CRAFTING BONE – SKELETAL TECHNOLOGIES THROUGH TIME AND SPACE

Proceedings of the 2nd meeting of the (ICAZ) Worked Bone Research Group

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Special Assemblages

Participants in the WBRG 1999 Budapest conference (left to right): Ülle Tamla, Elisabeth Brynja, Tina Tuohy, Liina Maldre, Karlheinz Steppan, Heidi Luik, Gitte Jensen, John Chapman, Alice Choyke, Janet Griffitts, Andreas Northe, Noëlle Provenzano, Jörg Schibler, Nerissa Russell, Colleen Batey, Lyuba Smirnova, László Daróczi-Szabó, Daniella Ciugudean, Mária Bíró, Kordula Gostenčnik, Eszter Kovács, Christopher Morris, Sabine Deschler-Erb, Ans Nieuwenberg-Bron, Katalin Simán, Isabelle Sidéra, Mickle Zhilin

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Introduction

Archaeologists and Archeozoologists, both study worked osseous materials (bone, antler and tooth, including ivory, in short all referred to as "bone"). Such reports, however, are often buried at the very back of faunal analyses appended to site reports. Furthermore, the two groups of specialists have had little chance to interact, even within Europe since they tend to attend different conferences and write for different fora.

At the root of this problem lay the arbitrary, largely institutional division between pre- and proto-historians, often imposed on bone manufacturing experts by nothing but formalism in research tradition. The most exemplary series of studies n this field is entitled: "*Industrie de l'os neolithique et de l'age de metaux*" (Bone industry *from the Neolithic and Metal Ages*). Another classic, a book, is sub-titled "The Technology of Skeletal Materials *since the Roman Period*". In very early prehistoric assemblages, attention is often focused on the question of whether a particular piece of bone was worked or not. In later assemblages, it is the intensity of manufacturing that often renders objects zoologically non-identifiable, so that important aspects of raw material procurement, including long distance trade, remain intangible.

The history of raw material use, however, is continuous and many of the constraints and possibilities inherent in skeletal materials are the same whether one is dealing with Paleolithic or Medieval artifacts. Indubitably, the organization of manufacture, the function and value of bone artifacts (as well as some technological innovations such as the regular use of metal tools or lathes), differ substantially between simple and complex societies through time. On the other hand, fundamental questions of tensile characteristics, procurement strategies, style and certain technological requirements are not only similar diachronically, but also open up new vistas when apparently unrelated periods are compared. The function of these objects as social markers, for example, remains remarkably constant through time, even if details vary. The papers in this volume reflect these conceptual similarities and differences as did the papers delivered at the conference itself.

The first meeting of what was to become the Worked Bone Research Group (WBRG) was organized by Dr. Ian Riddler in the **British Museum, London, in January 1997**. The committment and enthusiasm of that first workshop has greatly inspired subsequent efforts in recruiting a wide range of bone specialists, capable of contributing to discussions concerning bone manufacturing.

In keeping with the aims of the Worked Bone Research Group, since 2000 an official working group of the International Council for Archaeozoology (ICAZ), an effort was made to present these papers on the basis of what *connects* them rather than segregating them by archaeological period or region. Contributions mostly include articles based on papers delivered in September 1999 at the second Worked Bone Research Group meeting in Budapest, organized by the editors with the unfailing support of the Aquincum Museum (Budapest) and its staff. Several people who were unable to be present at this conference were also asked to contribute papers. Finally, five of the studies in this volume, originally delivered at a symposium on bone tools organized by Dr. Kitty Emery and Dr. Tom Wake, entitled "*Technology of Skeletal Materials: Considerations of Production, Method and Scale*", at the 64th Annual Meeting of the Society for American Archaeology (Chicago 1999), were added thereby expanding the academic spectrum both in terms of research tradition and geographic scope.

There are a total of 36 papers in this volume. Research was carried out on materials from Central and North America to various regions of Europe and Southwest Asia. The authors represent scientific traditons from Estonia, Hungary, Romania, and Russia, European countries in which, until recently, ideas developed in relative isolation. Other European countries represented include Austria, Denmark, France, Germany, Great Britain, Greece, and Switzerland. Last but not least, the North American scholarly approach is also represented here.

Schools of thought may be said to be exemplified by what used to be Soviet research, well known for pioneering works on taphonomy, experimentation and traceology. Bone manufacturing was first brought to the attention of Western scholars by the publication in 1964 of the translation of S. A. Semenov's *Prehistoric Technology*, published originally in 1957. Scholars in France have also carried out decades of co-ordinated work on operational chains in the manufacturing process from the selection of raw materials to finished products, with special emphasis on prehistoric modified bone. An entire working group, "Unspecialized Bone Industries/Bone Modification", is directed by Marylene Patou-Mathis. This working group itself is part of a larger research program on bone industry "*La Commission de Nomenclature sure l'Indistrie de l'Os Prëhistorique*" headed my Mme. H. Camps-Fabrer. Several specialists such as Jörg Schibler in Switzerland, have created laboratories where ground laying work has been carried out for years on worked osseous materials, especially from Swiss Neolithic Lake Dwellings and Roman Period sites. Language barriers have often prevented these important bodies of work from being as widely disseminated as they deserve. Arthur MacGregor in England, writing in English, has had a decisive influence on specialists working on more recent Roman and Medieval worked bone assemblages in Europe.

The work of all of these groups as well as certain individual scholars is well known within limited circles. Otherwise, however, the overwhelming experience of most researchers on worked bone have been feelings of isolation and alienation from most archaeological or archaeozoological work related, most importantly, to the absence of an international forum where their often specialized work can be presented and problems discussed.

In spite of the fact that there have been many practical obstacles to information flow between specialists in this field, there are really remarkable similarities of approach which should ultimately lead to the development of more compatible paradigms in research. Agreement on methodologies will have a positive feedback on communications, helping the field to grow and develop properly.

It seems that, at last, archaeologists and archaeozoologists and other specialists are talking to each other and sharing methodologicial points of view. One striking example of this can be seen in the the emphasis on raw materials studied in parallel to types found in the majority of papers in this volume. Previously studies often concentrated on typo-chronological questions, ignoring the questions of raw material morphology and availability. The series published by the *Centre National de la Recherche Scientifique*, edited by Mme. Henriette Camps-Fabrer in France is largely to be credited for beginning this new trend. It contains many papers concentrating on understanding manufacturing sequences and, indeed, from Europe to North America there are papers which explicitly deal with manufacturing sequences in individual assemblages.

