3 The experiments

3.1 Introduction

Experiments have played a very important role since people became interested in the function of flint tools. In the 1890's Spurrell had already attempted to replicate the sickle-gloss he observed on Near Eastern blades, as did Curwen in the 1930's (Spurrell 1892; Curwen 1930). Semenov (1964) was, however, the first to incorporate experiments on a systematic basis into his research. Since then, every student of wear-traces starts with a series of experiments in order to become acquainted with the sort of traces that develop. In this chapter, the value of ethnographic information for the research presented here will first be outlined, as well as the role of analogies (*3.1.1*). Subsequently, the limitations and possibilities of experimental archaeology will be discussed (*3.1.2*). In paragraph 3.1.3 a description is given of the experimental procedures followed, after which the actual experiments are outlined. This last part is divided into categories of contact-material. Each section starts with some ethnographic or ethnohistorical information concerning the manner of performing certain tasks, which, it should be stressed, is not intended to be exhaustive. The search for relevant literature concentrated on North-American Indian sources because of a certain similarity in environment and subsistence between source and subject; they are also relatively numerous. To a lesser extent, ethnohistorical data of craftmanship from the Netherlands were examined. Because of time-constraints this latter effort was not carried out in an extensive systematic fashion. Where available the organization of work in terms of scheduling, division according to gender, and specialization was noted. Such detailed information on the organization and procedures of simple every-day tasks is, however, surprisingly rare, especially where it involves flint tools. After the ethnographic information follows a description of wear-traces resulting from contact with the material in question. The last section of this chapter addresses the problem of representativity (*3.12*).

3.1.1 ETHNOGRAPHIC INFORMATION AND MODEL-BUILDING

Ethnographic information lies at the heart of an experimental programme. Although experiments which mainly serve as a simple reference are usually done in a very generalized way, because conditions have to be under control ('cutting' wood, and not the manufacture of a wooden net floater), we can learn much about the range of possible procedures from ethnographies. For example, we can obtain information on the different ways and steps in hide-processing, the desirability to soak antler before working it, or the time of the year when it is most profitable to collect a certain kind of plant. Such knowledge is generally not available in any other way. It has been demonstrated before (*2.2.6*), that an unexperienced way of carrying out experiments can be of great influence on the wear-traces which form on our tools.

Ethnographic information is not only important on the relatively simple level of procedures (resulting in an interpretation of motion and contact-material, i.e. of activity), but also for the reconstruction of tasks which were possibly carried out. Lastly, it can provide clues to build models of, for instance, the organization of subsistence tasks throughout a year (scheduling). We can obtain insight into the possibility of activities being related to each other and the manner in which they might be incorporated into the total culture. In this study, ethnographies have been used in such a way when interpreting the spectrum of inferred activities on a site in relation to other lines of evidence (*chapters 5 and 6*).

There has been much dispute about the validity of ethnographic analogies (a.o. Gould/ Watson 1982). Obviously, we can only interpret the past from our own perspective and this is of course an inductive way of reasoning. Because of the danger of imposing present-day situations upon the past, a number of rules about the use of analogies have been suggested. Firstly, it has been proposed that where continuity between past and present can be demonstrated, the analogy has more validity. These are called direct historical analogies and have played a role, for example, in Near Eastern archaeology (a.o. Kramer 1982). Another restriction which has been suggested is that analogies are more reliable if they derive from societies with an environment, subsistence base and technological expertise presumably similar to the prehistoric situation. A good example of such analogical reasoning is Clark's use of Eskimo society to interpret Star Carr (Clark 1954). In this last example, now much-critized for its simplicity, the dangers even within these restrictions are well-demonstrated.

The New Archaeologists, and especially the 'law and order' variant, have carried the argument even further. They consider the above-mentioned restrictions spurious and missing the essential point: that the use of ethnographic analogies is essentially inductive. They suggested that analogies should serve to formulate hypotheses, to be tested against the data (hypothetico-deductive method). This seems somewhat of a circular reasoning, especially because this testing is usually done only once. I would prefer the suggestion that analogies are a heuristic device. They form an illustration and, in certain cases, the best explanation for the time being. Also, we should perhaps search more for causal regularities and put less emphasis on correlations between observed features, which may be entirely coincidental. A recent approach towards a more valid and profitable use of analogies is the one proposed by Wylie (1982, 1985), who advocates a more dialectical relationship between archaeological data and explanation. More concretely, she argues for a systematic comparison, using a 'game of question-and-answer', of the archaeological configuration we want to understand and various models. These models can be derived from any possible source and are not subject to the recommendation that they must come from a similar environmental or economic context (see above). Wylie considers the archaeological data to be sufficiently powerful and independant, that they can adjust or falsify certain explanations.

3.1.2 EXPERIMENTS AND THEIR ROLE IN ARCHAEOLOGICAL REASONING

Experimental archaeology is a method of evaluating the plausibility of various explanations of specific, well-defined archaeological situations. As for archaeology in general, it is concerned with assessing the relationship between human behaviour and its material correlates (Ingersoll/ Macdonald 1977: XI). With much of traditional archaeology it shares an emphasis on those aspects of human behaviour considered to be most easily approached, that is technology and subsistence (i.e. Hawkes' (1954) 'first ladder of inference'), where the principle of actuality applies.

Experimental archaeology concerns a wide variety of topics (in fact all of our archaeological subject matter), everyone of which requires a different approach. The best-known experiments are the replicative ones such as flint knapping (with Crabtree as its most prominent practitioner), those assessing the efficiency of certain technological features such as silos, and those addressing questions concerning form and function. The latter experiments serve to strengthen simple formal analogies (Hodder 1982), and are pertinent to the research presented in this volume. Other approaches include the agricultural experiments at farms such as Lejre and Butser, which deal with a variety of archaeological problems, albeit almost always directed at technology or subsistence. All these examples share the fact that they involve an experiment which tests a hypothesis related to a specific problem; this means that one or more variables, which are assumed to be relevant, are controlled. It should be clear, however, that experiments can never be conclusive and cannot be considered proof, however much our hypothesis seems to be 'confirmed'. If the number of corresponding attributes between experimental and archaeological object or situation is high, then, at best, we can conclude that there is a high probability that similar causative factors operated. Obviously, it cannot be excluded that other factors had been responsible for the combination of attributes being investigated. On the other hand, experiments can certainly exclude certain possibilities and therefore narrow down the number of possible interpretations.

Coles (1973) emphasizes the need for corroborative evidence from the field of ethnography. However, I would suggest that such evidence must firstly come from the archaeological context: for example, the location in which an artefact has been found, or the association of different find-categories. Ethnographic descriptions should instead be considered as a source of inspiration. The combination of ideas derived from ethnographic sources and the archaeological context could suggest a number of possible experiments. The result of these experiments can subsequently be evaluated in the light of, for instance, the character of the wear-traces present, their distribution, or the 'efficiency' of the tool.

In use-wear analysis, experiments have mainly served as a reference. In a large collection of experimental pieces a number of variables can be controlled, and confronted with archaeological specimens. Every use-wear analyst begins by setting up such an experimental programme, which controls for variables as raw material, form of the tools, type and state of the contact-material, intensity and direction of motion; these are called generalized experiments, forming the basic reference collection. When subsequently examining an archaeological assemblage, one can recognize areas of use and often interpret the contact-material and motion (i.e. the activity) involved, because of similarities in traces between experimental and archaeological tools.

When no experimental tool in the existing reference collection displays the combination of attributes observed on the archaeological implement, additional experiments must be performed. Clues as to which activities might have taken place at a site come from the archaeological context (a.o. palaeobotanical or archaeozoological data), while ethnographic sources are a potential source of inspiration about possible procedures. An example of such a problem-oriented experiment is presented in chapter 5 and concerns the search for the activity which caused polish '23' (*5.4.2.7*). Theoretically, we should conduct such problem-oriented experiments for every artefact we cannot interpret in terms of function on the basis of the existing reference collection. We should also continue to modify these experiments until

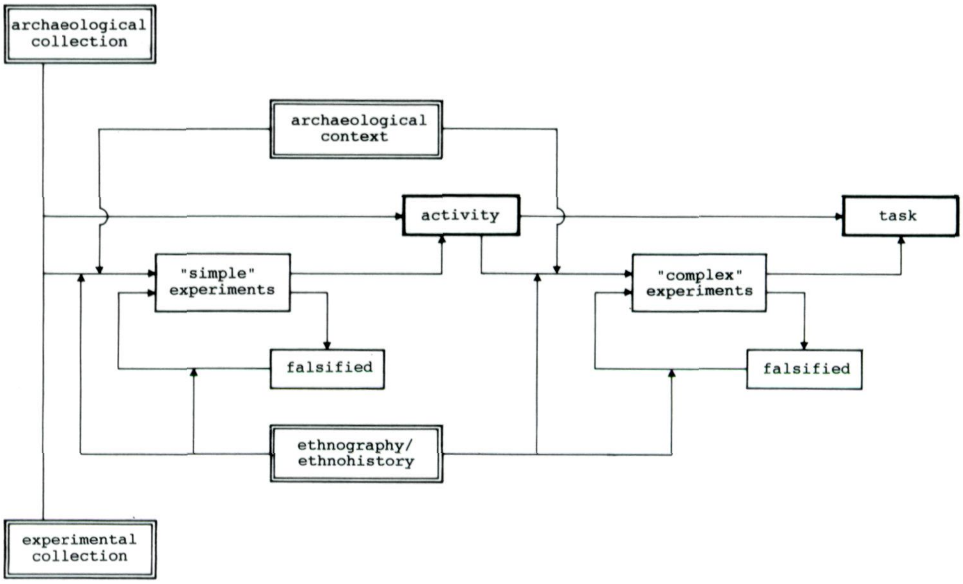

Fig. 11 Lines of reasoning in the interpretation of tool function, incorporating ethnographical or ethnohistorical information and archaeological context.

the wear-traces on experimental and archaeological tool match in every respect. In practice, this is clearly impossible because of the amount of time involved, and we are obliged to state the function of a tool as unknown. A search as described above is only worthwhile when one finds unknown but characteristic wear-traces on a group of tools from an assemblage.

Being able to interpret the activity in which a tool was used, does not necessarily mean that we have inferred the exact task which was performed. To do this, it is crucial to have corroborative evidence from the archaeological context from which the tools derive. For example, at Hekelingen III a number of tools was present with traces interpretable as being the result of bone-carving (contact-material and motion, i.e. activity). Only in combination with Maarleveld's (1985) inferences concerning bone awl and chisel manufacture, was it possible to provide an interpretation of the exact task in which these flint tools were involved (see *6.2.3.2*). Another example is drawn from the bead workshop at Kumartepe in Turkey, where flint borers have been found amidst a large quantity of shell-fragments and pre-fabs for shell beads (Calley/ Grace 1988). In such a case, the archaeological context suggests which experiments to carry out, whereas ethnoarchaeological information provides clues as to how to perform them. If the wear-traces observed on the experimental and archaeological tools exhibit sufficient similarities, we can infer with reasonable confidence, not only that the borers were used to drill shell, but that they served in the manufacture of shell beads. The first inference is limited to contact-material and motion (i.e. activity), the second specifies the task (see *fig. 11*). Usually, we do not know enough of the context to make such a detailed statement.

3.1.3 EXPERIMENTAL PROCEDURES

In the preceding paragraph it was outlined that a reference collection consists of two sets of experiments, the generalized and the problem-oriented ones. The first set concerns experiments which control for factors as motion, contact-material, duration and raw material type. They serve to monitor the development of the wear-traces according to these variables and as such function as a basic reference data-set. These experiments have the additional function to become accustomed to working with a flint tool, and realize its limitations and possibilities. It is also important to determine the specific morphological characteristics of edges which are the most appropriate for specific actions, something which can, at least partially, only be assessed experimentally.

The generalized experimental set includes transverse motions such as whittling, scraping and shaving, diagonal ones as splitting and carving, longitudinal actions as cutting and sawing and boring. Contact-materials include bone (fresh, soaked and dry), antler (in soaked or dry state), several species of wood (fresh, soaked and dry), hide in various states and with different additives, soft plants and cereals (together, more appropriately called herbal plants), shell, teeth, limestone, fish and meat. Duration of work varied from three minutes to five hours. Raw materials used for the experimental pieces were Rijckholt flint (both coarse- and fine-grained varieties), fine-grained moraine (northern) flint (mainly Senonian), flint from Kristiansstad (Sweden), from Cap Blanc Nez near Boulogne-sur-Mer (France), and North Sea flint recovered during dredging operations. For a description of the experiments the reader is referred to appendix II. At first, these generalized experiments were done without any practical background knowledge. As time passed, ideas, derived from ethnographic sources (mainly American Indian ones) and ethnohistory (Dutch context), were incorporated in the experimental procedures. This resulted in an increased verisimilitude. Nevertheless, there is of course no guarantee that they replicated the prehistoric way of doing things.

A small number of experiments was done with a machine devised by Prof. Dr. Ir. A. Wegener-Sleeswijk (Rijksuniversiteit Groningen) for Paula Bienenfeld (Bienenfeld 1986). This machine is capable of performing transverse and longitudinal motions on hard materials such as wood or bone, while controlling number of strokes and pressure exerted. The great advantage of such a machine is the strict control one has over various variables, specifically in the case of exerted pressure, as this factor is almost impossible to quantify when experiments are done manually. This way, one can relate these variables to questions about wear-trace formation. Obviously, it is important to address this question in a systematic, mechanised way, but as this study mainly has an archaeological rather than a methodological emphasis, it was decided to further omit the machine-driven experiments because the procedure bore too little resemblance to how we think people would have worked.

The problem of verisimilitude between the archaeological and the experimental situation becomes especially acute when it comes to skill. The most frustrating aspect of doing experiments is our lack of expertise. When addressing a specific problem, such as bone tool manufacture or bead-making, and when able to concentrate on this aspect only, it is possible to gather experience in due time. The problem with use-wear analysis is that, when we want information on entire sites, one is obliged to attempt to replicate a score of different tasks, some of which might, in prehistoric times, have been the work of specialist craftsmen. Otherwise, research is limited to questions concerning tool form and function. It goes without saying that we do a very bad job on most tasks. This became especially clear to me when I did butchering experiments in collaboration with Henk Nijland (Rijks-Instituut voor Natuurbeheer, Arnhem). Nijland is dissecting animals on a daily basis and the flint tools he used (he found them as effective as steel counterparts) displayed very few wear-traces compared to the ones I employed in the butchering process. This is clearly a matter of experience, but it has important implications for the interpretation of wear-traces on archaeological tools, especially regarding duration of use. It is misleading to infer the duration of use of archaeological artefacts on the basis of our own experiments. Instead, it would be more appropriate to infer intensity of wear, regardless of whether this is due to a longer working period or lesser skill (see also *2.2.6*). It should be remembered, however, that use-wear analysis is a very young discipline; in due time the experiments will hopefully bear more resemblance to the prehistoric situations, both in terms of procedures used and in amount of skill. When experimental collections are kept intact and stored in accessible places, it will become less and less necessary for new students in the field to perform the time-consuming generalized experiments. Instead, new researchers can immediately concentrate their efforts on specific issues and because of this specialisation, perform their experiments with greater skill.

3.1.4 QUANTIFICATION OF WEAR-ATTRIBUTES

In the early years of microwear analysis, little thought was given to the question of representativity of the activity-spectrum inferred from the wear-traces. Often this was taken at face-value. Not only was too little consideration paid to the effect of taphonomic processes, but it was also insufficiently realized that wear-traces do not develop on a 100% basis. Here taphonomic processes will not be dwelt upon (they will be discussed in the chapters dealing with the various sites, *chapters 5 and 6*), but rather the representativity of the wear-traces themselves. Keeley (1980) already noted that soft materials, such as meat, leave few traces, which are moreover difficult to interpret. Recently, more attention has been given to this aspect, not least because of the results of blind tests (a.o. Unrath et al. 1986). A few researchers have attempted to simply count the frequency of attributes characteristic for specific contact-materials. Vaughan (1985a) investigated a variety of materials, Van Gijn (1986a) considered traces of fish polish, and Fisher et al. (1984) analyzed arrow heads. In a recent study, Sussman (1988) has provided a system for the quantification of wear-attributes on experimentally-used quartz tools; Knuttson (1988: 65) has done the same, but in a less detailed fashion.

