Fig. 11. Punch from Rosenhof (Ros 1980, 75). 1 - general view; 2 - butt end; 3-4 - tip from above; 5 - tip from concave side; 6-8 - use-wear traces on the tip in various magnifications.

Abb. 11. *Zwischenstück (Punch) von Rosenhof (Ros 1980, 75). 1- Gesamtansicht; 2- abgetrenntes Basalende; 3-4- Spitzenansicht von oben; 5 Spitzenansicht von der konkaven Seite; 6-8- Gebrauchsspuren an der Spitze in unterschiedlichen Vergrößerungen.*

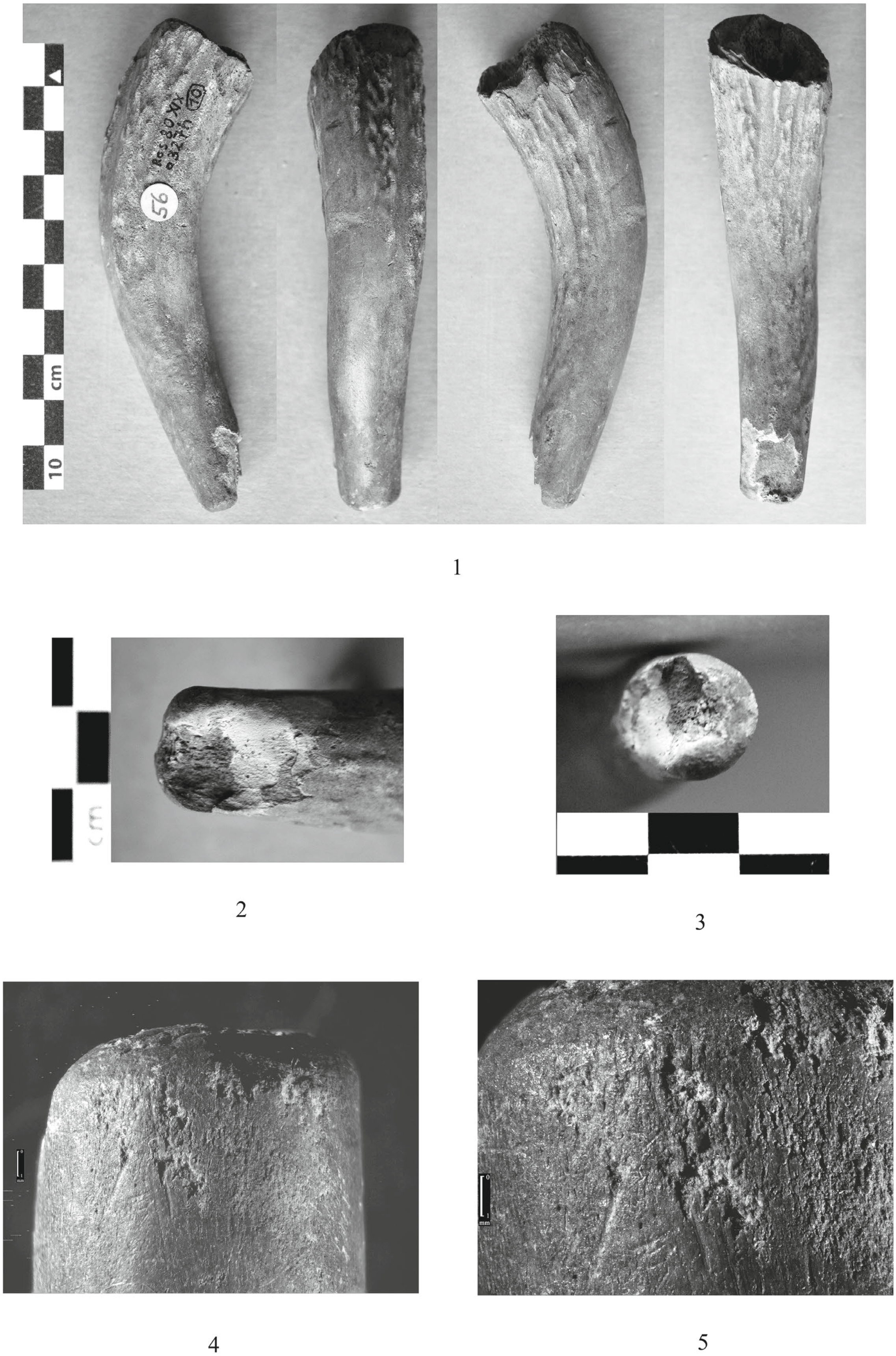

Fig. 12. Punch from Rosenhof (Ros 1980, XIX, 56). 1 - general view; 2 - tip from concave side; 3 - tip from above; 4-5 - use-wear traces on the tip in various magnifications.

Abb. 12. *Zwischenstück (Punch) von Rosenhof (Ros 1980, XIX, 56). 1- Gesamtansicht; 2- Spitzenansicht von der konkaven Seite; 3- Spitzenansicht von oben; 4-5- Gebrauchsspuren an der Spitze in unterschiedlichen Vergrößerungen.*

working end is smoothed by fine scraping and multidirectional polishing. The tip of working end is convex and was ground with fine abrasive slab. Some remains of deep grooves running from the tip are visible on the convex side, and a deep clearly cut groove 25 mm long runs from the tip along the lateral side of the tool (Fig. 12: 4-5). A flat facet with step termination runs from the tip along concave side from the middle of the tip destroying it (Fig. 12: 2-3).

During core reduction tips of punches were reshaped by grinding which partly removed earlier micro and macro traces. The main task of this operation was to remove cracks and restore the shape and size of the working edge. Longitudinal whittling or scraping helped to reshape the tip to its normal size about 10-12 mm in diameter. Such treatment made possible further use of these tools. In some case at the end of the knapping process, the punch was turned. But because of the shape and properties of red deer antler tines a deep crack soon emerged and a flake went off from the lateral or concave side making the tool unsuitable for further knapping.