There is also a consistent emphasis on experiment and manufacturing techniques present in much of the work in this volume. The related but fraught question of function continues to tantalize and frustrate most specialists. A number of articles attempt to apply techniques of hard science, such as scanning electron microscopy or light microscopy, together with experiment to get objective, "processual" answers to this important group of questions. Other researchers rely deductively on analogy, archaeological context, gross morphology, and textual sources as they try understanding how these objects were used.

When editing the volume, we tried to concentate on the underlying main concepts represented by each paper rather than grouping them diachronically or by geographical region. As a result, contributions follow a line from the theoretical through the problems of raw material selection, manufacturing techniques, experimental work, technical function and socio-cultural interpretations. Obviously many of these papers deal with several of these aspects simultaneously. Finally, analyses of assemblages are grouped to show the current state of general application of these principles as illustrated in papers in the rest of the volume. Reports on bone tool types will ultimately benefit from more unified typologies and also provide researchers with comparitive databases from regions beyond their own.

Finally, a word on the organization of papers in this volume. Although the editors have tried to group these papers by what they see as the main theoretical and methodological thrust of the authors it should be understood that most papers, to a greater or lesser extent, overlap between these artificial sub-titles. Happily, almost all these works include considerations of raw material exploitation, manufacturing and functional analyses and all make some attempt to consider the social context from which these artifacts emerged. It is exactly this cross-cutting of boundaries which allows us to hope that the study of worked osseous materials is well on the way to developing into a discipline in its own right.

In addition to the generous support given by our sponsors and technical editors for this volume, organizing the conference would not have been possible without the active help of numerous colleagues. Special thanks are due to Paula Zsidy, Director of the Aquincum Museum, Katalin Simán, archaeologist and two students from the Institute of Archaeological Sciences (ELTE, Budapest): László Daróczi-Szabó and András Markó. The Hotel Wien, Budapest and its efficient manager provided a comfortable setting for our discussions at a reasonable price. Last but not least, help with abstract translations by Cornelia Becker, Noelle Provenzano as well as Marjan Mashkour and Turit Wilroy should also be acknowledged here.

EXPERIMENTAL PRODUCTION OF NEOLITHIC BONE AND ANTLER TOOLS

Jörg Schibler

Abstract: In the course of the Neolithic period in Switzerland tools were increasingly fabricated from red deer antler. From the 32nd century BC on, more antler artefacts were produced which served as connecting devices between the wooden haft and the stone blades for axes or hatchets. The Corded Ware culture apparently employed exclusively hafted stone blades. This required intensification in the production of antler sleeves and consequently a greater demand for the raw material and the longer use of each individual sleeve. Experiments show that it is probable that bone chisels were used to work antler and to produce antler sleeves. The experimental production with these chisels led to surface traces that are comparable with those found on the original finds. The intensification of antler sleeve production in the settlements from the 32nd century BC onwards entailed the intensification of use of the bone chisels as well. They were used and therefore also polished more often. On average the chisels in the Horgen and Corded Ware settlements are clearly shorter. The present paper demonstrates that the combination of results from the fields of economic, technological, typological and experimental archeology can lead to new insights in the economic context of prehistoric settlements.

Keywords: Neolithic, Switzerland, production of antler sleeves, multifactorial contexts

Résumé: En Suisse, la fabrication d'outil sur bois de cerf n'a cessé d'augmenter tout au long du Néolithique. A partir du 32e siècle avant J.-C., davantage d'artefacts en bois de cerf ont été produits, servant d'élément intermédiaire entre le manche de bois et la lame de pierre des haches et des hachettes. La culture cordée employa apparemment exclusivement les lames de pierre emmanchées. Ceci appela l'intensification de la production des gaines en bois de cerf et, par conséquence, une plus grande demande concernant cette matière première, ainsi qu'une durée d'utilisation accrue de chaque gaine. Les expérimentations montrent qu'il est probable que des ciseaux en os aient été utilisés dans le travail du bois de cerf et la fabrication des gaines de hache. Les objets expérimentaux produits avec de tels ciseaux portent à leur surface des traces comparables avec celles observées sur les gaines archéologiques. L'intensification de la production de gaines en bois de cerf dans les gisements à partir du 32e siècle entraîna l'intensification de l'utilisation des ciseaux en os. Ils furent usés et ré-aiguisés plus souvent. En moyenne, les ciseaux des stations du Horgen et du Cordé sont nettement plus courts. Le présent article montre que la combinaison de résultats provenant des champs de l'économie, de la technologie, de la typologie et de l'expérimentation peut produire de nouvelles inférences concernant le contexte économique des occupations préhistoriques.

Mots-clés : Suisse, stations lacustres, Néolithique, outils en os, outils en bois de cervidé, production expérimentale.

Zusammenfassung: Während des Schweizerischen Neolithikums wurde Hirschgeweih zunehmend häufiger zu Werkzeugen verarbeitet. Dabei wurden ab dem 32. Jahrhundert v.Chr. immer häufiger Hirschgeweihartefakte hergestellt, welche als Zwischenstücke zwischen Holzholm und Steinbeil bei Äxten und Beilen dienten. Während der Schnurkeramik wurden offenbar ausschliesslich geschäftete Steinbeilklingen verwendet. Dies bedingte eine intensivere Produktion von Fassungen und somit eine stärkere Ausnutzung des Rohmaterials sowie einen längeren Gebrauch jeder einzelnen Fassung. Durch Experimente konnte wahrscheinlich gemacht werden, dass zur Geweihbearbeitung und zur Herstellung von Geweihfassungen Knochenmeissel verwendet worden sind. Die experimentellen Arbeiten mit diesen Meisseln führten zu Oberflächenspuren, welche mit denen auf den Originalfunden vergleichbar sind. Die zunehmende Intensität der Geweihverarbeitung in den Siedlungen ab dem 32. Jahrhunderts v.Chr. führte dazu, dass auch die Bearbeitungsgeräte, also die Knochenmeissel, intensiver genutzt wurden. Sie wurden häufiger gebraucht, also häufiger nachgeschliffen, was zu deutlich kürzeren durchschnittlichen Längen dieser Meissel in den Siedlungen der Horgener und Schnurkeramik Kultur führte. Die vorliegende Arbeit zeigt, dass durch die Verknüpfung von wirtschaftlichen, technologischen, typologischen und experimentalarchäologischen Ergebnissen neue Zusammenhänge im wirtschaftlichen Umfeld von prähistorischen Siedlungen erarbeiten lassen.