It was decided to contribute to the investigation of this methodological problem by counting how often attributes, considered 'typical' for certain contact-materials, developed on experimental tools. Generally speaking, the experimentally induced traces were described according to the same system as used for the archaeological ones (see *appendix I*). In appendix II the descriptions of all 301 experiments are provided. On the basis of these tables, calculations were made as to the frequency of various attributes considered to be characteristic of specific contact-materials. These results will be presented in the following pages.

3.2 Hide-working

3.2.1 ETHNOGRAPHIC ACCOUNTS

Ethnographic descriptions of hide-processing are relatively numerous, especially for the North-American Indians.

Unfortunately, exact procedures and, especially, terminology are not always clear. No instances were found in which mention was made of the time which the various stages of hide-working involved.

A skin consists of two layers: the epidermis and the corium or dermis. The *epidermis*, the outer layer, contains the follicles from where the hairs grow. To make leather, this layer, along with the hairs, must be removed. Underneath we find the *corium*, which is the part that is tanned. It can vary in thickness depending on its anatomical location. The lower part of the corium is formed by a membrane which is sometimes referred to as the *subcutis*. It consists of fatty tissue which interferes with tanning and must therefore be removed (Stambolov 1969).

Many animals, such as deer and elk, have very little subcutaneous fat; their skins can be dried immediately without the need for extensive scraping (see for instance the Cocopa, as mentioned by Gifford (1934)). This differs from fur-bearing animals such as bears and foxes, whose skins are covered with fat and moisture when removed from the carcass. My own experiments and those of others (Brink 1978b) suggest that the removal of this fat is only possible, or in any case is greatly facilitated, when abrasives are added to absorb the moisture. After the 'fresh hide' scraping, skins are usually dried. To do so they may be staked hairside down onto the ground and exposed to the sun. Skins dried in such a way can be stored for a long time, allowing the postponement of the tanning-process. This is important because the best time to take animals for their hides is usually early autumn. This applies especially to animals such as deer, elk and caribou. Spiess points out that the caribou wintercoat is too heavy for making clothes, while the spring and summer coats are unsuitable because of shedding; during late summer the caribou skin is eaten by larvae (Spiess 1979: 30). As early autumn is exactly the time when food needs to be gathered and prepared for storage during winter, it seems likely that no time would be left to go through the tedious process of tanning the hides. Among the Copper Eskimo, processing hides is a typical winter task (Jenness 1970). Of course this schedule is different for the fur-bearing species as these are most profitably taken in winter and must be stripped from their subcutaneous fat immediately after killing.

Not all skins are preserved with the hairs attached: for making leather they have to be removed. To depilate, the skin is soaked in warm water to allow bacterial growth. Sometimes ashes or stale urine (as among the Eskimo) are added to further the process. In any case, a pH of 12 or above is needed (Stambolov 1969). After soaking, the hair is removed by scraping with a stone (Tanaina: Osgood 1937). The depilated skin must be thoroughly washed and de-alkanized by, for instance, the use of animal dung.

Experiments have shown that, while the subcutis is almost impossible to remove while the hide is fresh, it can be rubbed off when the hide is dried. In fact this can easily be done with, for example, a rough sandstone (H.Plisson *pers. comm.*). Dried hides must subsequently be soaked. It requires about 2-3 days for sufficient swelling to take place to allow the penetration of the tanning agents (Stambolov 1969). Among the North-American Indians brains or liver constitute important tanning agents. After soaking, or, for that matter, when still fresh, the hide is rubbed with brains among the Tanaina (Osgood 1937), and the Plains Indians (Lowie 1954). Alternatively, the brains were dissolved in hot water, and the hide was left in this solution for some time. This practice has been reported for the Cocopa (Gifford 1934), the Surprise Valley Paiute (Kelly 1934), and the Hopi (Beaglehole 1936). Kelly notes that, if brains are put between white cloth and hung outside to dry, they can be kept for a long time. Birch bark is also reported to be able to preserve brains for an extensive period (Densmore 1928, describing Chippewa Indian hide-processing practices). It is generally assumed that the amount of brains required to tan a hide, corresponds with the size of the brains of the animal in question (Witthoft 1958). During tanning the hides are regularly 'worked', sometimes with a smooth stone as among the Plains Indians (Lowie 1954). Subsequently, the hide must be washed and dried. A softening process usually accompanies the drying. Softening is done by rubbing the skin with a rough-edged stone (Plains Indians), or by pulling the skin over a beam to loosen it while it dries (Cocopa). A well-known process is the chewing practised by Eskimo women (Balikci 1970). Sometimes fish oil is added as a softener as among the Tanaina (Osgood 1937). Much of the above refers to animal tanning agents, which are most common among American Indians. It should be stressed however that vegetal tanning, with, for instance, an extract of oak- or birch bark, is frequently used as well. It would definitely be worthwhile to investigate such methods and perform experiments with these tanning agents.

The final process to which hides may be subjected is smoking. It is often assumed that this is simply a way of colouring the hide, but it also has a tanning effect. In addition, smoking causes the hide to remain soft, irrespective of exposure to moisture, which is important, for instance, when used for mocassins (Lowie 1954).

From this description a few things can be concluded. First of all, fresh hide scrapers *per se* might not exist, because either the skin comes off clean enough for processing (apart from having to remove the subcutis), or, in the case of fresh bear and fox hides, absorbants may be added to deal with the moisture, having the additional effect of abrading the working-edge of the tool. Secondly, although scrapers are often used in the softening stage of hide-processing, i.e. as dry hide scrapers, this task can also be performed in other ways, for example by pulling the hide over a wooden beam.

Thirdly, the number and variety of tanning agents and other additives is quite considerable, and it is likely that associated wear-traces display great variability.

3.2.2 WEAR-TRACES FROM HIDE-WORKING

Both fresh and dry hide experiments were done. As was discussed in the preceding paragraph, this distinction is somewhat misleading, not least because fresh hides dry out during working, resulting in 'dry hide'-like wear-traces (e.g. exp. 226, 227, 230, 272). A total of 49 experiments was done with hide (see *appendix II, table 1*), involving Rijckholt, Cap Blanc Nez and northern flint. Motions included boring, cutting, scraping (with various preservative agents), and skinning. Total experimental time amounted to 24 hours and 27 minutes.

Edge-removals occurred in only five instances: three with dry leather, two with fresh elephant skin. The retouch was scalar, with a deep initiation and a hinged or feathered termination. The degree of edge-rounding was variable: moderate to heavy rounding was more frequent on scraping tools than on cutting or boring implements. There does seem to be a correlation between the dryness of the hide and the degree of edge-rounding: scraping dry hide and scraping dried-out fresh hide both produced this feature (see below). However, this observation also implies that we cannot deduce dry hide scraping as a task from a heavy rounding of the edge.

Polish developed on 32 of the 49 tools (65%). Boring resulted only once in a polish. In most cases (N = 17) the polish was distributed in a band along the edge (*figs. 12a,*

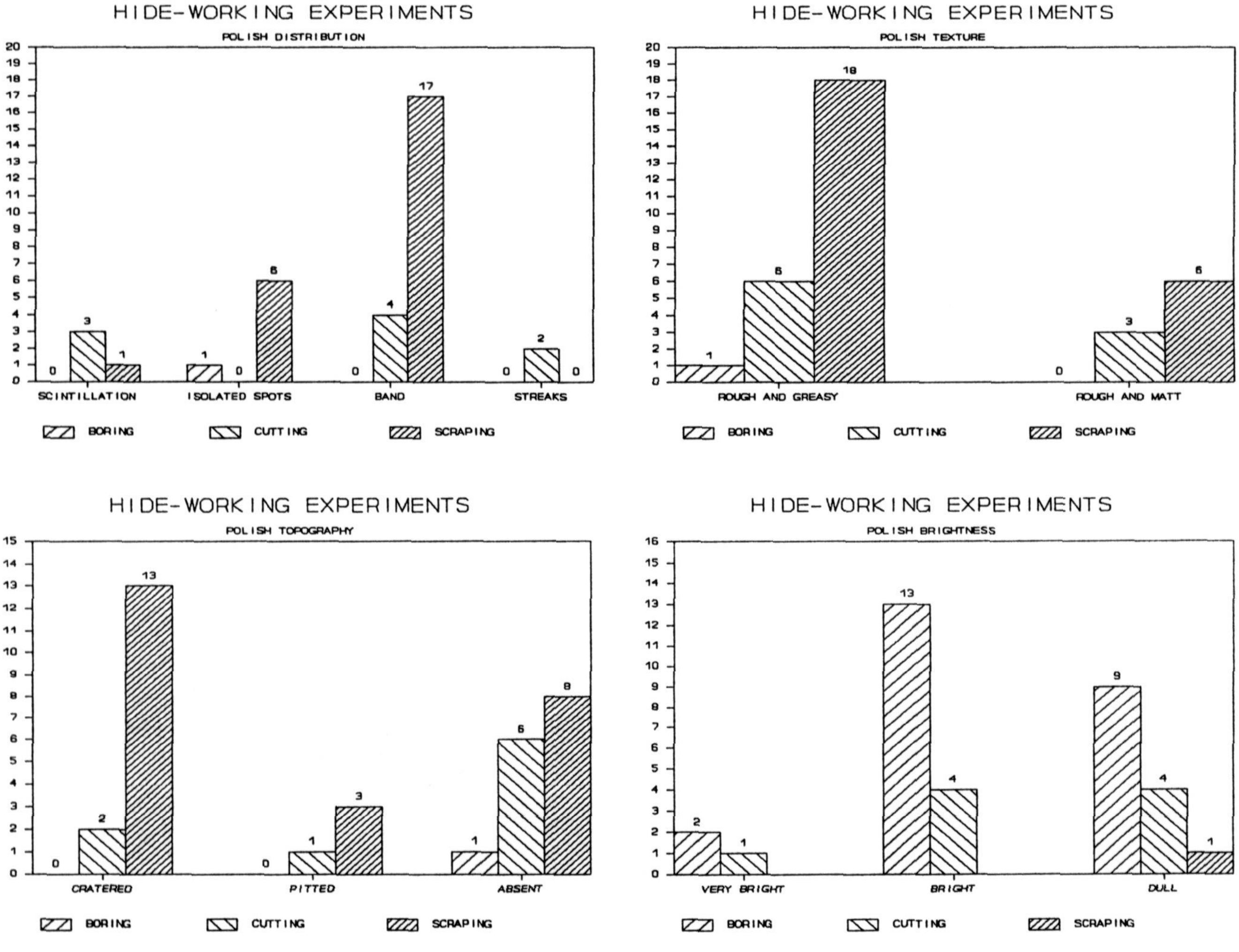

Fig. 12 Lotus graphs of polish characteristics from contact with hide. a) distribution, b) texture, c) topography, d) brightness.

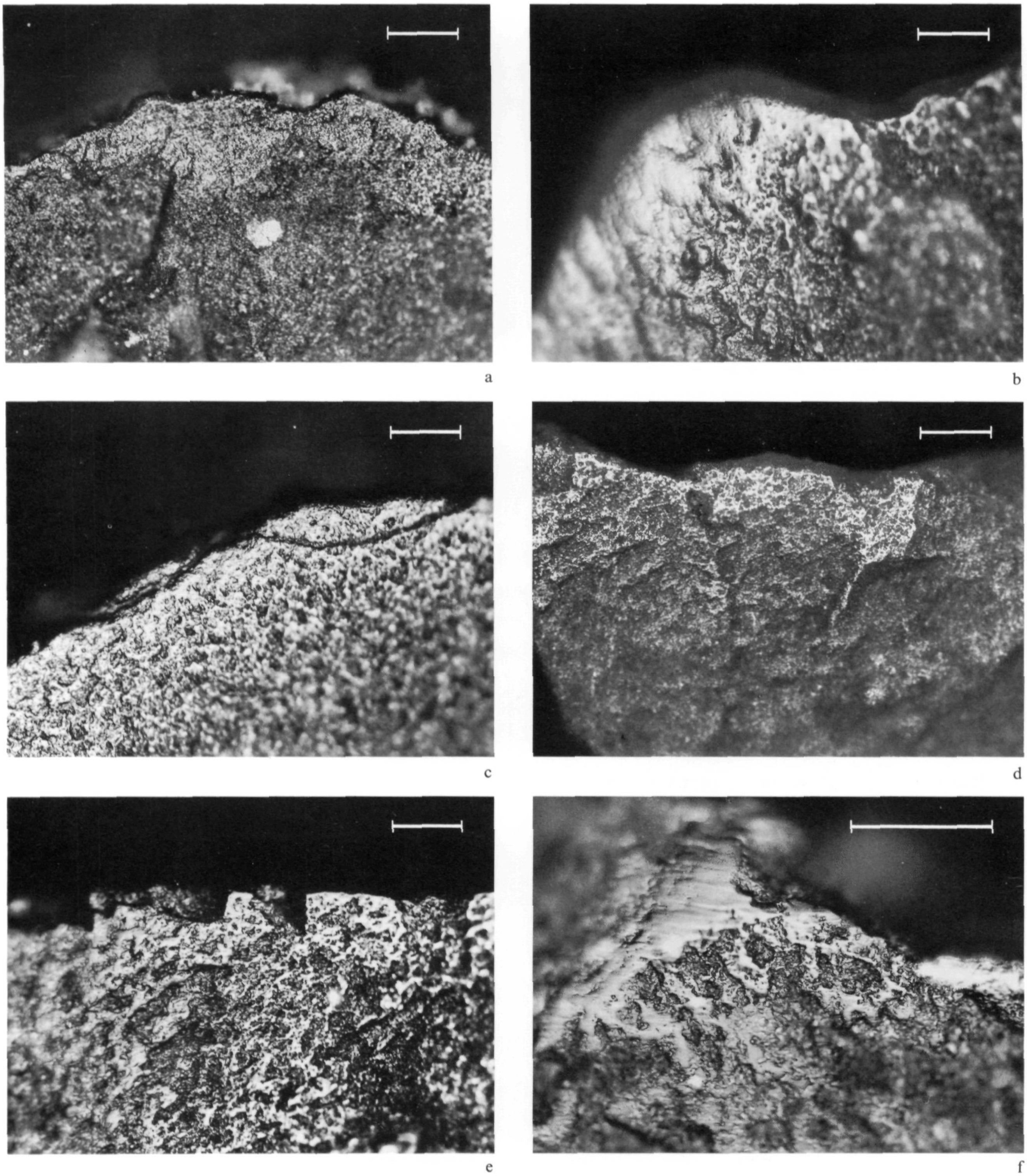

Fig. 13 Micrographs of experimental wear-traces. All scale bars equal 50 μ. a) characteristic band of polish from scraping fresh hide on experimental tool 100 (200x), b) polish development on experimental tool 249 used to scrape hide with powdered ochre and liver (200x), c) rough, cratered polish from contact with a drying hare-skin found on experimental tool 226 (200x), d) polish and edge-removals on experimental tool 208, used for sawing wood (200x), e) more or less reticulated distribution of wood polish on experimental tool 306, used to debark willow (200x), f) troughs in polish seen on experimental tool 55 used for whittling seasoned oak (400x).