Repair in this case could not save the tool because a larger portion of the working end should be removed which left the remaining part of a tine with thin compact walls and a diameter of the tip larger than needed. Because of thin walls and thick porous antler core it could not be reduced to normal size and such tool was abandoned. The Rosenhof collection contains punches at different stages of manufacture, use, reshaping and discarding.

Discussion

Antler tools were used for blade production during the Mesolithic over large territories from England to Central Russia. According to recent research (David & Sørensen 2016) in northern European Lowlands indirect lithic blade reduction (pressure technique) could be demonstrated in Star Carr, Sværdborg I, Strandvagen, Agerod I: A, Friesack IV and Dabki 9. Most of these sites are dated to Early and Middle Mesolithic (i.e. Maglemose and Kongemose Culture), whereas Dabki 9 belongs to the Terminal Mesolithic. For the Ertebølle Culture both coastal and inland sites with several antler punches from northern Germany could be added, for instance Rosenhof LA 58 (this study), Wangels LA 505, Neustadt LA 156, Kiel-Ellerbek LA 1, Flensburg LA 105 (coastal sites) and Satrup LA 2, Kayhude LA 8, Bebensee LA 76 (inland sites; Goldhammer 2008, Vielstich 1992, Hartz 2016, Glykou 2016, and unpublished).

In Eastern Europe punches were found at a number of Mesolithic sites such as Zveinieki 2 in Latvia (Zagorska & Zagorskis 1989); Pulli (large bone punch, David & Sørensen 2016) and Kunda Lammasmagi (Indreko 1948) in Estonia; Nizhnee Veretje in the Russian North (Oshibkina 1997); Zamostje 2, Ozerki 5, Okayomovo 5, Ivanovskoye 7, Stanovoye 4, Sakhtysh 9 and 14 in Central Russia (Lozovski et al 2013; Zhilin 2001, ibid. 2012). They played an important role in technological concept from the beginning until the end of the Mesolithic and are characteristic for such cultures as Kunda, Veretje and Butovo.