Schlüsselworte: Neolithikum, Schweiz, Herstellung von Hirschgeweihfassungen, multifaktorielle Zusammenhänge

Introduction

A large number of Neolithic lake shore sites are known from Switzerland (Hasenfratz & Gross-Klee 1995) and southern Germany (Schlichtherle 1990). These settlements are particularly numerous on the shores of the large lakes on the Swiss plateau: Lake Neuchâtel, Lake Bienne, Lake Zürich and Lake Constance. Further settlement remains have been found on the shores of smaller lakes such as Lake Zug, Lake Pfäffikon, Lake Hallwil, Lake Baldegg and Lake Bürgäschi among others. Bog settlements have also been found, for example in Thayngen-Weier or Niederwil. Artifacts made from animal bone and antler have been found at all these sites (Schibler 1981, Suter 1981 and Schibler 1997). From the 39thcentury BC onwards copper was used in the Neolithic settlements for the fabrication of tools and ornaments (Fasnacht 1995, 183). However judged by the large quantities of bone, antler and flint artifacts, this raw material played a subordinate role.

The settlements from which antler and bone artifacts were found date from between 4300 and 2400 BC.

Due to the excellent conditions of preservation in the lake shore sites organic remains including wood are preserved. These sites can practically be dated to the year by means of dendrochronological analyses. Therefore the relatively exact settlement history can be reconstructed at least for the regions of the larger lakes of the Swiss plateau. The excellent preservation of organic finds also enabled detailed analysis of the plant macro- and microfossils as well as of the animal bones from these settlements. We are therefore very well informed on the ecological and economical environment of the Neolithic settlements especially for the Lake Zürich region (Schibler and Hüster-Plogmann et al. 1997). In Zürich there are also ample stratigraphical sequences from settlement remains of Neolithic villages within which the economic and technological development can be followed. Due to these favorable circumstances the relationship between economy and technology as well as the typological development of bone and antler artifacts can be reconstructed. Furthermore, the well preserved surface of the artifacts allows us to draw conclusions on the manufacturing techniques in particular of antler artifacts and to verify these by means of experimental production.

The importance of animal bone and red deer antler as raw materials for the production of tools and ornaments

In the Zürich region, results on animal bones and on bone and antler artifacts are available from 38 settlement levels (tab. 1). These archeological levels date between 4300 and 2600 BC. There is a long find gap due to unfavorable circumstances of preservation between 3600 and 3239 BC. The period between 3100 and 2700 BC is also insufficiently represented (tab. 1).

If we consider the relationship between bone and antler artifacts within the stratigraphical sequence in Zürich we see that between the 43rd and 32nd centuries BC bone artifacts predominate whereas between the 32nd and the 26th centuries BC antler artifacts do (fig. 1). If we compare the frequency of bone and antler artifacts independently of each other as the percentage of the unworked animal bones and antlers respectively, we find the same result (fig. 2). With this second method the proportion of bone artifacts hardly shows fluctuations; their importance in terms of frequency remains more or less constant. Antler artifacts, however, are better represented in the settlement levels from the 32nd century BC on (fig. 2). Calculations of the bone and antler find concentrations lead to the same results (fig. 3). They are based on the find frequency per square meter and per settlement layer. Because the settlement phases usually fluctuate insignificantly between 15 and 25 years, we consider this means of calculation to be more exact than the find concentrations based on the layer volume. Erosion and level compression have influenced individual settlement levels in different ways so that level volume hardly represents a trustworthy basis for calculation. The bone frequency per square meter and settlement phase is a relative, not an absolute value. This approach leads to the above-mentioned result: Antler artifacts clearly attain greater importance from the 32nd century BC on, while bone artifacts do not fluctuate largely.

The division of antler artifacts into individual typological categories shows that the differences are due principally to the greater frequency of antler sleeves (fig. 4). Antler sleeves were used as connecting and cushioning devices for axes or hatchets between the wooden haft and the blade (fig. 5). The antler sleeves spared the wooden hafts which were time-consuming to fabricate. They prevent the stone blade from penetrating the haft and weaken the shock of the blow on the haft. In earlier Neolithic settlements the stone blades were hafted directly in the wood (fig. 5.1). From the 32nd century BC on, Neolithic craftspeople fabricated axes and hatchets predominantly with antler sleeves. In the youngest settlements of the Corded Ware Culture stone hatchets were fabricated exclusively with antler sleeves (fig. 5.2-7). The demand for red deer antler was therefore especially high in the Corded Ware settlements. Comparison with the archeozoological results, however, shows that red deer bones are not well represented at this time (fig. 2). Hunting alone could certainly not have met the demand for this raw material. Shed antlers must have been gathered as well. Antler sleeves became progressively shorter in the Corded Ware settlements indicating that this was a rare raw material despite these efforts (fig. 6). Repeated sharpening of the stone blades also polished part of the antler sleeve crown away. Therefore, entire sleeve length or the crown length can be utilized as a measure of the use intensity. The results for the most frequent sleeve types clearly show that these became increasingly shorter during the youngest settlement development (fig. 6). They were therefore subject to increasingly intense use. In this phase the production of antler sleeves was so high that red deer antler as a raw material became scarce.