13a); this invariably concerned scrapers. Cutting resulted in far less instances of polish; in two cases of dry leather cutting, longitudinal streaks of polish were produced (*fig. 12a*). The texture of the polish was either rough and greasy or rough and matt (*fig. 12b*), the brightness varied from intense to dull (*fig. 12d*). Fifteen tools displayed the deep craters in the polish considered to be typical for contact with hide, while four instances were described as 'pitted'. 13 tools exhibited no topographical polish characteristics (*fig. 12c*). The mean extent of the polish amounted to 483 μ (range 50-2000 μ). Striations were observed only twice.

To try to account for various additives, a series of experiments was initiated with mineral and animal tanning or preservative agents. Most remarkable were the traces resulting from scraping a hide with the addition of powdered ochre (a possible preservative) which was moistened by liver (a tanning agent) (*fig. 13b*): the polish was extremely bright but still recognizable as being from contact with hide due to the rounding of the edge and the fact that the polish followed every protrusion or indentation of the edge. Scraping with fat for softening produced a rough, greasy polish which was never well-developed, but extended far back into the piece, especially on the dorsal aspect; this was due to the fact that it was mainly the retouched aspect of the scraping-edge which was used for rubbing the grease into the skin. Unfortunately, no definitive conclusions can be drawn from these experiments because of insufficient numbers.

The above description of wear-characteristics resulting from contact with hide conforms well with observations made by other authors. The only exception concerns a series of scrapers used to remove the subcutis from fresh hare- or deer-hide; strangely enough a characteristic 'dry hide polish' developed. A band of polish, with sometimes craters or pits, was visible, following the entire contour of the edge, which displayed moderate to heavy edge-rounding (*fig. 13c*). Apparently such a hide, which is quite dry and contains only a few pieces of grease and meat (cf. the preceding paragraph), causes heavy attrition of the edge: no grease is present to protect the edge (cf. Brink 1978b). This observation confirms that, although hide as a general category is quite easy to recognize (see Unrath et al. 1986), the exact state of the hide is more difficult to infer. A large field, that of the use of vegetal tanning agents, still lies unexplored, while the role of animal tanning agents also requires some additional research.

3.3 Wood-working

3.3.1 ETHNOGRAPHIC ACCOUNTS

Whereas ethnographic descriptions of hide-working are numerous, albeit not always as detailed as we would like them to be, accounts of wood-working are extremely scarce. Even scarcer is information about the role of stone tools in the manufacture of wooden objects. Obviously, it would have been possible to, instead, turn to the numerous ethnohistorical sources which exist on the topic of wood-working with metal tools. I refrained from doing so, firstly because of time-restrictions, and secondly because it seemed doubtful whether such an effort would pay off in terms of a better understanding of wear-traces from wood-working.

One reference to stone tools derives from the Paiute, who peeled (whittled) willows with an obsidian knife, working away from the person; splitting was done with the teeth however (Kelly 1934). The Chippewa used ash for the manufacture of sleds, as this wood is very tough (Densmore 1928), but no mention is made as to the way of manufacture. What did become clear was that stone tools did not form the sole wood-working implements, as testified by the frequent references to the use of beaver incisors as a tool for smoothing wood (Tooker 1964, referring to the Huron; Oswalt/ Van Stone 1967, reporting on the Crow Indians). Not much information could be obtained about the organization of wood-working in terms of yearround scheduling. The Paiute collected the willows during the fall, as they were too brittle in the summer; the shoots must be soaked prior to use.

3.3.2 WEAR-TRACES FROM WOOD-WORKING

A total of 62 wood-working experiments were performed including such motions as whittling (*fig. 14*), cutting, scraping and boring, and covering a great variety of wood species (*appendix II, table 2*). No real tasks were carried out. Types of raw material used included Rijckholt, northern flint, and Cap Blanc Nez material. Total working time amounted to 24 hours and 19 minutes.

Of the 62 experiments, 36 tools did not display any edge-removals (*fig. 13d*). Most of them had been used in a transverse motion, while one cutting tool (experiment 30.1) was probably used too briefly (6 minutes) to cause damage. If present, edge-removals varied in width from 50 μ to 700 μ. Generally, the form of the retouch was deep/ well-defined

Fig. 14 Whittling experiment on maple.

scalar, or trapezoidal, while two transversely-used implements displayed half-moon-shaped retouch. Termination varied from feather (N = 8), hinged (N = 15), to snap (N = 1). Distribution was rather varied and did not exhibit a correlation with motion. The type of wood used was of some influence on the appearance of edge-removals: a harder wood like oak is more likely to cause edge-damage than soft species like elm or poplar. Fresh wood always inflicted less damage than dry, aged wood, even when this had been soaked. It is suggested that it is not so much the duration of use, but the type of motion that determines the presence or absence of edge-removals.

Polish developed on 53 of the 62 tools (i.e. 85.5%). Distribution varied from a faint scintillation, via isolated spots, to a band along the edge, and finally, a more linked spread of polish (*fig. 15a*). A reticulated pattern, as has been reported by various authors (Keeley 1980; Moss 1983a; Plisson 1985a; Vaughan 1985a), was also observed (N = 11) (*fig. 13e*). I tend to agree with Newcomer et al. (1986) that such a pattern is dependent on the grain-structure of the raw material and not linked with working wood *per se*. Texture is usually smooth and matt (N = 43), although a few instances of a rough and matt (N = 2), or a smooth and greasy version (N = 3) also occur (*fig. 15b*). In most cases the polish was domed (N = 38) (*fig. 15c*) and very reflective (N = 30) (*fig. 15d*). Nine tools displayed no polish whatsoever. This may be the result of very short work periods (5-15 minutes). The tool of experiment 76 was used during 29

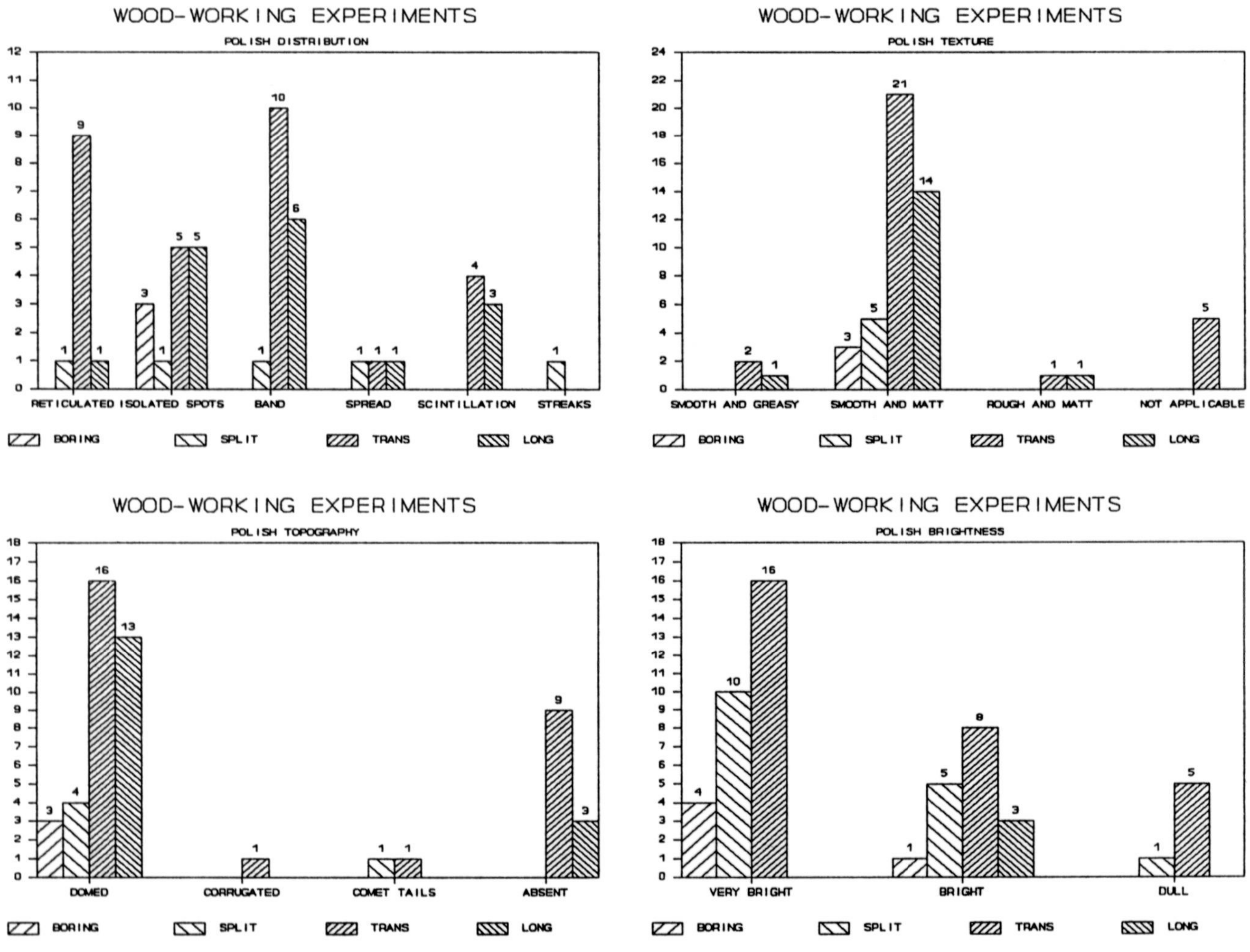

Fig. 15 Lotus graphs of polish characteristics resulting from contact with wood. split = splitting, trans = transverse, long = longitudinal, a) distribution, b) texture, c) topography, d) brightness.

minutes but displayed virtually no polish; perhaps here less pressure was exerted.

Striations are usually absent: only 13 tools exhibited deep, short and wide striae. Sometimes, as in the case of an implement used for sawing oak (experiment 55), these striae resemble the comet-tails often observed on bone-working tools (*fig. 13f*). On two whittling tools (experiments 202 and 278.2) linear distributed, matt streaks of polish were seen.

From the preceding description of wear-characteristics resulting from contact with wood it can be concluded that there is a considerable variation in traces, although a domed topography, usually considered indicative of wood, occurs frequently. Keeley (1980: 35) considered wood-polish to be quite distinctive, as did Moss (1983a: 91), although she already noted its incidental similarity to antler-polish. In blind tests, however, the identification of wood has consistently been a problem (Gendel/ Pirnay 1982; Keeley/ Newcomer 1977; Unrath et al. 1986). This might relate to the fact that the polish from wood-working forms rather slowly and therefore goes through stages of development, which vary in appearance (cf. Vaughan 1985a: 33).

3.4 Bone- and antler-working

3.4.1 ETHNOGRAPHIC ACCOUNTS

The use of bone and antler tools is reported from a variety of contexts. The Nisean of Central California make awls, for basketry purposes, from the lower front leg of deer (Beals 1934). The Tanaina in Alaska use bone points for their fish spears (Osgood 1937). Bone splinters are employed as barbs among the Klamath Indians (Spier 1930). Many more examples can be cited, most notably from the Eskimo who, because of the lack of wood in their surroundings, made every conceivable object from bone or antler, such as bent whale bone buckets, or antler snow-goggles. However, there is, generally, a lack of information about the manufacture of such objects and the possible role of flint tools in this endeavour. It seems likely that they played an important role in the initial shaping. With respect to the finishing stage, Osgood (1937) reports that the Tanaina sharpened their awls, made of bear-bone, by rubbing them with a stone. No mention is made either of the state under which the bone or antler was most profitably worked. It is generally assumed that the bone must be fresh, or else thoroughly soaked. This conforms with the experience of the author that dried, old bone is virtually impossible to work. The same applies to antler: however, when kept wet while modifying it, antler is almost 'pulpous'.

Another aspect of bone and antler tool production which has received insufficient attention is the organization of these craft activities. By analogy to the Eskimo, it is usually taken for granted that they are performed during winter, when subsistence activities are suspended and more leisure time is available. Binford, however, has demonstrated that the same Eskimo communities produce bone or antler objects on many occasions and during all seasons (Binford 1978a; 1978b). A favourite time is, for instance, on a hunting stand while waiting for game to appear. This observation has important implications for the interpretation of site function on the basis of wear-traces present (see also *6.2.6*). Data on gender differentiation in bone or antler tool production derive solely from the Eskimo, where only men (either on hunting stands or at home) are involved in such tasks.

3.4.2 WEAR-TRACES FROM BONE- AND ANTLER-WORKING

3.4.2.1 Bone

A total of 53 experiments was done involving bone as contact-material, using a variety of motions (*appendix II, table 3*). Experiments were conducted for a total of 18 hours and 22 minutes. Many represented an attempt to replicate the bone awls and chisels found in great quantities at sites attributed to the Late Neolithic Vlaardingen-group (cf. *6.2.3.2*). Some of these experiments were done by Van den Broeke and Stapert (Van den Broeke 1983). Experiments 281.1 and 281.2 formed an effort at producing a harpoon. One experiment was done with the experiment-machine (nr.21), while the remaining were generalized reference experiments, not aimed at replicating specific archaeological objects.

Traces produced by contact with bone are generally considered to be quite distinctive. Keeley differentiated a rough and a smooth polish variety, the rough kind being associated with longitudinal activities, the smooth version with transverse motions. The polish is described as being highly reflective, displaying tiny pits and having a localized distribution (Keeley 1980: 43).

The experiments reported here corroborate the results above. Scraping fresh bone results in very little edge-removals, slight edge-rounding, and in some cases (N = 7) a polish-bevel (*fig. 17a*). The polish is highly reflective (N = 8), has a smooth, almost metallic, appearance (N = 9), and exhibits comet-tails and pitting (*figs. 16b-d*). Sawing or cutting fresh bone causes much edge-damage, generally consisting of overlapping deep scalar or square scars with a stepped, hinged, or feathered termination. The associated polish, distributed in isolated spots (*fig. 16a*), is rougher and sometimes appears 'broken' (*fig. 17b*). Comet-tails are at times present (N = 6). It is likely that this roughness is due to the fact that sawing or cutting generally takes place against the grain of the bone causing attrition of the polish. Carving also results in quite heavy use-retouch, consisting of overlapping scalar scars with hinged or stepped termination. The polish is highly reflective, often metallic, smooth and almost always lined with comet-tails (in 16 of the 19 carving experiments); here too the polish appears 'broken' at times (*fig. 17c*). Wear-traces which are considered to be distinctive for bone as contact-material include a polish-bevel (Plisson

1985a), comet-tails (Vaughan 1985a: 31), and tiny pits (Keeley 1980: 43). From figure 16c it can be seen that these attributes did develop on 32 of the 50 experimental tools displaying polish (64%), suggesting that microwear traces from prehistoric use on bone cannot easily be missed.

3.4.2.2 Antler

Many reports on microwear analysis purposely do not differentiate between bone- and antler-working traces. As Keeley (1980: 56) has stressed, antler polish does not only occasionally resemble bone-, but may also look like wood-polish. Although caution is sometimes justified, antler-working traces can be quite distinctive. This means that it seems more appropriate to consider antler as a separate category. When no diagnostic features are present on the archaeological pieces, it is always possible to give an 'and/or' interpretation.

A total of 18 experiments was done with antler, covering a number of motions (*appendix II, table 4*). All of the experiments were generalized ones, i.e. not aimed at the production of a specific object. Antler was worked for six hours and 40 minutes. It should be stressed that all but two (early) experiments were performed with soaked antler, as this is extremely easy to work.