The main difference between East European punches and artefacts studied in the present paper is that in Eastern Europe they were produced from elk antler, while in Ertebølle Culture they were made from red deer antler. Elk was the main hunted mammal during the Mesolithic in Eastern Europe, while red deer was very scarce or either absent there (Zhilin 2004, 2014). Elk antler normally has straight or very gently curved tines, which were used either with minimal treatment of the working edge, or shaped into massive straight rods with conical tip by longitudinal whittling (Zhilin 2001, 2012; David & Sørensen 2016).

Red deer was actively hunted by the population of Ertebølle Culture, and its antler was widely used as raw material (Glykou 2016). Antler tines artificially detached from the beam are among most numerous organic finds from above mentioned sites. As our study of collections from Neustadt LA 156, Wangels LA 505 and Rosenhof LA 58 showed, some of them have no other traces of any artificial modification at the tip. Most probably these tines could be treated as blanks. Some tines have sharp ends treated by longitudinal scraping and/or whittling, most of them showed no use wear traces. But the major part of these tines display use wear traces, characteristic for punches described above.

Comparison with red deer antler tine tools used for flint working during Early and Middle Mesolithic in Northern Europe (David & Sørensen 2016) shows some common features, but difference is more pronounced. First, no tines with teat like working ends and use wear traces characteristic for pressure sticks, were identified among the collections from Ertebølle sites in Schleswig-Holstein. Second, no elk antler punches were identified, though elk bones are found in small quantities at sites of Ertebølle Culture, for instance in Neustadt LA 156 (1.4 %, Glykou 2016) and Rosenhof LA 58 (1.5 %, Nobis 1975). Third, studied tools from the northern German sites are not made from "almost rectilinear complete antler tines" as observed for Early and Middle Mesolithic punches (David & Sørensen 2016). Instead they are produced from curved tines which are often more than 15 cm long. Fourth, many of the studied punches from the above mentioned Ertebølle sites were turned at the final stage of their exploitation, what led to their unrecoverable damage, which is also not reported for earlier Mesolithic punches.

At the same time punch technique at Ertebølle sites in Schleswig-Holstein follow earlier traditions of indirect percussion technique in selecting tough and flexible raw material as antler, which for the first time came in use during the Late Maglemose Culture. After that it developed strongly for macro blade production during Kongemose Culture in southern Scandinavia (Sørensen 2006, 2017). While the shape and size of the working ends from Ertebølle punches are more or less similar to those from the Kongemose Culture, the tools from this period are in general longer and sometimes more curved than Ertebølle ones. The size, shape and technological features of blades from Ertebølle sites in Schleswig-Holstein correspond well with indirect percussion technique and the use of antler punches (Pelegrin 2006; David & Sørensen 2016).

Conclusions

The study of red deer antler tines from Rosenhof and two other Ertebølle sites in Schleswig-Holstein showed that the majority of them was used as punches for macro blade production. Experiments conducted by the authors and traceological research of 37 artefacts from Rosenhof made possible to reconstruct the mode of their production and use. The tools were made from lower antler tines detached from the beam with the help of breakage; sometimes a circular groove was made at its place with the help of chopping or sawing. The butt end was either not treated, or ground with an abrasive slab. The working edge was carefully shaped in different ways to create a slightly convex round tip with 1-1.3 cm in diameter. During core reduction various use wear traces typical for punch tools such as cracks, pitting, various linear traces and marks appeared on the tip and nearby areas. At the final stage of work the majority of studied punches were turned at 90-180° and broken. Such traces recorded on punches from studied sites correspond well with traces on experimental tools confirming traceological definitions. Comparison with antler flint-working tools from Early to Late Mesolithic sites of Northern Europe showed further development of punches in the Ertebølle Culture. Wide use of punches in the latter is in accordance with the character of flint blades from its sites which served as the main blank for the production of many tool types. The absence of antler pressure sticks in inventories of studied sites corresponds well with the lack of micro blades at Ertebølle sites in Northern Germany.

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