Site	Layer	Culture	Date	Artifacts		Unworked Bones	
				bone	antler	total	identified
Mozartstrasse	1 oben	Early Bronze Age	1609-1502 BC	9	15	2471	1452
Mozartstrasse	1 unten	Early Bronze Age	1647-1628 BC	12	20	3873	2003
Mozartstrasse	1 allgemein	Early Bronze Age		2	17		
Mozartstrasse	1 total	Early Bronze Age		23	52		
Mozartstrasse	2 oben	Corded Ware	2605-2568 BC	305	652	6575	3957
Mozartstrasse	2 unten	Corded Ware	2625-2606 BC	168	211	4622	2556
Mozartstrasse	2 allgemein	Corded Ware		312	1022		
Mozartstrasse	2 total	Corded Ware		785	1885		
Mythenschloss	2 total	Corded Ware	2680-2548 BC	53	?	2542	1345
Kanalisation Seefeld	A	Corded Ware	< 2675 BC	12	49	876	506
Kanalisation Seefeld	B/C	Corded Ware	2685-2679 BC	223	332	3956	2722
Kanalisation Seefeld	D	Corded Ware	2705-2689 BC	199	189	3241	2267
Pressehaus	C2	Corded Ware	2719-2683 BC	7	148	1409	1010
Kanalisation Seefeld	E	Corded Ware	2718-2710 BC	192	345	3018	1714
Kanalisation Seefeld	F	Corded Ware		32	31	510	357
Kleiner Hafner	2A-D	Horgen	2802-2781 BC	4	8	189	80
Kanalisation Seefeld	1	Horgen	< 2887 BC(?)	1	8		
Pressehaus	E	Horgen	appr. 2950 BC	9	6	277	153
Kanalisation Seefeld	2	Horgen	3078 BC	29	58	677	422
Mozartstrasse	3 oben	Horgen		170	189	2997	1642
Mozartstrasse	3 unten	Horgen		44	54	951	646
Mozartstrasse	3 allgemein	Horgen		160	179	2811	
Mozartstrasse	3 total	Horgen	3126-3098 BC	374	422	6759	
Kanalisation Seefeld	3	Horgen	3179-3158 BC	172	93	5078	3486
Pressehaus	G	Horgen		16	15	558	451
Kleiner Hafner	3A+B	Horgen	3242-3201 BC	8	1	180	84
Kanalisation Seefeld	4	Horgen	3239-3201	158	48	1712	1406
Kanalisation Seefeld	5	Pfyn	appr. 3612 BC	30	6	1641	655
Mozartstrasse	4 oben	Pfyn	3613-3600 BC	51	11	2736	1503
Mozartstrasse	4 mitte	Pfyn	appr. 3640-3620 BC	167	35	5414	3301
Mozartstrasse	4 unten	Pfyn	3668-3661 BC	127	40	5029	2866
Mozartstrasse	4 allgemein	Pfyn		284	165		
Mozartstrasse	4 total	Pfyn		629	251		
Kanalisation Seefeld	6	Pfyn	3684-3681 BC	1	0	176	112
AKAD/Pressehaus	J	Pfyn	3718-3683 BC	298	174	12829	7655
Kanalisation Seefeld	7	Pfyn	3719-3686 BC	41	30	1550	970
Kanalisation Seefeld	8	Pfyn	3728-3722 BC	32	11	2023	1064
Pressehaus	L	Pfyn	appr. 3800-3750 BC	33	55	1961	1188
Kanalisation Seefeld	9	Pfyn/Cortaillod	3827-3804 BC	47	169	1953	677
Kleiner Hafner	4G	Pfyn/Cortaillod		8	5	274	149
Mozartstrasse	5 oben	Cortaillod	3839-3834 BC	16	7	725	385
Mozartstrasse	5 unten	Cortaillod	3854-3847 BC	16	10	641	439
Mozartstrasse	5 allgemein	Cortaillod		64	66		
Mozartstrasse	5 total	Cortaillod		96	83		
Kleiner Hafner	4F	Cortaillod		14	7	370	184
Kleiner Hafner	4E	Cortaillod	3865-3845 BC	40	16	723	391
Mozartstrasse	6 oben	Cortaillod	3888-3871 BC	66	20	2037	1264
Mozartstrasse	6 unten	Cortaillod	3908-3906 BC	97	47	3977	2326
Mozartstrasse	6 allgemein	Cortaillod		80	60		
Mozartstrasse	6 total	Cortaillod		243	127		
Kleiner Hafner	4D	Cortaillod		28	20	489	243
Kleiner Hafner	4C	Cortaillod	4105-4085 BC	20	17	386	206
Kleiner Hafner	4A+B	Cortaillod	4125-4115 BC	43	21	1120	513
Kleiner Hafner	5A+B	Egolzwil	appr. 4350 BC	29	5	406	156
Total				3944	4687	94983	54506

Tab. 1 Neolithic sites and layers in Zürich, their dating and their numbers of bone and antler artifacts

Manufacturing techniques with red deer antler

Before sleeves or other tools could be produced the antler beams and tines first had to be detached from one another. Two detachment techniques can be observed on the original finds. The first technique leaves indentations on both sides of the beam and the tines and a thin fracture front on the compacta. The second method using the string-straw technique was used primarily to remove the antler tines. By adding sand and water a string can be used like a saw. The string-saw technique leads to a smooth and polished fracture surface on the compacta. The compacta was never completely sawed through. As soon as the remaining compacta was thin enough the pieces were broken off. The string-saw technique is only rarely documented on our finds. Our experiments with this method showed that at least for inexperienced producers like us, this technique is more strenuous and time consuming. It demanded more people to hold the pieces in place, to saw and to add water and sand. On the other hand, with the indentation technique one person alone could detach a beam or a tine in less time.

In our first experiment we used flint blades to cut an antler into two pieces. It did not take long to realize that it was not possible to cut or saw the antler compacta with flint. As soon as the flint blade entered the compacta somewhat deeper, it got stuck. Further penetration proved impossible.

In a second trial with flint blades the antler beam was indented. This technique proved to be extremely laborious and difficult because the lever conditions were very unfavorable. In addition, this technique did not produce the scale-like indentations observed on the original finds.

As we were also producing bone artifacts, we finally employed a chisel fabricated from a halved red deer metatarsus. This chisel form corresponds to a type found in practically all Swiss lake shore sites (Schibler 1981, types 4/6, 4/12 or 4/13). They were preferentially produced from the halved metapodials of red deer or domestic cattle. The proximal or distal articular ends were often used as the base, however, chisels without an articular end and with a polished base are also frequent. On the original finds the articular ends often display the marks of blows which appear as the compression or the splintering of the compacta. These artifacts have a relatively narrow cutting edge of on average 10 mm (Schibler 1997, fig. 186). Chisels without articular ends (type 4/6) are between 5 and 12 cm long (Schibler 1997, fig. 188). The length of these artifacts, however, has no typological significance, as it represents only the intensity with which they were polished.

With such a chisel (fig. 7), the indentation technique and wooden, antler or stone hammers, we attempted to separate an antler. In order to do so, the antlers should not be dry. We used antlers that were freshly shed or from freshly slaughtered red deer. Desiccated antlers that had been stocked for a longer period of time have to be soaked in water for at least a week or two before use. Written references to the processing of red deer antler are available from the Middle Ages. They indicate that it is advantageous to soak the antlers in a brew. Our experience shows that this is not necessary and that water alone suffices. However, it can not be excluded that Neolithic craftspeople did not also use some kind of a brew.

When these conditions are met, red deer compacta can easily be worked with a bone chisel. The chisel must be applied to the antler surface at an angle of 45° (fig. 8a). Relatively long compacta splinters can be removed by applying strong blows at short intervals on the chisel base with the hammer (fig. 8b). As the antlers progressively dry out, the compacta becomes increasingly brittle, which renders the work difficult. By soaking them in water for a short period of time (about 5-10 minutes) their working can be rendered easier. If two notches are made on both sides of the antler a relatively symmetrical indentation emerges quite soon. After, at most, an hour of work it is deep enough for the antler to be broken in two pieces. Using this method, the traces which arise on the compacta, the indentation as well as the fracture front correspond exactly to those observed on the originals (fig. 9).