Edge-scarring occurred only on tools used in a longitudinal motion, and on one whittling implement. It featured well-defined scalar scars with a deep initiation and a hinged or feathered termination. Distribution was irregular, and its

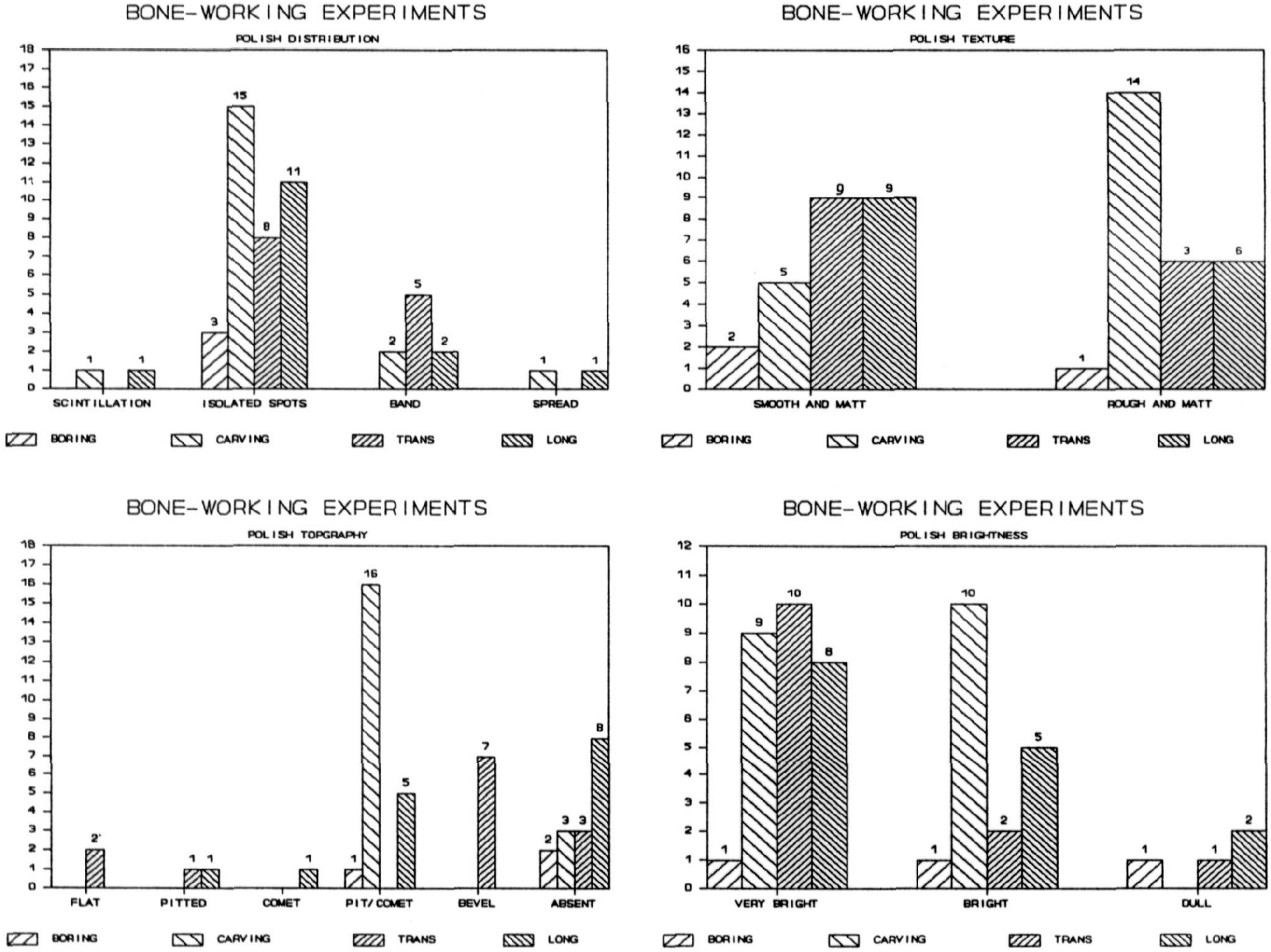

Fig. 16 Lotus graphs of polish characteristics resulting from contact with bone. trans = transverse, long = longitudinal, a) distribution, b) texture, c) topography, d) brightness.

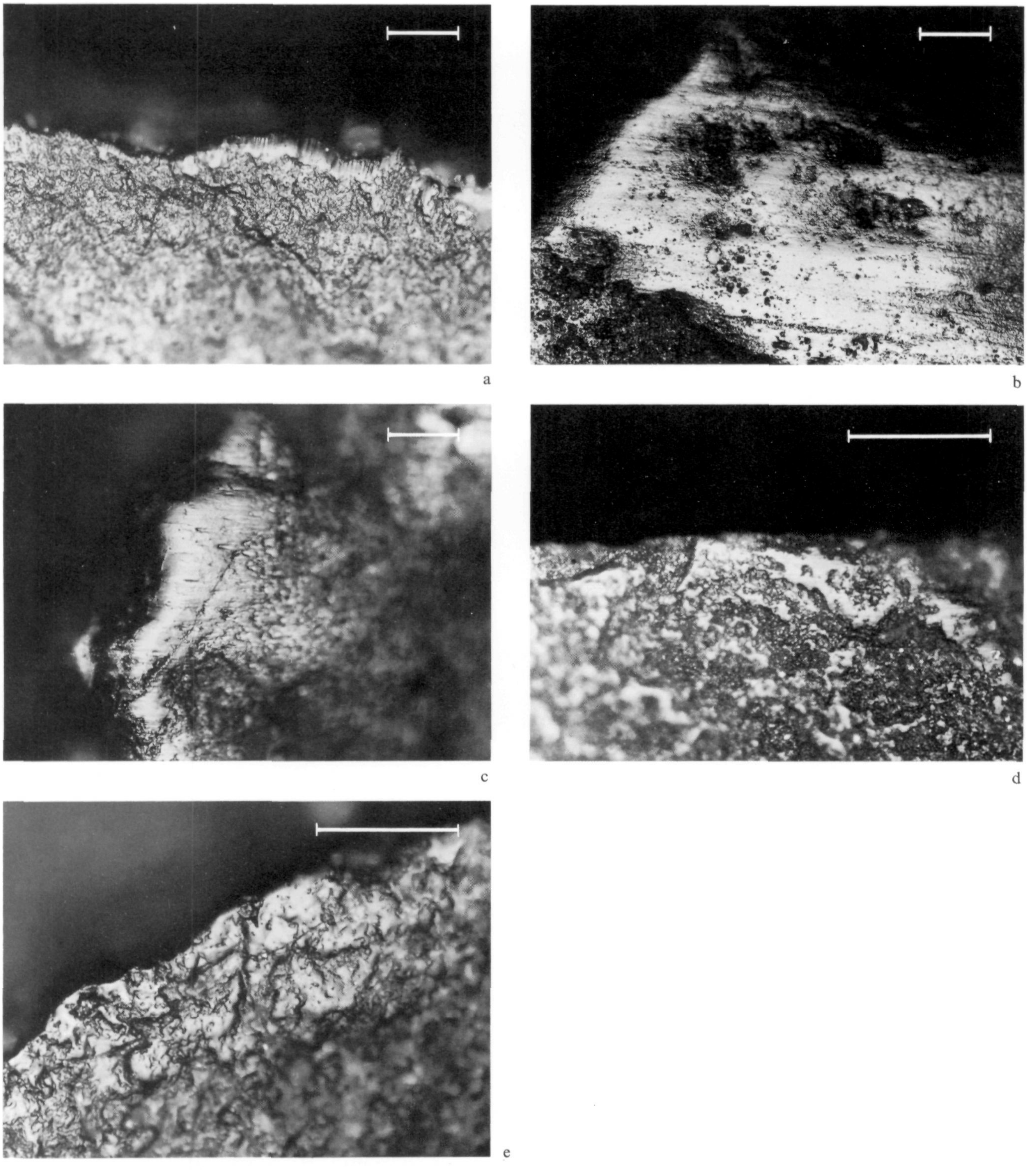

Fig. 17 Micrographs of experimental wear traces from bone-working. All scale bars equal 50 μ. a) polish bevel seen on experimental tool 220, used for scraping bone (200x), b) flat, rough polish from sawing bone (experimental tool 109, 200x), c) 'broken' polish with comet-tails on a bone-carving tool (experimental tool 56, 200x), d) flat polish resulting from sawing antler on experimental tool 170 (400x), e) polish from scraping antler seen on experimental tool 254 (400x): note the tiny pits in the polish and the latter's 'fingering' distribution.

mean width amounted to 400 μ. The degree of edge-rounding varied, but was usually minor. Polish developed on all scraping and cutting tools (N = 11), but was absent on two out of the five borers, and on an engraving implement. Experimental tool nr. 200.3, used for whittling antler, had too sharp an edge-angle for this activity: the edge-damage probably eliminated the polish. Polish characteristics are quantitatively displayed in figs. 18a-d. Longitudinal actions produced a bright to very bright polish with a flat topography (*fig. 17d*). The distinction between rough and smooth antler-polish associated with longitudinal and transverse motions respectively, as noted by Keeley (1980: 56), is not so evident on the experimental tools presented here: of the five sawing/ cutting implements, only two exhibited a rough polish (no. 210 and 277). Scraping, on the other hand, caused a smooth, matt polish in all instances, with, in two of the six cases, a domed topography; three scraping tools displayed tiny pits (*fig. 17e*). Although not presented in the graphs or tables, it seems that a 'fingering' distribution of the polish on scraper edges is very characteristic for contact with antler (*fig. 17e*; see also Keeley 1980: plate 51). The polish on scraping tools never extends far into the piece (87 μ on the average, range 20 — 150 μ). Striations have not been noted on any of the experimental implements, but directionality in polish is present on nine tools.

It is difficult to say whether antler-working can be easily

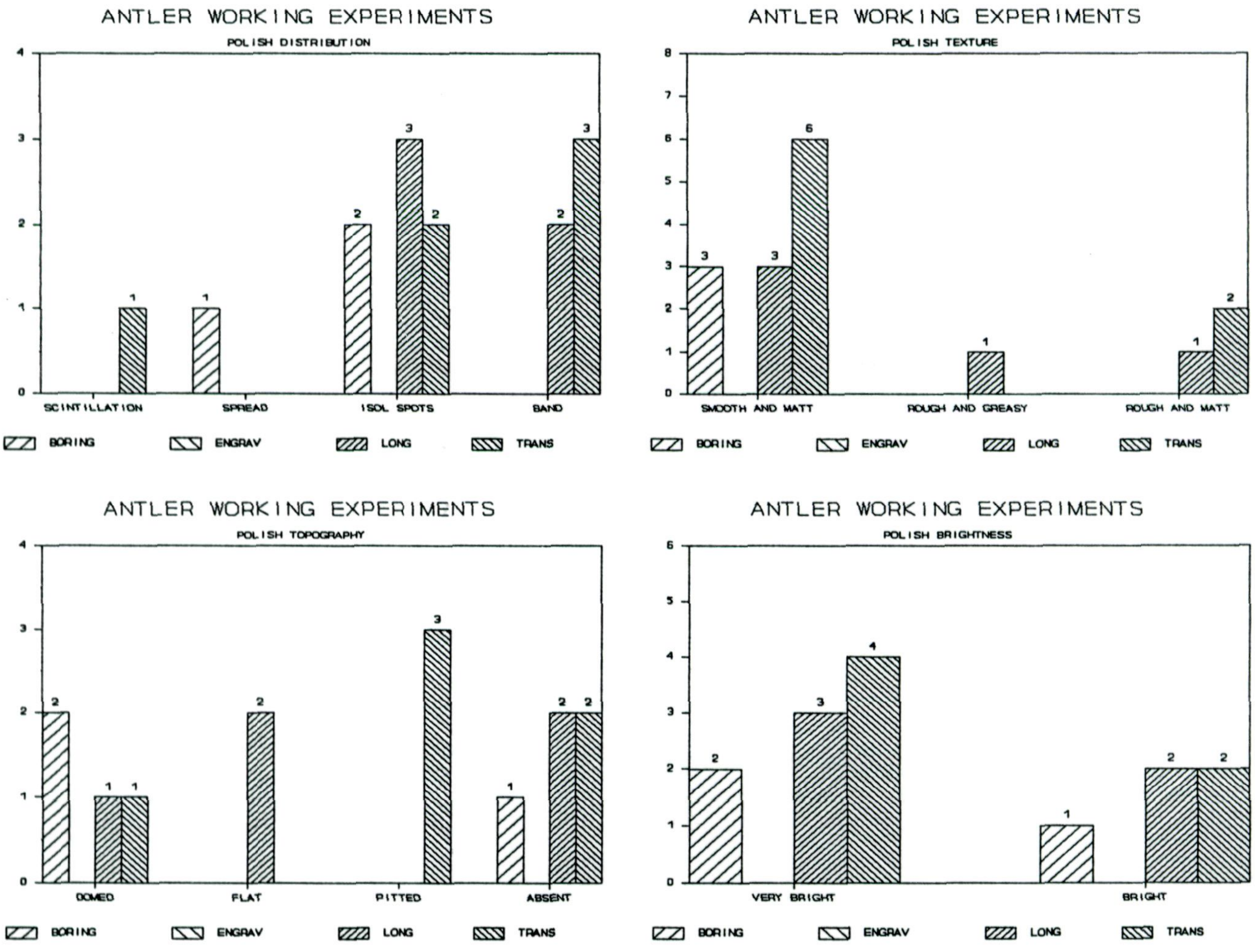

Fig. 18 Lotus graphs displaying polish characteristics on experimental antler-working tools. engra = engraving, long = longitudinal, trans = transverse, isol spots = isolated spots, a) distribution, b) texture, c) topography, d) brightness.

traced archaeologically, because this also greatly depends on the state in which the material was worked in prehistoric times. The fact that antler-polish sometimes displays a domed character (suggestive of wood), or in the case of longitudinal actions, a flat topography (resembling bone-sawing traces), gives rise to doubt. However there are tools, especially scrapers, which display the characteristic 'fingering' polish with pits, indicating that a separate category is still warranted.

3.5 Plant-working

In Neolithic context, the most important plants are the various domesticated cereals. Although the shift from the gathering of wild cereals to the cultivation of domestic varieties of these plants is difficult to pin-point, the behavioural implications in terms of tool use and organization of the work may be different. In the following pages therefore, wild and cultivated plants will be discussed separately. It should also be noted here that it would probably have been more appropriate to refer to all non-woody plant species as *herbal* plants. The indication 'soft plant', also used in this study, is confusing but has been retained because the term is employed by other use-wear analysts as well (cf. *5.4.2.4*, *5.4.2.5*).

3.5.1 ETHNOGRAPHIC ACCOUNTS

3.5.1.1 Wild plant gathering

Much of the ethnographic material presented so far derives from North-American Indian sources. Innumerable plant species have been used by the Indians (see for instance Densmore (1928) for the Chippewa). No references for flint tools having played a role in the gathering or processing of wild plant material were found. Many plants were simply hand-picked. Keeley reports that, during a literature survey of North-American Indian sources, he has found only one example of stone tools having been used for the gathering or processing of food plants (discussion in Cauvin (ed.) 1983: 128). Based on research in the Western Desert of Australia, Hayden (1978) arrives at a similar conclusion. Tubers and roots are generally collected with a digging stick.

Instead, attention was turned towards the role of wild plants in the Dutch context, emphasizing species which might possibly be more economically collected or processed using flint blades. Turnip was selected as a root type. Although it was probably collected with a digging stick, the root might have been cut up with flint tools. Reeds were considered good roofing material, and were cut both in green and dry state. Stinging nettle (*Urtica dioica*) has of old been gathered as medicinal plant; young shoots are full of vitamins A and C, iron, calcium and many other minerals. It was also cooked as a vegetable and used for the manufacture of string and cloth. Water-hemlock is also a medicinal plant. Horse-tail (*Equisetum*) is traditionally applied for polishing pans in Dutch farmsteads (B.Decker *pers.comm.*), probably because of its highly silicious stems[1]. The leaves of cat's-tail (*Lythrum*) form good matting material, while the tubers are rich in carbohydrates and protein. Moor grass (*Molinia*) was, in former days, often used for making bee-hives.

One cultivated plant, flax (*Linum usitatissimum*), is dealt with here as well, because its stems do not contain silica. As only one experiment was performed involving this plantspecies, a category 'non-silicious domesticated plants' was not warranted. Instead, it is discussed in the section on non-silicious wild plants (*3.5.2.1*). Flax cannot be cut: it must be pulled out of the ground. Only in the subsequent processing of this crop could flint tools have played a role (*fig. 19*).