Further endeavors to manufacture sleeves from detached pieces of antler beams with bone chisels were also a success. The surfaces of these sleeves could be subsequently processed and the socket in which the stone blade is shafted could be worked out with the bone chisels. We therefore conclude that the regularly and relatively often found bone chisels (types 4/6, 4/12 and 4/13) were important instruments for antler processing and not as supposed in the past, used exclusively for the processing of wood (Becker 1963).

Bone chisels are relatively sturdy. Now and then the chisel edge splinters or fragments after a hammer blow. The damage is then easily repaired by polishing the chisel on a sandstone block. A bone chisel can be employed efficiently and for a long period of time by regular and quick abrading of the chisel edge.

Similar chisel forms were also produced from stone. These stone chisels could also have been used for the production of antler tools. However, they are found much less often in the remains of settlements and therefore it can be excluded that they were the preferred tools for antler processing. The production of the consistently numerous antler artifacts found requires a large number of processing tools. Based on the experiments described above and the frequency distribution of the bone chisels and the antler artifacts it is probable that the frequently found bone chisels were the preferred red deer antler processing tools. As the use of antlers as a raw material clearly increased from the 32nd century BC onwards, we should also expect an increase in the bone chisels. A stratigraphical comparison of the proportion of the bone chisels shows no such obvious increase (Schibler 1997, Fig. 190). If we consider the average chisel length, however, we can observe that it declines in the Horgen and Corded Ware settlements (fig. 10). This indicates intensified abrasion and reuse of these tools in the settlements from the 32nd century BC on.

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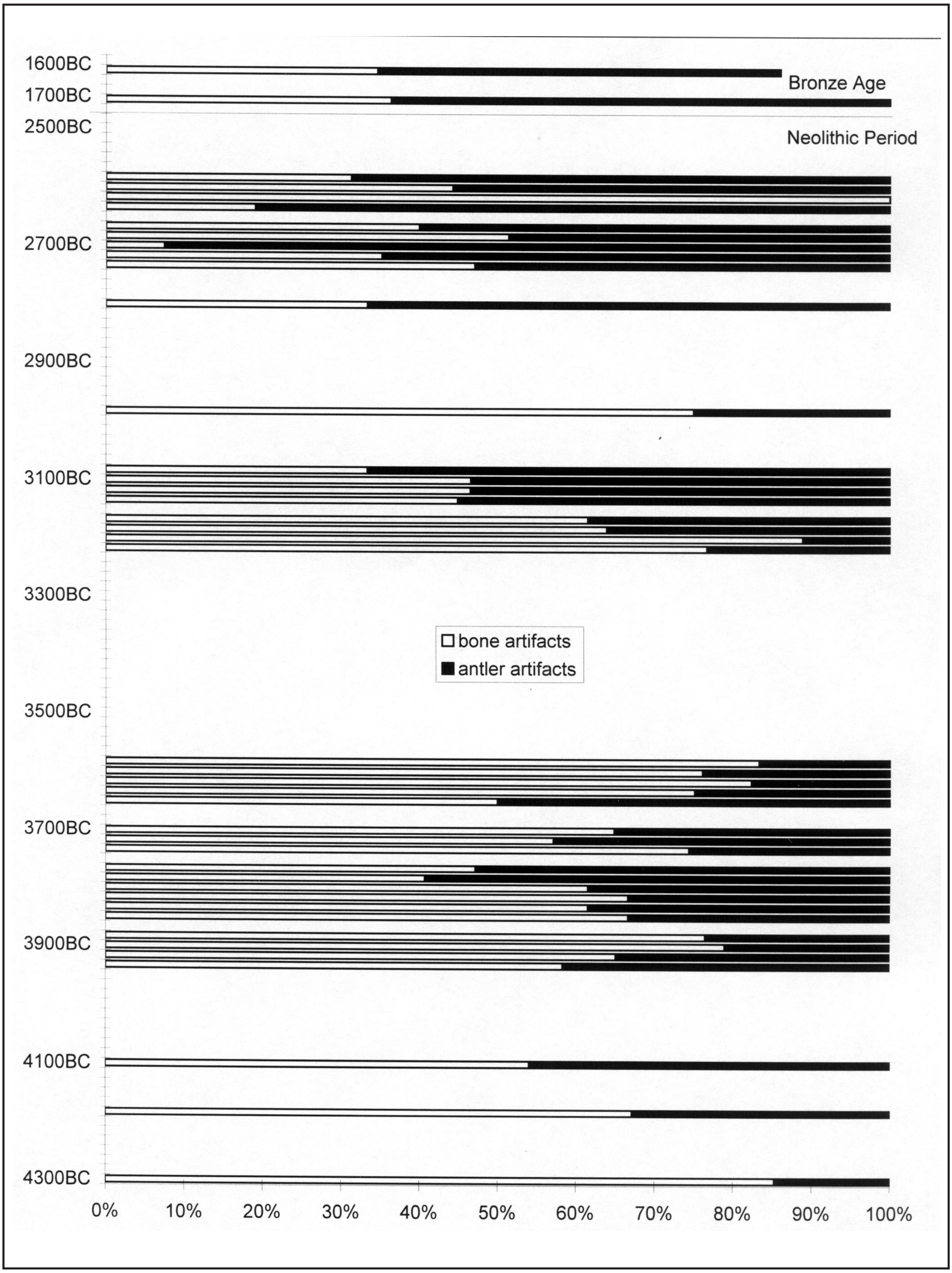

Fig. 1 The relationship between bone and antler artifacts in the stratigraphical sequence between 4300 BC and 2600 BC in Zürich, Switzerland. 100%: bone and antler artifacts (statistical bases: tab. 1)

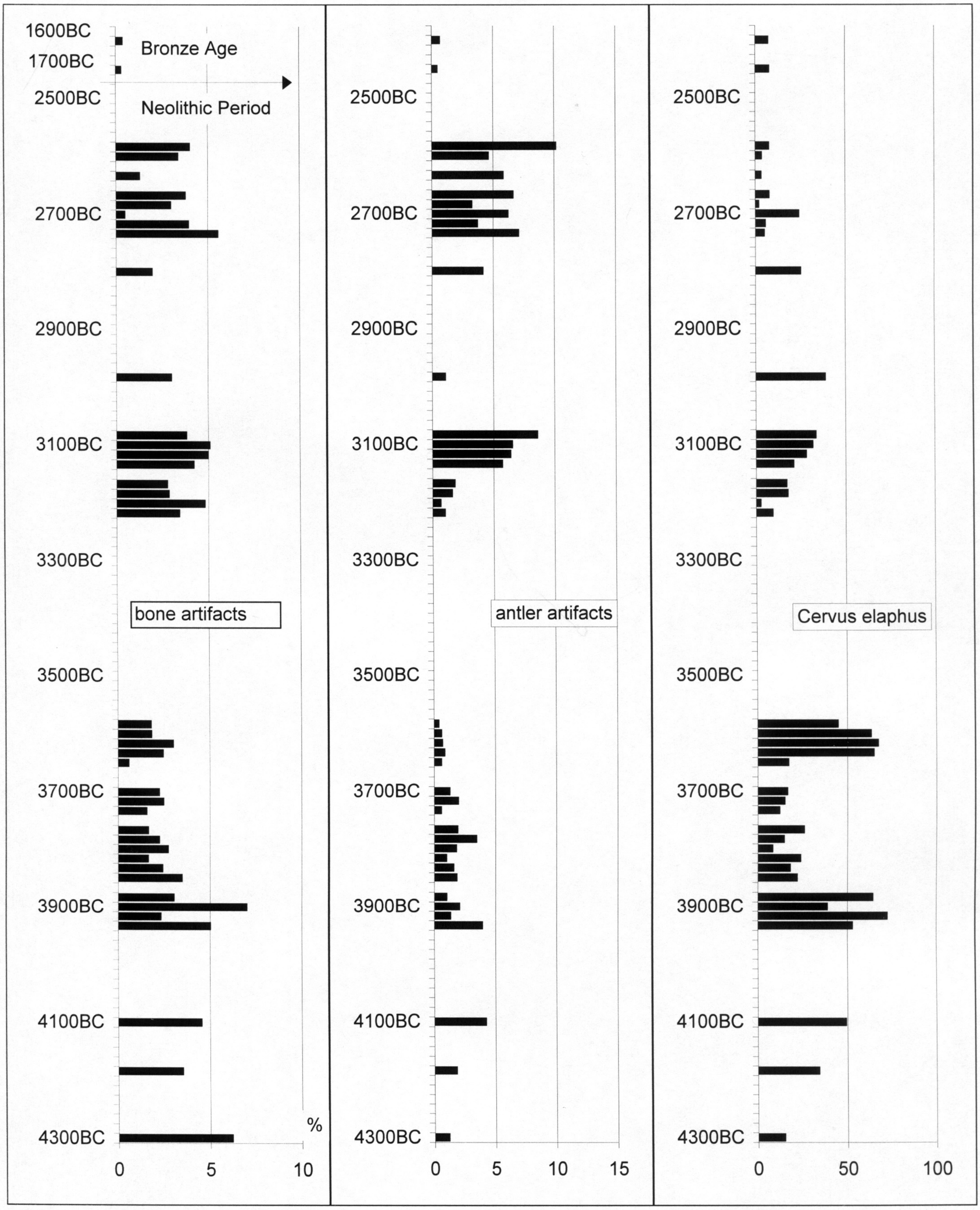

Fig. 2 The frequencies of red deer bones, bone and antler artifacts in the stratigraphical sequence between 4300 BC and 2600 BC in Zürich, Switzerland. For artifacts: 100% are unworked animal bones/antler, bone and antler artifacts; for red deer: 100% are all determined bones (statistical bases: Hüster-Plogmann & Schibler 1997, tab. 1 and Schibler 1997, tab. 16)

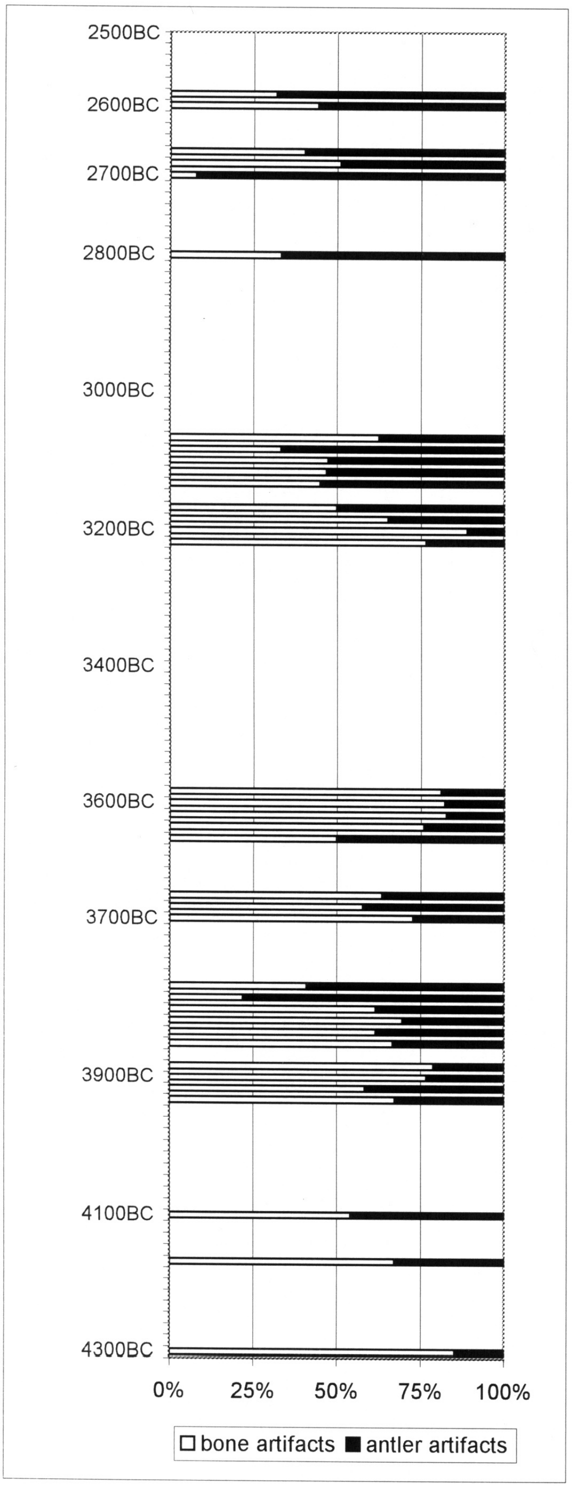

Fig. 3 Relationship between the frequencies of bone and antler artifacts based on find concentrations by square meter and settlement phases in the stratigraphical sequence between 4300 BC and 2600 BC in Zürich, Switzerland (statistical bases: Schibler 1997, tab. 16)