Obviously, many more wild plants could have been of great value to prehistoric man. However, when experimenting it became clear that, in terms of wear development, two groups could be differentiated: silicious plants such as reeds, wild grasses, horse-tails, cat's-tails and, to a lesser extent, stinging nettle, versus all the other 'green' plants. While the former produced a reflective polish, the latter did not cause any distinctive damage. Although the number of experiments involving wild plants could be extended, this would probably not have added much new information. Scheduling collecting activities obviously varies per species: springtime is the period to harvest herbs and several other green 'leaf'-plants, while during autumn various fruits, berries and nuts should be gathered. January is the most appropriate time to cut reeds for roofing; even now this is still the time when this activity is carried out, aided at times by the presence of ice.

3.5.1.2 Cereal-harvesting

For the most part, ethnographic information concerning the harvesting of domesticated cereals derives from the Near East. Here, flint sickles played a very important role. How-

Fig. 19 The loosening of the inner flax fibres from the rotten outer skin; an obtuse-angled tool is used to break and remove the outer layer.

ever, none have been observed in operation, since metal counterparts are used nowadays. Direct or indirect evidence for hafting is usually present on the archaeological sickle blades so that the overall shape of prehistoric sickles can be reconstructed (cf. Stordeur 1987). These reconstructions suggest that the archaeological sickles might have been used in a similar fashion as their metal counterparts.

The main issue is actually how far down the stem the grain was cut. Three options have been suggested. A first possibility is that the stems were cut or broken just below the ears (Reynolds 1981; Anderson-Gerfaud 1988) (*fig. 20*). This can nowadays still be observed in northern Syria, where young girls enter the fields to pick the green ears (cf. film presented by Dominique Vaughan during the symposium 'The exploitation of plants in prehistory', held in Jalès, France in June 1988). A second option implies that the stems were cut a little below the ear (*fig. 21*), somewhere

Fig. 22 Barley field at the experimental farm at Lejre, Denmark. Note the variable height of the ears and the large amounts of weeds present.

Fig. 20 Breaking off, with the aid of a flint tool, the cereal ears from their stems.

Fig. 21 Harvesting barley with a composite sickle somewhere half-way the stems.

Fig. 23 Reaping barley close to the ground in a 'modern' field, with the aid of a crescent-shaped sickle.

halfway. My own experiments would suggest that this is not a very practical procedure in fields where the stems do not attain roughly the same height (*fig. 22*). One has to cut further down to be sure to collect all the ears, including those of lesser height. This method yields straw of variable length, which is less useful for purposes such as roofing. The third option is cutting just above the ground surface (*fig. 23*). This has the advantage of leaving a stubble-field on which animals can graze while manuring the field at the same time. Leaving the straw attached to the ear also facilitates the removal of the kernels during threshing, thereby protecting the grains from being squashed. However, this harvesting method also implies the loss of possible roofing material. It has been suggested that reaping close to the ground would be too physically demanding for the harvesters, but this seems to be a western imposition and should not automatically be assumed correct. Alternatively, it is possible to uproot the entire stalk, but this is only done for barley (Hillman 1981). Van der Kooij (1976) mentions that this method is used when stems stand wide apart. It is also believed that the presence of soil particles might be a hindrance for threshing.

As to the organization of the work in Northwestern Europe, the harvest would have occurred in late summer, the exact period depending on latitude. Probably everyone available was needed, allowing little time for other activities during that period. Obviously, the fields had to be tended during the spring and early summer, but this concerns less-concentrated efforts than the actual harvesting.

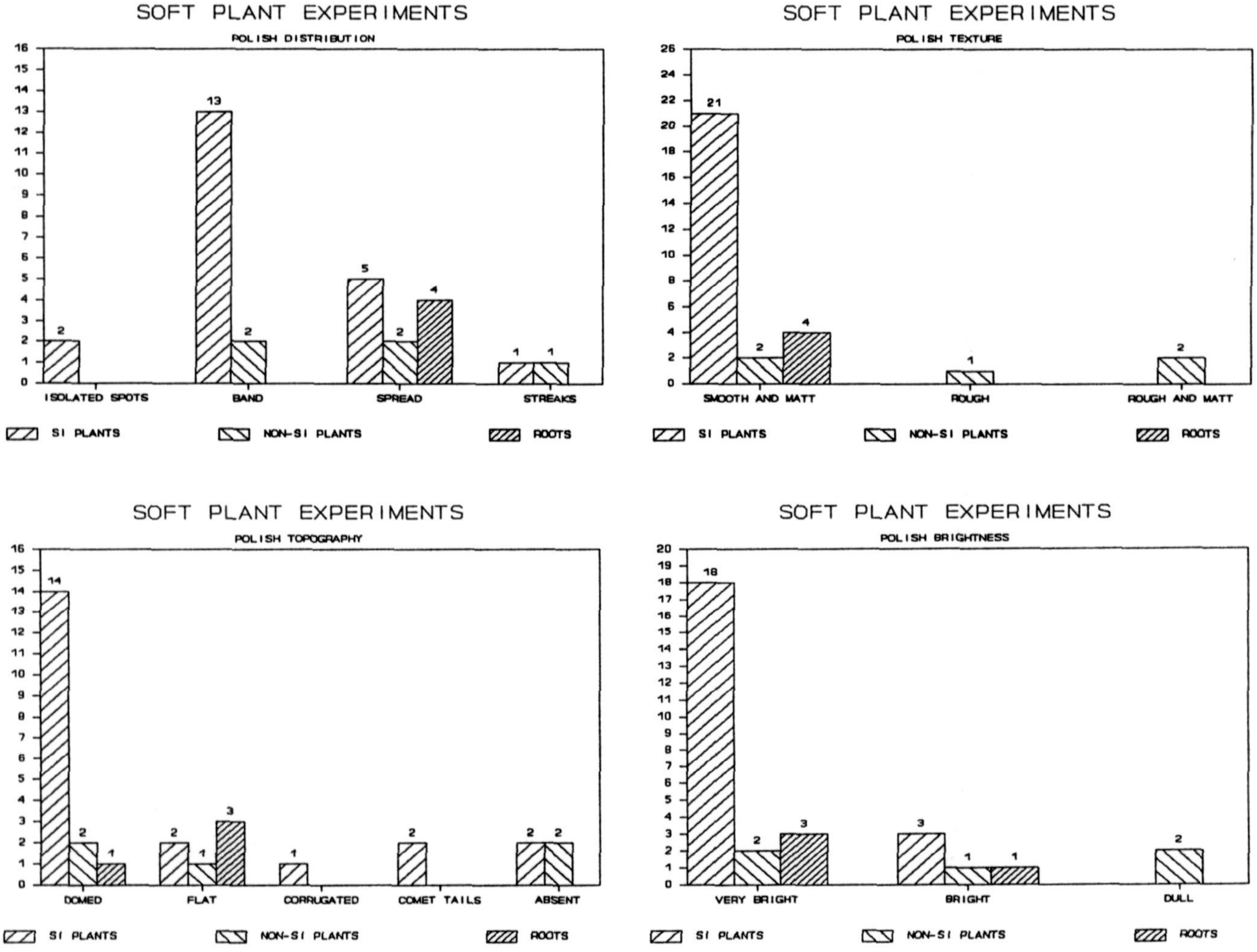

Fig. 24 Lotus graphs displaying polish characteristics on experimental tools used on soft plants other than cereals. si = silicious, a) distribution, b) texture, c) topography, d) brightness.

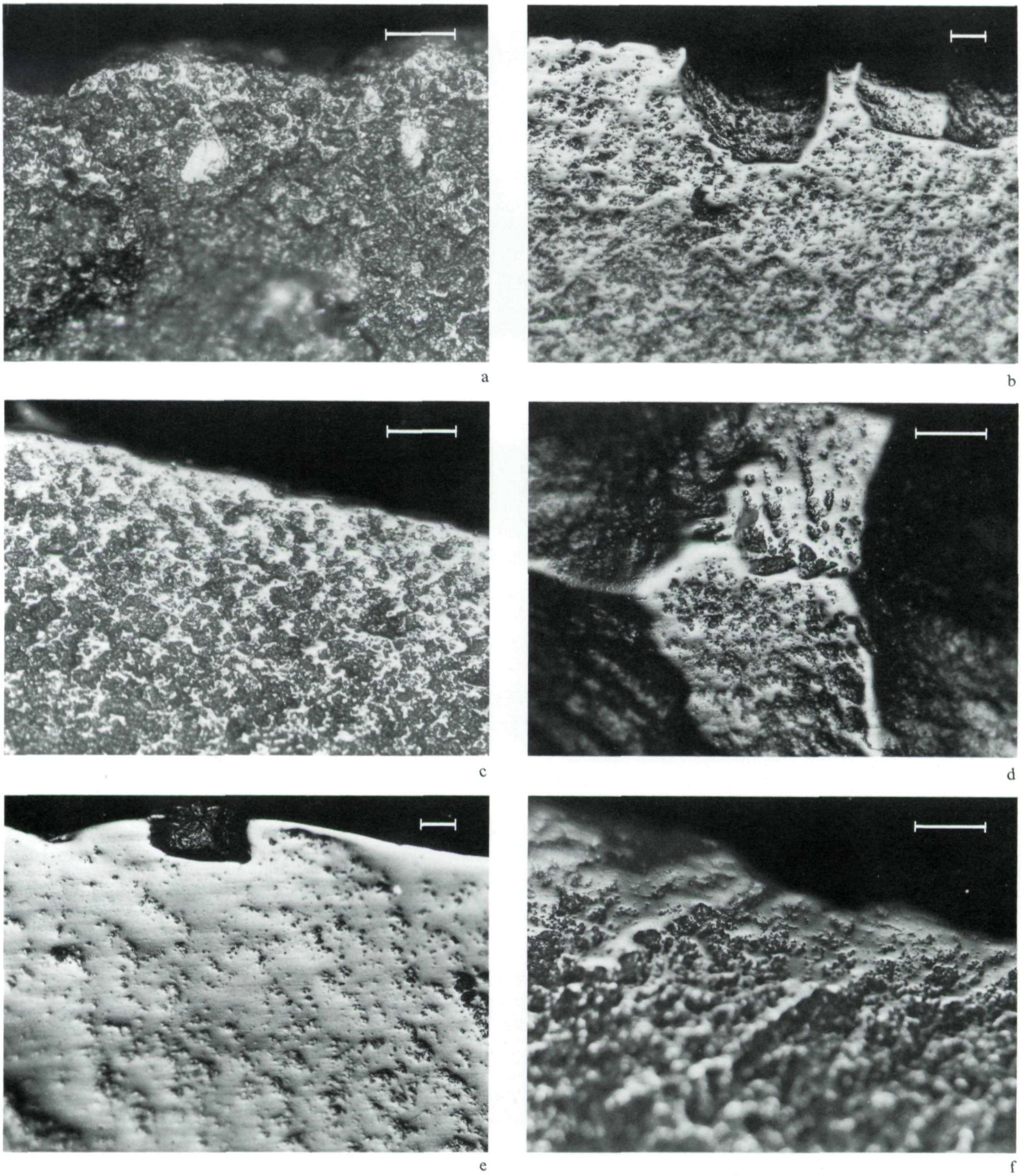

Fig. 25 Micrographs of wear-traces on experimental soft plant-processing and cereal harvesting tools. All scale bars equal 50 μ. a) polish and edge-rounding from working putrefied flax in perpendicular fashion (experimental tool 326, 200x), b) polish from cutting reeds (experimental tool 183, 100x), c) narrow band of polish resulting from cutting grass with experimental tool 186 (200x), d) domed polish on experimental tool 234 after 90 minutes of reaping barley (200x), e) well-developed polish on experimental tool 238 after 4.5 hours of reaping barley (100x), f) polish from reaping emmer (experimental tool 120, 200x).

3.5.2 WEAR-TRACES

3.5.2.1 Wear-traces from cutting wild plants

A total of 35 experiments was performed with cutting various soft plants (*appendix II, table 5*). The total time worked amounted to 16 hours and 57 minutes. Three categories of wild plants were differentiated: silicious wild plants (a.o. reeds, wild grasses, cat's tail), non-silicious 'green' plants (a.o. celery, cabbage), and roots (turnip). Frequencies of various polish characteristics are depicted in fig. 24a-d.

Four experiments were done using turnip as an example for the gathering of root crops. The resulting polish, covering a large area of the tool, was smooth and matt in texture. Edge-damage was scalar with feathered or hinged terminations. The great extent of the polish is probably due to the presence of soil on the turnip. Non-silicious 'green' plants and vegetables such as celery, cabbage or green ('pasture') grasses did not cause any polish, edge-removals or even edge-rounding. Water-hemlock (experiment 310) produced some, albeit rather minimal, wear which would clearly not be interpretable on archaeological tools. Stinging nettles contain some silica in their 'stinging hairs', and produce a very narrow band of dull polish. The experiment with flax (nr. 326) involved the breaking of putrefied stems to loosen the inner fibres (*fig. 19*). Some light edge-rounding occurred, as well as some scalar edge-damage (*fig. 25a*). The polish was distributed in 'streaks', rather bright, smooth and matt in texture, and exhibiting a clear directionality.

Cutting silicious wild plants produced only slight edge-rounding. Micro-scarring occurred on the implements used on cat's-tail (experiments 314 and 315) because of the very tough stem of this plant: the retouch is half-moon in shape with snapped termination. The extensive use-retouch on these tools might explain the lack of a well-developed band of highly reflective polish. Remarkably enough, comet-tails are present in the polish on one of these two tools (experiment 315), implying that the development of this feature is associated with resistant, hard contact-materials as a general category, rather than just with bone (cf. *3.4.2.1*). The other occurrence of edge-scarring was on dry reed cutting tools (experiments 41, 280 and 288); here it concerned scalar scars with a feather termination, irregularly spaced. The experiments with horse-tail and fresh reeds only produced slight edge-rounding and a well-defined band of highly reflective, almost 'fluid' polish, matt and smooth in texture, with a domed topography (*fig. 25b*). No striations were observed on any of the plant-working tools, although the polish frequently displayed directionality. Grasses also caused a very well-defined band of polish (*fig. 25c*). In general, this band is much narrower than the ones produced by thicker stemmed species. One exception forms experiment 280, a dry reed cutting implement, which displays a metallic, narrow band of polish, only 300 μ wide. Such a metallic appearance of the polish seems to be confined to tools used on dry reed.

It can be concluded that finding (and interpreting) wear-traces from non-silicious fresh plants is virtually impossible in archaeological context. This would imply that, assuming such plants were collected with the aid of flint tools (which is by no means a necessity), these activities will remain archaeologically invisible (unless botanical evidence is present). As far as the silicious wild plants are concerned, traces produced by them are very evident, and post-depositional surface modifications will have to be extremely severe to cause such traces to be uninterpretable. Traces from cutting grass might disappear a little faster, because of their somewhat narrower width.

3.5.2.2 Wear-traces from reaping domesticated cereals

A total of 21 experiments with reaping cereals was performed (*appendix II, table 6*). Species included barley, emmer, bread wheat and oats. The total harvesting time amounted to 45 hours and 38 minutes. The time worked varied from 30-300 minutes. Two experiments, one with a composite sickle, were done on a weed-infested barley field at the experimental station at Lejre, Denmark (*figs. 21, 22*). In three other cases a retouched cresent-shaped sickle was employed (see also Van Gijn 1988) (*fig. 23*). In six experiments the flint implements were hafted with a mixture of resin and bee-wax[2].