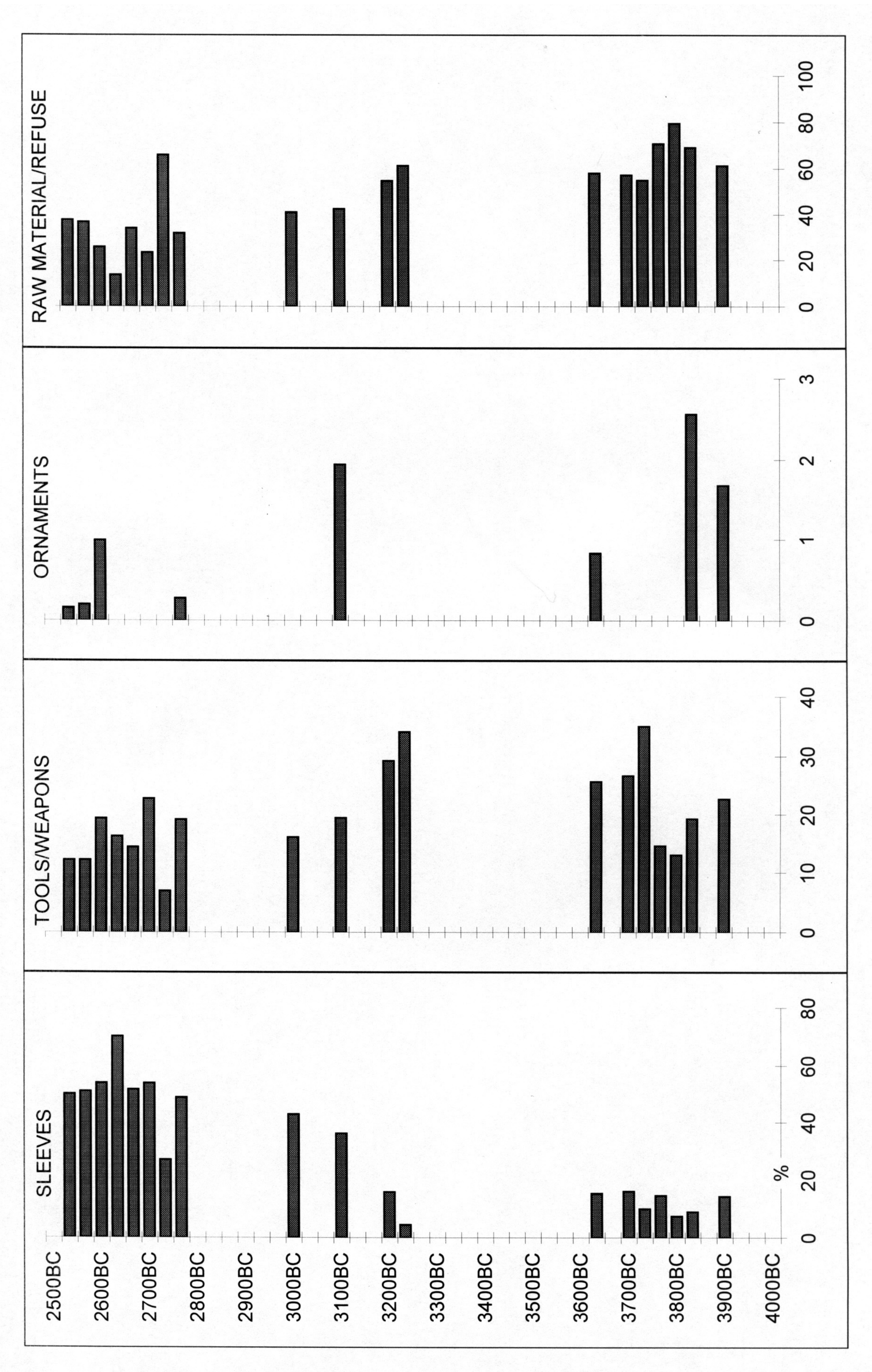

Fig. 4 Frequencies of different typological categories of antler artifacts in the stratigraphical sequence between 4300 BC and 2600 BC in Zürich, Switzerland (statistical bases: Schibler 1997, tab. D 271- D 305)

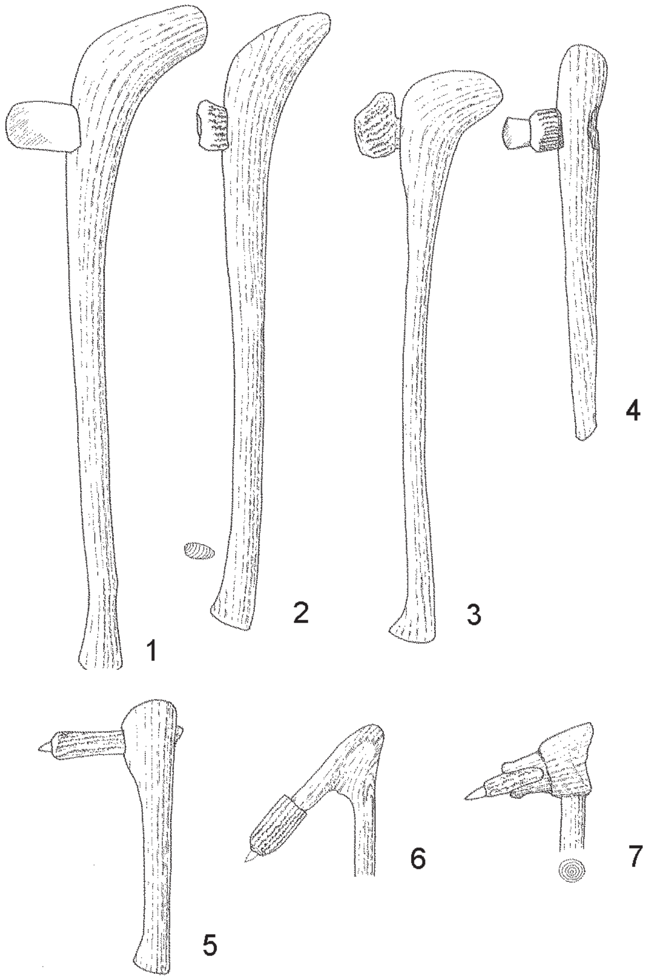

Fig. 5 Different types of axes or hatchets with antler as connecting and cushioning devices between the wooden haft and the stone blade (M 1:8; from Gross-Klee & Schibler 1995, Fig. 98)

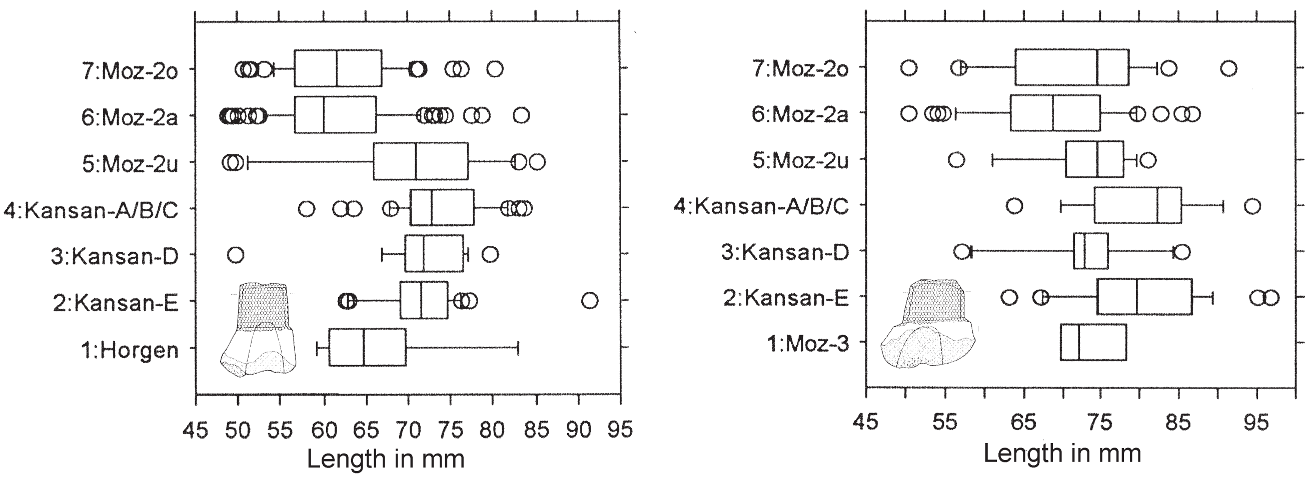

Fig. 6 Average length of two different types of antler blade sleeves made from pieces of beam from different settlement periods in Zürich. The shorter average length in the later layers of the Mozartstrasse settlement (layer 2) prove the more intensive use of the sleeves.
1: Seefeld layer E. 2: Seefeld layer D. 3: Seefeld layers A-C. 4: Mozartstrasse layer 2 unten. 5: Mozartstrasse layer 2 allgemein. 6: Mozartstrasse layer 2 oben (cf. tab. 1)

Fig. 7 Bone chisel (type 4/6 after Schibler 1981) made from a metatarsus of red deer (length: 14 cm)

Fig. 9 Antler beam which was separated in two pieces by using a bone chisel

a

b

Fig. 8 To work antler with a bone chisel, it must be applied to the antler surface at an angle of 45° (a). Relatively long compacta splinters can be removed (b) by applying strong blows at short intervals on the chisel base with the wooden hammer

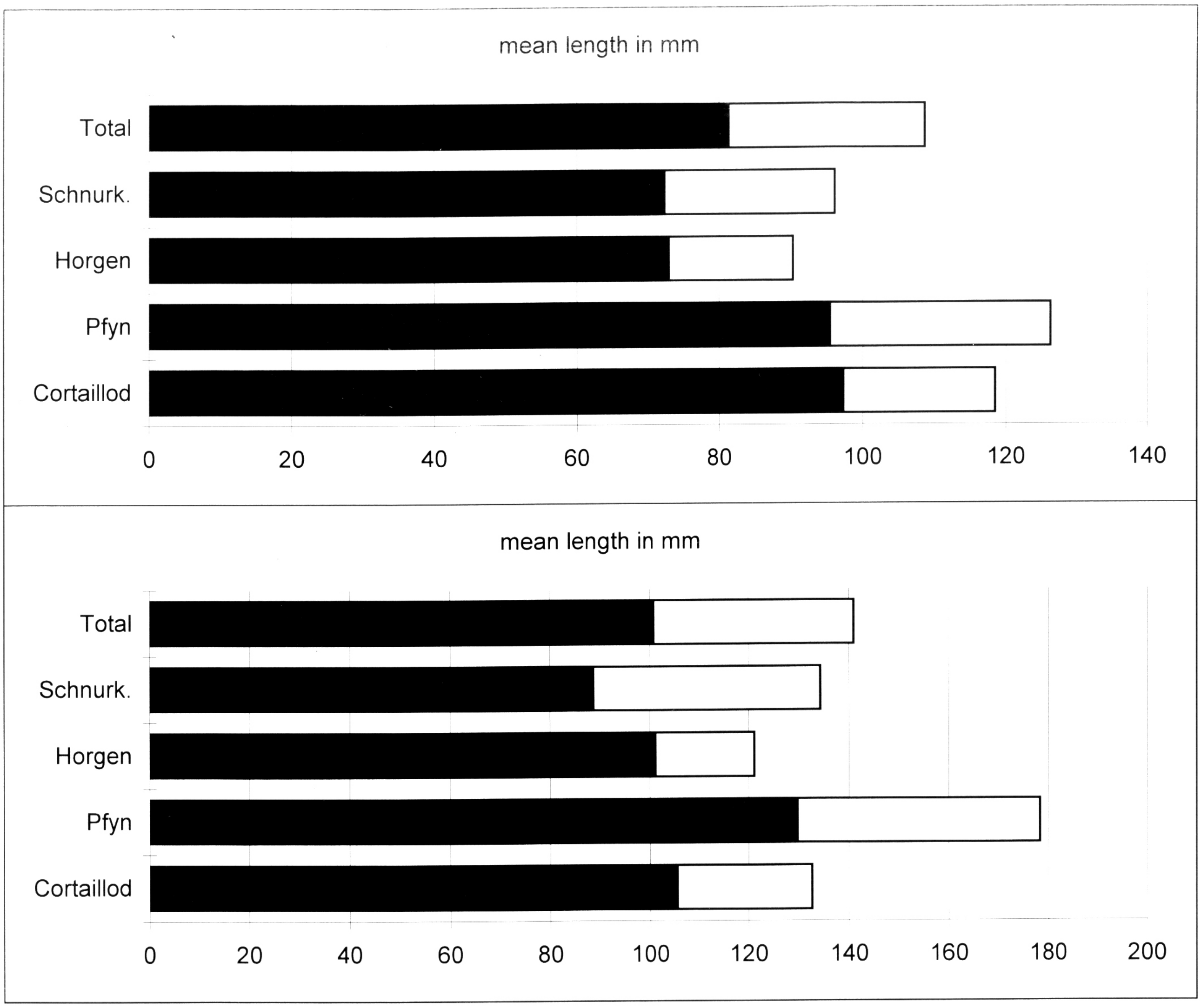

Fig. 10 Mean length of the massive bone chisels (a: types 4/6 without epiphysis, b: 4/13 with epiphysis; after Schibler 1981) found in the neolithic layers in Zürich grouped by cultures (Schnurk.: Corded Ware Culture). Black: mean values; white: standard deviations