Use-retouch developed on only six tools; in all instances it concerned feather-shaped scars with a hinged termination, irregularly and widely spaced, extending inwards to a maximum of 200 μ. The edge-rounding varied and seemed to be related to the duration of work, as well as to the relative coarseness of the flint. The polish is distributed in a band of at least 0.5 cm width (*fig. 26a*). The polish itself is highly reflective (*fig. 26d*), matt and smooth (*fig. 26b*), and displaying a clear directionality parallel to the edge. Those tools briefly used (i.e. with a less heavily developed polish) display a rather domed topography (*fig. 25d*), while on the tools displaying an outspread distribution, the topography seems flat (*figs. 25e, 26c*). Striations developed only in five examples; for the most part it concerned shallow striations.

The traces described here generally conform with those reported by other authors. No evidence was found for differences in the character of the polishes from barley and emmer (*fig. 25f*). It is suggested, however, that it is possible, at least experimentally, to differentiate between polishes from cutting reeds and those from reaping domesticated cereals, in the sense that the former have a 'wet', fluid-like appearance (even in the case of a well-developed polish (*fig. 25b*)), while the latter have a somewhat rougher and flatter polish.

Recently, claims have been made that it is possible to differentiate between harvesting wild and cultivated cereals (Korobkova 1981; Unger-Hamilton 1985, 1988). In archaeological context it has frequently been observed that sickle-

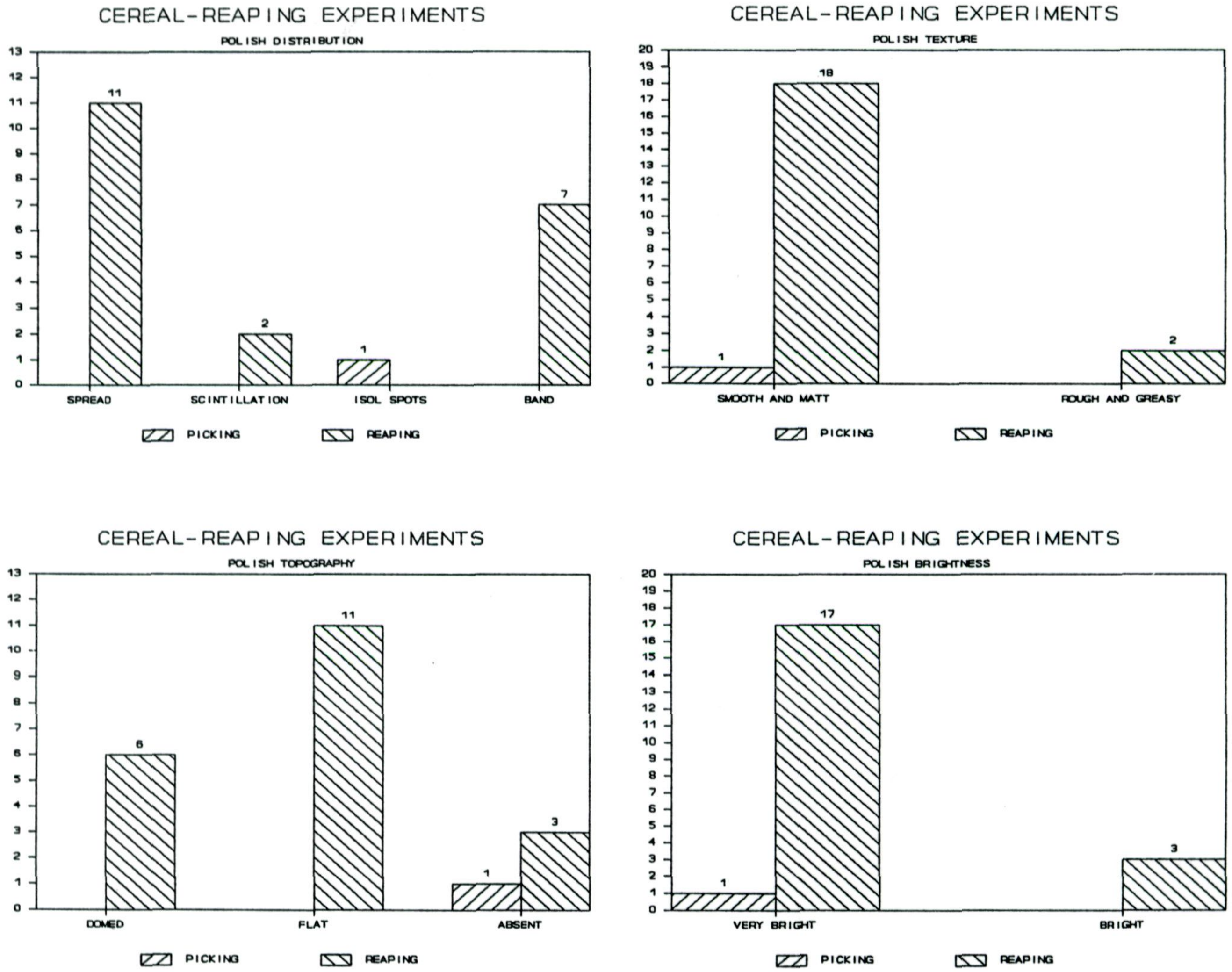

Fig. 26 Lotus graphs of polish characteristics on experimental cereal harvesting tools. a) distribution, b) texture, c) topography, d) brightness.

sheen has a very rough and striated appearance. Unger-Hamilton has done experiments with both wild and domesticated grain: the former caused a smooth, the latter a rough polish variety. She explains this by the fact that cultivated fields are ploughed and weeded, causing disturbance of the soil, particles of which may be deposited on the stems. Flint sickle blades would be scratched by these soil particles. The large majority of the cereal-harvesting experiments reported here were done on weeded, ploughed fields, but the polish never displayed this strange rough and striated appearance. Juel Jensen has postulated a more likely explanation for the striated appearance of archaeological sickle blades. She hypothesized that the roughness is due to large amounts of weeds in the fields. This was corroborated experimentally on a weed-infested field at Lejre, Denmark (H.Juel Jensen *pers. comm.*). My own experiments at Lejre did not produce a striated polish, probably because of their relatively short duration (*fig. 27a*).

3.6 Butchering and meat-cutting

3.6.1 ETHNOGRAPHIC ACCOUNTS

Ethnographic data on the use of flint implements in butchering are virtually non-existent. The Copper Eskimo are reported to scrape off the meat and tendons from a caribou skin, using a stone knife (Jenness 1970). Sinew is a sought-after article, as it provides excellent thread for sewing,

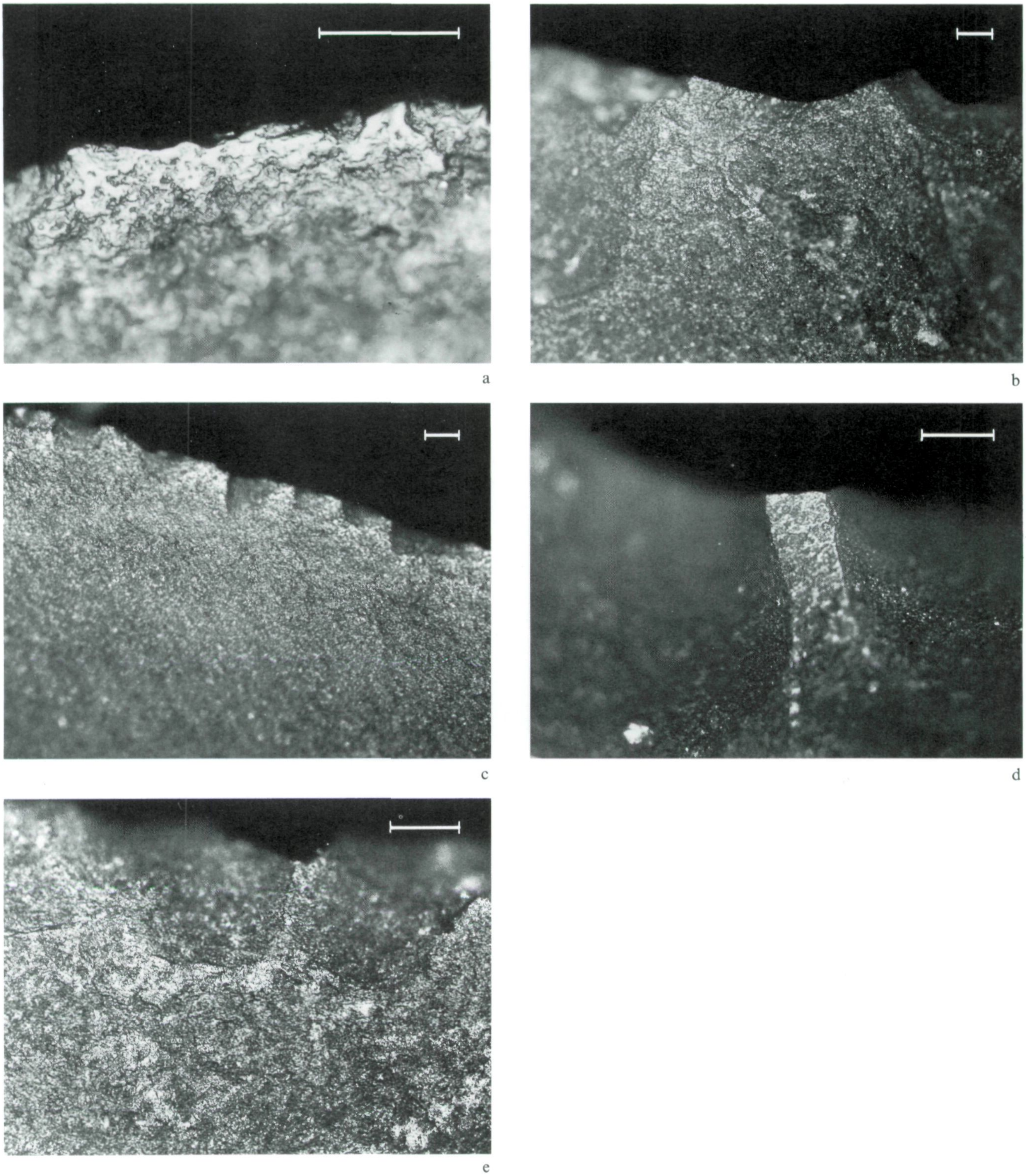

Fig. 27 Micrographs of experimental wear traces. All scale bars equal 50 μ. a) polish on experimental tool 318a used for harvesting weed-infested barley (400x) (see also *fig. 21*), b) edge-damage and faint polish on experimental tool 224 used for butchering a roe-deer (100x), c) scalar scars from cutting sturgeon-skin (experimental tool 184, 100x), d) 'bone' polish from cutting fish (experimental tool 194, 200x), e) linear streaks from scaling fish (experimental tool 193, 200x).

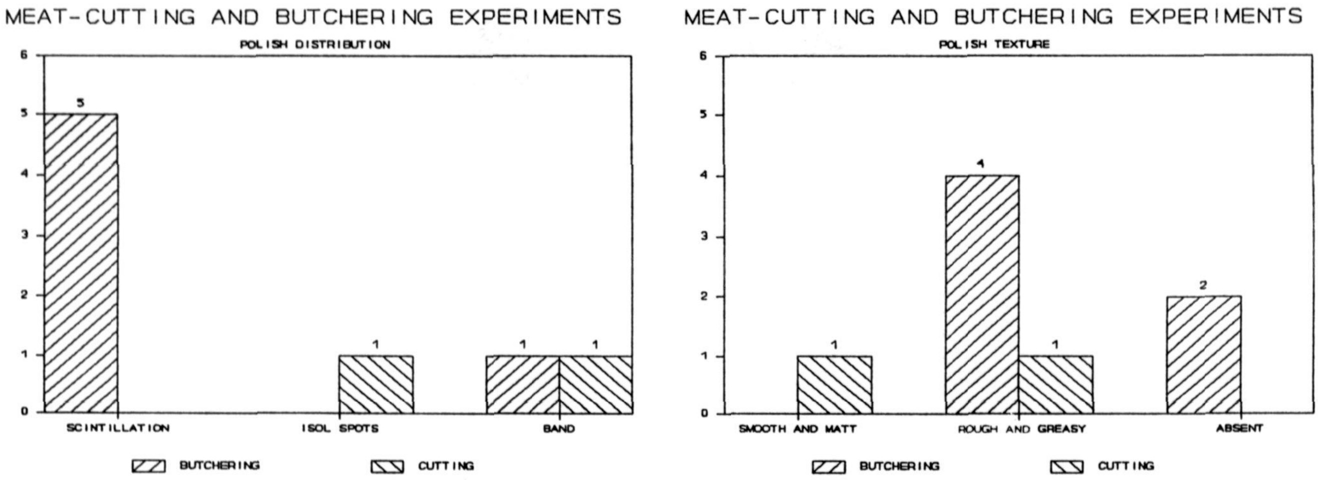

Fig. 28 Lotus graphs of polish characteristics on meat-cutting and butchering tools. a) distribution, b) texture.

snares and lashings (Osgood 1937, referring to the Tanaina). Most American Indian people customarily dry strips of meat for later storage; some pounded the dried meat to mix with berries (Densmore 1928). Butchering commonly seems to occur in the vicinity of the kill-site (Beaglehole 1936), unless it concerns small game.

Most of the information concerning the techniques and organization of butchering derives from ethnoarchaeological sources (Binford 1978a, 1983; Frison 1978, 1979), or from recent experiments (Patterson 1975, 1976; Walker 1978; Jones 1980; Odell 1980a). The latter were generally concerned with edge-characteristics most suitable for the task and with the examination of the resulting macroscopic wear-traces (see *3.6.2*).

3.6.2 WEAR-TRACES FROM BUTCHERING AND MEAT-CUTTING

A total of eight butchering and four meat-cutting experiments was performed (*Appendix II, table 7*), involving five hours and 13 minutes of work. Five butchering experiments involved roe-deer, two concerned fox, and one involved badger. In four experiments edge-scarring occurred, always scalar, and in three cases with a feathered termination (*fig. 27b*). There does seem to be a correlation between duration of work and the occurrence of scarring, although the tool of exp. 58, used longer than any other experimental piece, displayed none. However, this piece had not come into any contact with bone, contrary to exp. 53, exhibiting the most extensive use-retouch. Edge-rounding was moderate at most. Polish developed in six experiments, generally confined to a faint scintillation (*fig. 28a*). It concerned a rough and greasy lustre in appearance (*fig. 28b*), seldom displaying directionality, and lacking topographical characteristics. In some cases minute spots of 'bone-polish' were present. Striations were absent.

The meat-cutting experiments showed traces of use in only two cases. In experiment 164, used to cut meat off bone, it concerned bone-polish (bright, smooth and matt, with clear directionality), while the invasive retouch present is probably due to bone contact as well. The other tool displayed a band of rough, greasy, relatively bright polish; some small scalar, feathered scars were present. This tool was used for 45 minutes on meat with a lot of tough fat. The remaining two meat-cutting tools exhibited no traces of use whatsoever.

Traces from butchering, and especially meat-cutting, have been a source of much debate among wear-analysts. Keeley maintained that meat-polish was quite distinctive, because of its pronounced greasy lustre (Keeley 1980: 53). He observed a general smoothing of the stone's microtopography, with few striations. Keeley differentiated between fresh hide- and meat-polish, as did Moss (1983a). Anderson-Gerfaud (1981) and Vaughan (1985a) do not distinguish these two groups, the latter asserting that both only caused a generic weak polish (Vaughan 1985a: 38). Instead, Vaughan considered butchering-traces as a separate category, because of the bone-contact involved. As far as fresh hide-cutting (skinning) is concerned, I do agree that these traces are comparable with those caused by meat. However, this is definitely not the case with scraping fresh hides. In this study therefore, meat-cutting, skinning and butchering were kept in the same category.

While skinning and meat-cutting produced traces of wear which would seldom be visible archaeologically, butchering traces can be quite distinctive. Although it is very possible to butcher an animal without touching bone (Patterson 1981; H.Nijland *pers.comm.*), in most instances a characteristic pattern of small scalar scars occurs, sometimes associated with isolated spots of bone-polish or some weakly developed lustre. Still, an expert butcher does not have to damage the tool very much. This implies that, contrary to some claims (Odell 1980a), only one cutting implement is generally necessary to dissect, for instance, a roe deer (H.Nijland *pers.comm.*). Patterson (1976) arrives at the same conclusion. To conclude, meat-cutting tools and, to a lesser extent, butchering implements will be severely underrated in archaeological wear-trace reports.

3.7 Fish

3.7.1 ETHNOGRAPHIC ACCOUNTS

A lot of information is available about fishing procedures among the American Indians (see, for instance, Rostlund 1952; Stewart 1977). Of interest to the present study, however, is only if and how the fish was processed. When fish was caught for winter storage, some form of cleaning was always practised before the product was smoked or dried. Most Northwest Coast Indian tribes slit open the salmon, removed the entrails, and cut off the head. In the case of big, fat fish, they also cut the fillets for greater thinness (Spier 1930; Stewart 1977). To perform these operations, they sometimes made use of bone knives ('herring-knives'), slate knives (Stewart 1977: 155) or, occasionally, mussel shells. It is likely that also flint tools were employed in fish cleaning. Although cleaning is necessary when it concerns large quantities of fish to be processed for storage, there are however many instances in which no cleaning was practised. Osgood (1937) reports that the Tanaina buried silver salmon in the permafrost, using alternating layers of fish, fish-eggs (their saltiness acting as a preservative), and grass. The Huron buried fish in mud or hung it up, without removing the viscera; the resulting product was considered to be a good seasoning for the soup (Rostlund 1952).

As to the organization of the work, it is apparent that in almost all instances in which seasonal runs of anadromous fish were exploited, this was done in an organized fashion. Anadromous fish, such as salmon or sturgeon, are the only species that lend themselves to large-scale preservation for winter storage, because they can be caught in enormous quantities. In order to catch the shoals, facilities such as traps or weirs were constructed. These can be considered tended facilities (*sensu* Oswalt 1976), because it is necessary to regularly check whether or not the runs have arrived. This is the reason why specific expeditions were organized at the time of the runs. Camp was set up close to the weirs or traps (Osgood 1937; Balicki 1970). The Huron, basically an agricultural people, built fish-cabins of bark (having two fireplaces) on the islands to which they went to fish (Tooker 1964). The fish was gutted on the spot and hung to dry on racks (Trigger 1969). Other people are also reported to process the fish close to the catch-site (cf. Nelson 1973, reporting on the Kutchin, or Osgood 1937 on the Tanaina).

It is apparent that even agriculturally-based people such as the Huron organized fishing expeditions. After the harvest, in autumn, it was worthwhile to go through the trouble of freeing labour, travelling, and building specific fishing cabins (Tooker 1964; Trigger 1969). This observation is particularly relevant when we examine the site of Hekelingen III (*6.2*).

3.7.2 WEAR-TRACES FROM FISH

In a previous paper (Van Gijn 1986a) the character of the wear-traces resulting from contact with fish have been extensively discussed. Here a summary will suffice (*fig. 29a-d*). A total of 27 experiments was performed with various species of fish (*appendix II, table 8*). Total working time amounted to nine hours and 53 minutes. Edge-rounding never exceeded the stage of moderate. Use-retouch developed in 20 cases, and was mostly closely distributed (*fig. 27c*). The form of the retouch was somewhat variable, with trapezoidal or square shapes mainly associated with longitudinal movements on bony fish with resistant scales, such as bream (exp. 5 and 7). Lasting polish (as compared to 'residue', see Van Gijn 1986a) was visible on 18 tools. In nine instances it concerned a very bright, smooth and matt polish, indistinguishable from bone-polish and displaying comet-tails (*fig. 27d*); this occurred on experimental tools which had been used in a longitudinal fashion. On seven tools (in four cases in combination with bone-polish) did the characteristic linear streaks of polish develop (*fig. 27e*); these occur mostly when removing hard and resistant scales such as those of rudd. Only once was a greasy scintillation ('meat-polish-like') visible.

These results lead to the conclusion that the processing of fish is largely invisible from the point of view of use-wear analysis. Certainly, fish-processing tools can be hidden among the tools interpreted as butchering implements, or among bone-working tools. Only the linear streaks of polish seem to be characteristic for fish-processing, but they are exclusively associated with scaling and are absent when scaling soft-scaled fishes, such as pike. Although they can be differentiated in experimental context, in archaeological context these linear streaks of polish might be difficult to separate from the MLITS which develop on projectiles (see below).

3.8 Projectiles

3.8.1 ETHNOGRAPHIC ACCOUNTS

Ethnographic accounts are not specific about the relationship between the shape of an arrow head and, for instance, the animal species hunted. Therefore most information

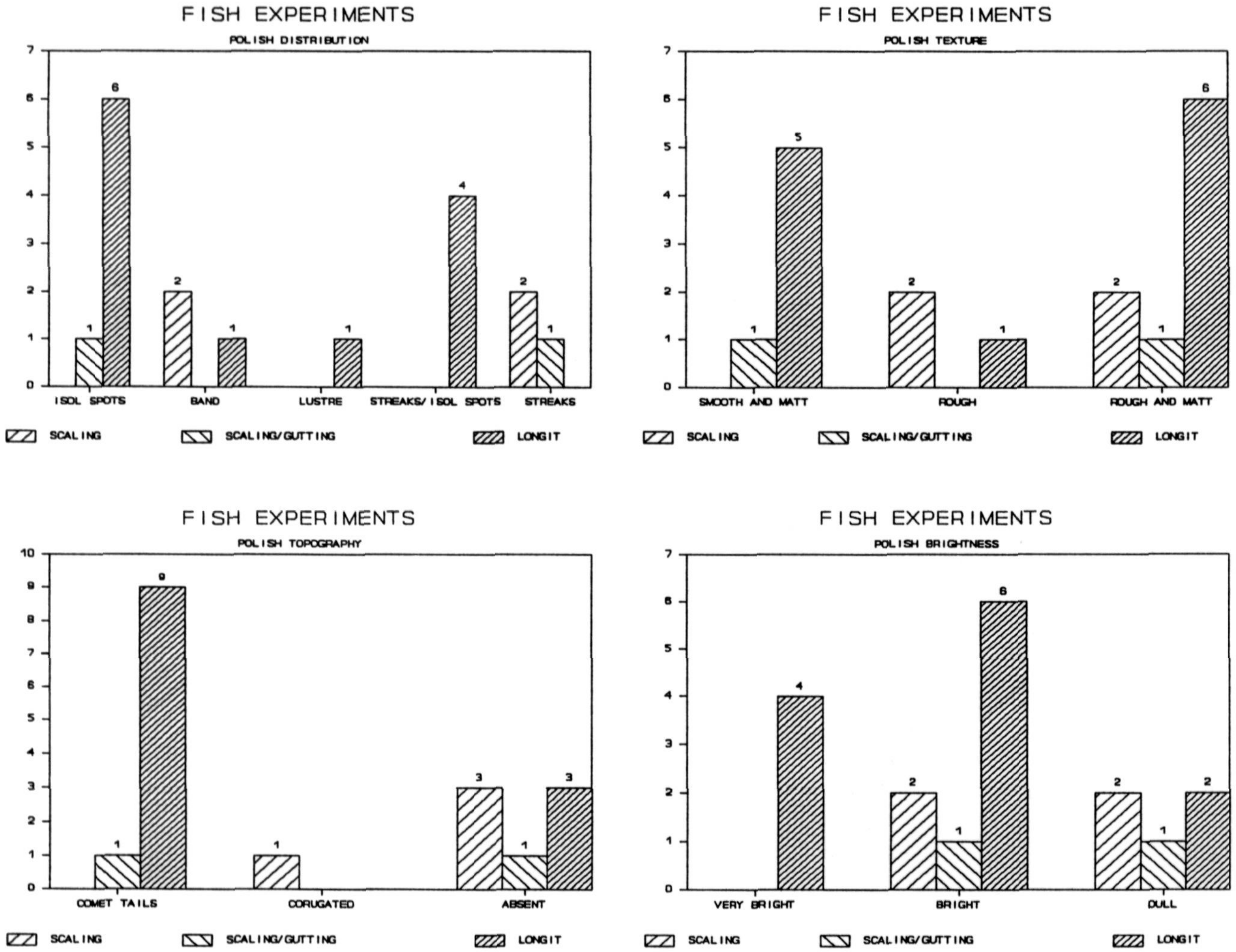

Fig. 29 Lotus graphs of polish characteristics on experimental fish-processing tools. isol spots = isolated spots, str/isol spots = streaks + isolated spots, longit. = longitudinal, a) distribution, b) texture, c) topography, d) brightness.

comes from recent experimentation (a.o. Fisher et al. 1984; Odell/ Cowan 1986) and will be discussed in the next paragraph.

3.8.2 WEAR-TRACES FROM THE USE OF PROJECTILES

In cooperation with Drs. Jaap Beuker (Drents Museum, Assen), a total of 11 transverse arrow heads were shot at a dead roe-deer hung up between two trees beside a leaf covered sand road (*fig. 30*). The bow used was a 48 lbs modern type. All arrow heads, manufactured by Beuker from either very fine-grained northern flint or Rijckholt material, were shot only once. Two arrow heads could not be retrieved (*appendix II, table 9*). After the experiment, the roe-deer was butchered by Henk Nijland (Rijks-Instituut voor Natuurbeheer, Arnhem) to determine the precise trajectories of the arrow heads inside the body. In this way we hoped to find out whether the arrow heads had come into contact with bone. On two of the nine tools no damage was visible (22%). The remaining (78%) showed impact fractures of half-moon shape with deep initiation and feather termination. Six tools (67%) displayed the characteristic linear streaks of polish (MLITS) (*fig. 31a*), running parallel to the direction of impact.

These results coincide with previous reports about experimentally-induced wear-traces on arrow heads (Fisher et al. 1984; Odell/ Cowan 1986). Fisher et al. (1984) mention that on 66% of the transverse arrow heads microwear-traces (i.e. linear streaks of polish) developed, while 61% of the used Brommian points displayed this feature. However, they note a much lower number of instances (41%) in which macro-traces (i.e. fractures) were present. Odell and Cowan (1986: 204, table 1) report a 100% occurrence of macroscopic damage on the tip. These results indicate that with relatively little effort a possible previous use as projectile point can be ascertained in at least 66% of the cases.

3.9 Pottery

3.9.1 ETHNOGRAPHIC ACCOUNTS

In Neolithic contexts, one of the contact-materials that has to be considered is pottery. It is conceivable that stone tools were used during the manufacturing process, for instance for scraping the inside of a pot after the clay had partially


Fig. 30 Shooting transverse arrow heads at a dead roe-deer.

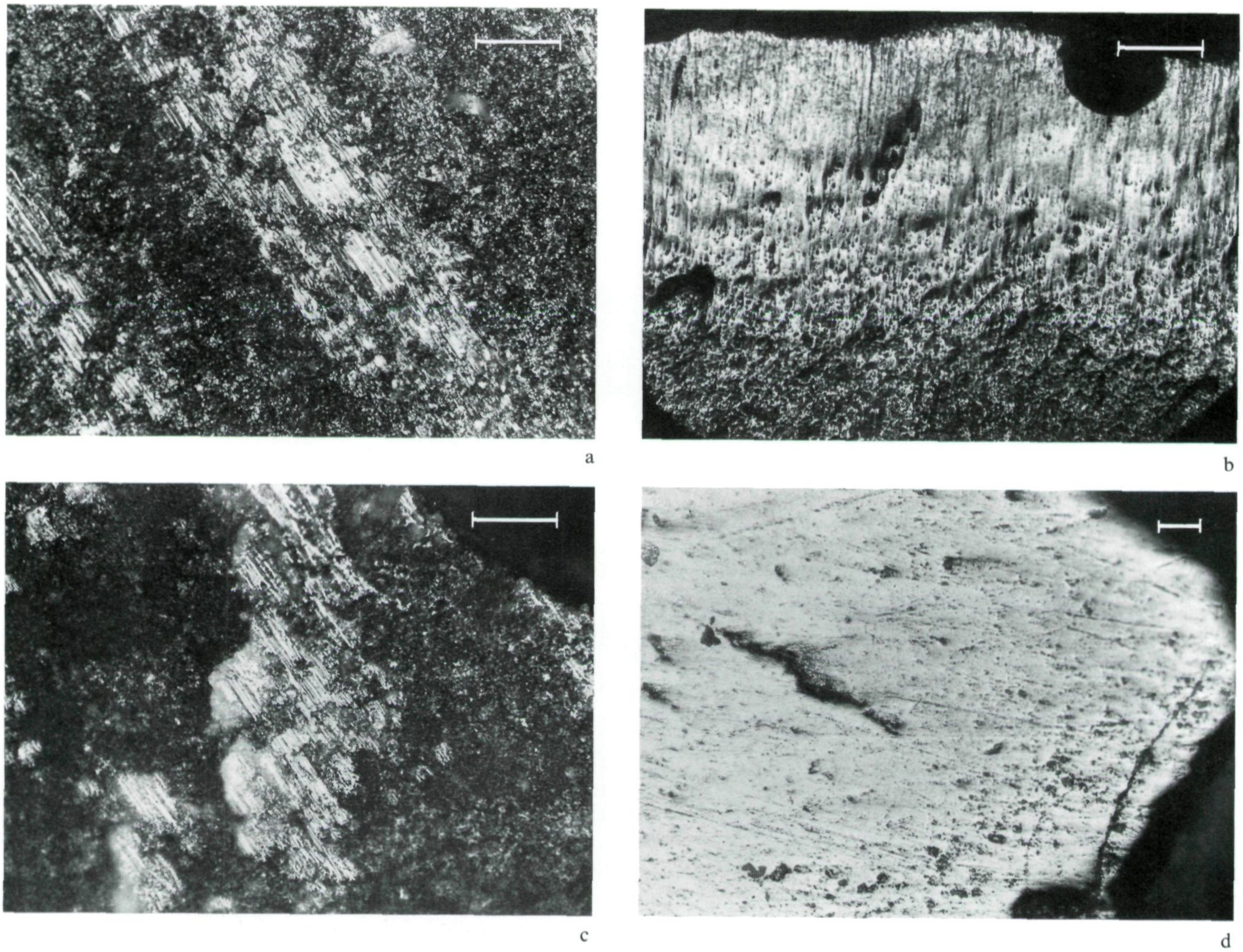

Fig. 31 Micrographs of experimental wear-traces. All scale bars equal 50 μ. a) microscopic linear streaks of polish (MLIT) resulting from use as projectile on experimental tool 129 (200x), b) polish on experimental tool 199 employed for scraping dried clay (200x), c) wear-traces on experimental tool 78 used for cutting limestone (200x), d) well-developed polish resulting from cutting sods, observed on experimental tool 182 (100x).

dried, or for decoration. It is also possible that flint borers were employed for repairing baked pottery. Hardly any ethnographic examples of the use of flint for pottery making were found. The Cocopa in California are reported to have used an unhafted stone blade, or a clam or oyster shell, to shape a pottery vessel (Gifford 1934). In general, ribs of sheep or pigs are said to perform that function. No instances were found of the use of flint borers for the repair of baked vessels.

3.9.2 WEAR-TRACES FROM POTTERY

Six scraping and two boring experiments were done, involving a total of three hours and five minutes of work (*appendix II, table 10*). The scraping experiments all involved dry clay, either untempered or tempered in various ways. In two cases a retouched edge was used, but this was clearly unsuitable as the retouch scratched the clay surface too much: an unretouched obtusely-angled blade was much more appropriate. On all six tools a heavily rounded edge developed, as well as a highly reflective polish, extending far back into the piece. The polish was distributed in a wide band (*figs. 31b, 32a*), had a rough and matt texture, a corrugated topography, and a directionality perpendicular to the edge. In six instances the polish was very bright (*fig. 32b*). In the cases with quartz- or chamotte-tempered clay, deep, long, and wide striations developed. Only once (exp. 199) did use-retouch occur, probably due to the acute angle of the working-edge. The two boring experiments did not cause a similar heavy edge-rounding, perhaps because both implements were only used briefly. A rather dull, rough, matt polish developed on protruding points. On the tool employed for boring chamotte-tempered baked clay, some edge-damage occurred.

With respect to the scraping of dried, unbaked vessels, it does seem that characteristic wear-traces are produced on a 100% basis after a relatively short period of time. The boring of baked vessels seems more problematic in terms of the development of wear-attributes: although both tools were only briefly used, it is doubtful whether the polish would have increased, as edge-damage would have eliminated the polish spots.

3.10 Stone, shell and teeth

3.10.1 ETHNOGRAPHIC ACCOUNTS

Many people use soft stone, shell or teeth ornaments. It is likely that flint tools often played a role in their manufacture. Again, however, reports on the process of manufacture are extremely rare. Among the Surprise Valley Payute, pipes were made of soft stone, and obsidian blades were used to scrape out the cavity (Kelly 1934). It is also assumed that flint tools were used for sawing soft stone or shell, but no ethnographic accounts were found on this matter.

3.10.2 WEAR-TRACES FROM STONE, SHELL AND TEETH

Only one experiment (*appendix II, table 11*) was performed on soft stone: a slab of limestone was cut for seven minutes, resulting in severe edge-damage (overlapping, hinged scars), and isolated spots of polish. Striations also developed (*fig. 31c*). Clearly, it is not possible to base conclusions on only one experiment; it is intented to direct more experiments towards working with various types of stones in the future. The same applies to the category teeth; with this material only one experiment was done as well. Edge-removals had a square or trapezoidal shape, and stepped terminations: the polish was rough and matt, distributed on the protruding parts of the implement, and displaying clear directionality.

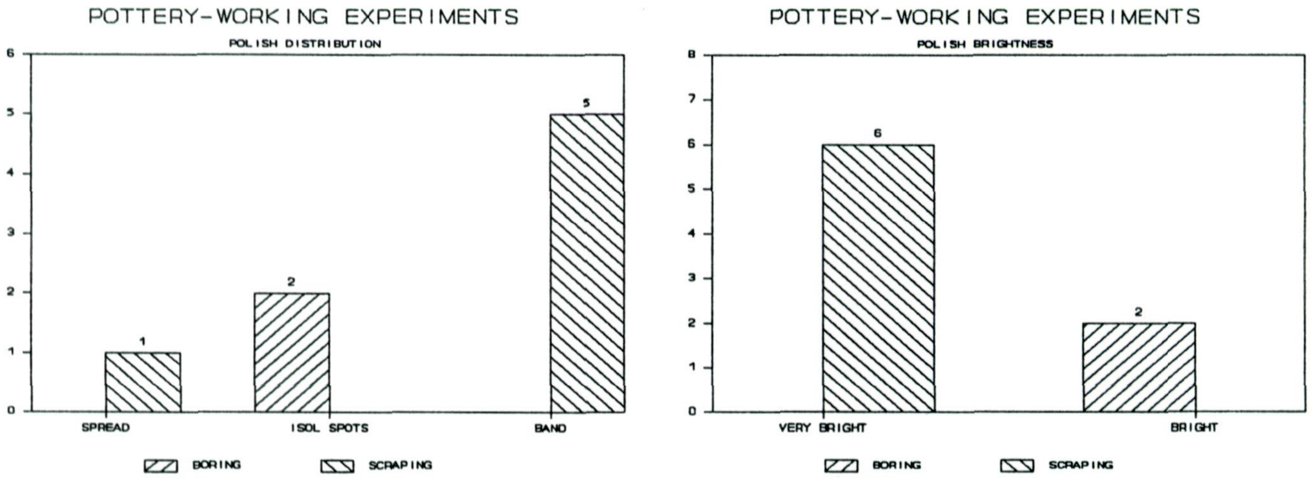

Fig. 32 Lotus graphs displaying polish characteristics from working pottery. a) distribution, b) polish brightness.

More experiments were performed with shell, mostly concerning a boring motion. Edge-scarring was frequent; of three implements the entire tip broke off, on the others square or trapezoidal stepped scars occurred. The polish was never extensive, localized as it was on protruding points (*figs. 33a, 33b*), while striations were not observed.

3.11 Soil

3.11.1 ETHNOGRAPHIC ACCOUNTS

Soil as contact-material is somewhat ambiguous. There are many ways in which flint implements can come into contact with soil without an intentional (human) action being responsible, such as in the case of soil remnants on a root being cut (see *3.5.2.1*), putting the implement down on the ground, or simply post-depositional contact. Here, the concern is with soil as an intentional contact-material, i.e. during hoeing and sod-cutting. Californian Indians are known to have employed obsidian hoes (R.Whallon *pers. comm.*). Ethnographic parallels for the use of flint tools for cutting sods have not been found.

3.11.2 WEAR-TRACES FROM SOIL

Only five experiments involved soil (*appendix II, table 12*). Four concerned sod-cutting experiments performed to test the suitability of crescent-shaped sickles for this purpose (cf. Van Gijn 1988, *in press b*). The fifth tool was used for hoeing. A total of 220 minutes of work is represented. Very little use-retouch occurred, while edge-rounding was extensive. Polish developed quickly; in all cases it displayed a spread-out distribution, a matt, rough texture, a flat topography, and extreme brightness (*fig. 31d*). Examined with the naked eye this polish clearly resembles 'sickle-gloss' (Van Gijn 1988, *in press b*). Striations were long and narrow, with varying depth and a random or parallel directionality. As the wear-traces on all five tools were identical, no graphs were made.

3.12 Counting experimental wear-attributes

In the preceding pages the various wear-attributes, as they occur on the experimental tools, were presented. It is apparent that characteristics deemed unique for a certain contact-material do not always develop. For example, a cratered (or sometimes pitted) topography is commonly associated with hide, but was only present on 20 out of the 49 tools. Characteristic 'wood-polish' is supposed to be domed: a mere 38 of the 53 tools with polish displayed this feature (of 62 experimental tools). 'Bone-polish' has comet-tails and/or pits or, in the case of scraping-tools, a bevel; 32 of the 53 implements showed one or more of these features. Of the harder contact-materials, 'antler-polish' especially lacks distinctive attributes which would differentiate it from 'wood'- or 'bone-polish'. As far as the more yielding contact-materials are concerned, the absence of distinctive wear-traces is even more evident. If we exclude the experiments with turnip (which actually mainly involved contact with the sandy root-surface), non-silicious soft plants rarely produce polish or use-retouch. If damage occurs, it is non-distinctive. The same applies to contact with meat. Silicious plants however, whether it be wild species or domesticated cereals, produce a very distinctive polish within a short time with a spread-out distribution. Impact damage on projectile points is quite distinctive and develops frequently. Too few experiments were done with other categories of materials to allow conclusions to be drawn.

Looking at the results in a slightly different way, cross-tables were made of contact-material and motion, noting

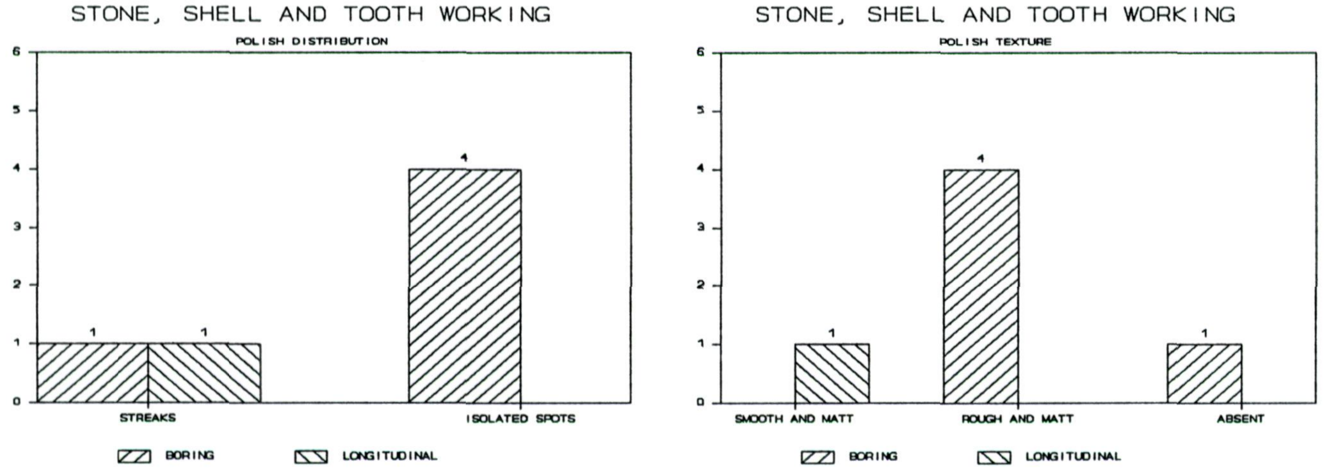

Fig. 33 Lotus graphs of polish on experimental implements employed on stone, shell or tooth. a) distribution, b) texture.

Table 1 Experimental tools: frequency of the occurrence of polish according to contact-material and motion. * concerns carving bone, ** includes the four experiments with turnip, involving extensive contact with the soil particles adhering to the root's surface.

	longitudinal	%	transverse	%	boring	%	other	%	total	%
hide	9/15	60	22/28	70	1/6	17	–	–	32/49	65
wood	16/17	94	29/35	83	3/3	100	5/7	71	53/62	86
bone	15/15	100	13/15	87	3/4	75	19/19	100*	50/53	94
antler	5/5	100	6/7	86	3/5	60	0/1	0	14/18	78
silicious wild plant	22/23	96	–	–	–	–	1/1	100	23/24	96
non-silicious wild plant	6/10	60**	1/1	100	–	–	–	–	7/11	64
cereals	20/20	100	–	–	–	–	1/1	100	21/21	100
butchering	6/8	75	–	–	–	–	–	–	6/8	75
meat	2/4	50	–	–	–	–	–	–	2/4	50
fish	12/16	75	4/5	80	–	–	2/6	33	18/27	67
projectile	–	–	–	–	–	–	6/9	67	6/9	67
pottery	–	–	6/6	100			2/2	100	8/8	100
shell/stone	1/3	33	–	–	5/8	63	–	–	6/11	55
soil	4/4	100	–	–	–	–	1/1	100	5/5	100

Table 2 Experimental tools: frequency of the occurrence of edge-removals according to contact-material and motion.

	longitudinal	%	transverse	%	boring	%	other	%	total	%
hide	4/15	27	0/28	0	1/6	17	–	–	5/49	10
wood	15/17	88	11/35	31	0/3	0	0/7	0	26/62	42
bone	14/15	93	4/15	27	0/4	0	17/19	90	35/53	66
antler	5/5	100	1/ 7	14	0/5	0	0/1	0	6/18	33
silicious wild plant	7/23	30	–	–	–	–	0/1	0	7/24	29
non-silicious wild plant	3/10	30	1/1	100	–	–	–	–	4/11	6
cereals	6/21	28	–	–	–	–	–	–	6/21	29
butchering	4/8	50	–	–	–	–	–	–	4/8	50
meat	2/4	50	–	–	–	–	–	–	2/4	50
fish	15/16	94	3/5	60	–	–	2/6	34	20/27	74
projectile	–	–	–	–	–	–	7/9	78	7/9	78
pottery	–	–	1/6	17	1/2	50	–	–	2/8	25
shell/stone	3/3	100	–	–	4/8	50	–	–	7/11	64
soil	0/4	0	–	–	–	–	0/1	0	0/5	0

presence or absence of polish (*table 1*) and edge-removals (*table 2*). No table was made for the presence of striations as these occurred rarely, with the exception of longitudinal motions on wood: this resulted in striae on 8 of the 17 implements used in this fashion.

If we examine table 1 it can be seen that polish (whether it displays particular characteristics or not) is present on a very large percentage of the used implements. Cereals, soil and pottery even cause polish on a 100% basis. Silicious wild plants, such as reeds, and bone score also very high: in 96% and 94% of the cases, respectively, a polish developed. The rather low score of hide (65%), commonly regarded to develop microwear-traces relatively quickly, and of a quite diagnostic nature, needs some explanation. Included in this score are experiments with modern leather, which in most instances was dyed; this material caused polish in only five of the 11 cases. If we omit these present-day 'pollutive' experiments, the frequency of the occurrence of hide-polish increases to 71%. Antler and butchering also score c. 70%, while wood produces polish in 86% of the experiments. MLITS on projectile points developed on 67% of the tools. The rather high percentage of polish occurrences on soft plants is due to the inclusion of the experiments with turnip, which actually mainly involved contact with soil. If we omit these four implements, the score drops dramatically to 20%. The 50% for meat is also too high, as experiment 164 is included, which involved contact with bone; omitting this implement produces a score of 25% for meat. However, the numbers involved here are so low, that quantitative comparisons are meaningless. Fish produced traces in more cases, 67%, but this is complicated by the fact that this concerns 'bone-polish' in most cases, while traces really characteristic of contact with fish occurred on only 26% of the tools. In the case of the shell/ stone/ teeth-category, the relatively low score of polish occurrences (55%) is due to the removal of polish by use-retouch.

Percentages of the occurrence of use-retouch produce a different picture (*table 2*). Hide scores extremely low: only 10% of the tools display scarring. Plants score around 30%; the high score for non-silicious plants is due to the experiments with turnip, which has a very resistant skin. The 50% score of meat is due to the inclusion of experiment 164 (see above).

The low score for pottery can be attributed to the fact that it concerned dried (not baked) material. Projectile points display impact scars on 78% of the implements. Rather surprising are the relatively low total scores for bone, wood and antler (66%, 42% and 33% respectively). However, if we examine the percentages per motion, it is clear that longitudinal motions scored extremely high for these three materials (93% for bone, 88% for wood, and 100% for antler). In contrast, transverse motions scored extremely low, especially for antler (14%); such motions are commonly carried out parallel with the grain, while the used tool edge is more stable due to retouch and a steep edge angle.

The results described here conform generally with the unfortunately rather few instances in which experimental results are quantified (Fisher et al. 1984; Vaughan 1985a). The relatively more frequent development of polish, when compared to the occurrence of use-retouch, is somewhat surprising. The low-power approach seems, considering the infrequent occurrence of scarring on some experimental tools, to be potentially missing used tools, especially if compared with the high score of polishes. However, it should be stressed that this polish is not always distinctive or well-developed and could thus be easily missed or misinterpreted on archaeological implements. This is especially the case, because polish is more vulnerable and can be more easily modified, even after relatively minor chemical or mechanical attack. I would think, therefore, that the instances in which used pieces would be missed in archaeological assemblages could be about equal for both approaches. Certainly, softer materials such as meat and non-silicious plants will be under-represented in both low- and high-power analyses (Shea 1988: 71). From tables 1 and 2 it can be seen that in certain cases polish development is strong, with edge-scarring being absent (i.e. hide), while in other instances the opposite is observed (i.e. stone, shell, teeth). The most profitable avenue of approach would thus be a combination of low- and high-power analyses.

notes

1 In fact *Equisetum*, or scoring-rush as it is called, is reported to have been used by the Klamath to smooth wooden arrow shafts (Spier 1930: 195). Carpenters in Denmark used it to finish furniture (H.Juel Jensen *pers.comm.*).

2 A mixture of resin and bee-wax works well, but the relative amounts needed from the two components depend on the weather. When the work is carried out in hot temperatures, more resin is needed for better adherence. In cold weather, one has to add more wax to improve the flexibility which prevents the flint inserts from breaking out of the haft.