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Interpretation of agricultural activities

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The question of plant exploitation, including husbandry or cultivation, can be addressed in the archeological record by attempting to identify the operation carried out (ex. tilling, gathering, processing, storage) from data such as :

– plant remains which may represent the part of the plant used or the part left behind after use (pollen, and macroremains -seeds, glumes, stems, roots, or phytoliths, which are siliceous microremains of the latter three categories) ;

– microtraces on tools, showing use to work soil, or harvest and process plant material ;

– soil micromorphology characteristics (ex.due to tilling) ;

– ard or plow marks ;

– other data which may in particular cases be related to grain storage, ex. rodent remains, structures.

The first three data categories in particula are in the process of development as methods of archeological analysis, often use similar techniques of observation, and have the same kinds of restrictions as to interpretation : all require a copious reference framework of present-day, experimental, or ethnographic data. (A great deal of important research on agriculture has been carried out in all of the above areas, much of it recent and ongoing ; I regret there is not space here to cite more than a very few studies as examples, for others see articles *in* Anderson (Ed.), 1992 ; *in* Harris and Hillman (Ed.), 1989 and *in* Cauvin (Ed.), 1991.)

Tools can sometimes provide the only evidence of the *technique* used for an *operation* related to particular plants or parts of plants (or to soil). Use alters the parts of the tool edge and surface which repeatedly contact the worked material according to : the particular properties of the material (hardness, granularity, humidity, degree of homogeneity, mineral content etc.) in the state it was worked, and the use-action (force, direction, length and angle of each stroke, etc., corresponding to scraping, cutting, grinding, etc.). These variables occur in particular ways according to the operation carried out and can be perceived through observation of alteration of tool micromorphology (ex. wear traces : polish, striations, edge damage) using the naked eye and microscopes, or residue material may be identified using microscopy and analysis of mineral residues, or chemical analysis of organic residues. Of course, not all tools thought to have « sickle gloss » were used to harvest grasses and cereals, or even plant material, again underlining the need for careful experimentation and microwear analysis to discriminate processing of crops, for example, from such operations as shaping of clay recipients when wet (Anderson-Gerfaud *et al.*, 1989), working of soil, cutting of sod (Van Gijn, *in* Anderson (Ed.), 1992), and working of plant material for artisanal uses (ex. Juel-Jensen, 1988) with sickle-like tools.

Characteristic reference data from known living equivalents of plants in the archeological record – regional and climatic context, cultivation techniques, « behavior » in response to different operations, etc., which can be gleaned from ethnology (ex. Sigaut, *in* Cauvin (Ed.), 1991), phytosociology (ex. Hillman, 1984), and, particularly, experimental reconstruction inspired by these other observations – can help in interpreting archeological materials in several ways : by providing precise technical data (ex. characteristic micromorphology of plant remains, of different use-traces on tools) ; by pointing to the context and effect of the *operation* as a *technique* (see Sigaut, *op. cit.)* ; and, at another level of inference, by placing an identified operation in a related sequence (as a link in a *chaîne opératoire*) of plant exploitation. Most of the links in this sequence may be missing from the archeological record, because of such factors as destruction of remains due to subsequent natural and human action such as activity location away from the site, or that no (recognizable) tools or structures were used. This last situation could correspond to preparing fields using wooden tools which were not preserved (Koda this chapter, Skakun this chapter) ; to harvesting grain by uprooting the plant, or by beating or picking the seed heads ; to de-husking glumed cereals using a wooden mortar and pestle, or even just a hole, pebbles and a tree trunk (Stahl, *in* Hillman, Harris (Ed.), 1989 : 175).

Experimenting with tools in early agricultural contexts can require creating elaborate, long-term experimental frameworks ; experimental reconstructions of ancient agricultural field conditions have tested cultivation of the kinds of plants which correspond to grain found in Neolithic, Chalcolithic, Bronze Age and Iron Age sites in Europe, Central Asia and Southwest Asia, using corresponding tool types, recording tool efficiency, and, in a few cases, traces and products produced by their use. Examples include Steensberg and Lerche (Steensberg 1986) in Denmark, members of Semenov's laboratory in St Petersburg (see articles by Korobkova and Skakun in this chapter, Korobkova, 1981), Reynolds (Anderson (Ed.), 1992) at Butser Farm in southern England, Meurers-Balke and Lüning (*in* Anderson (Ed.), 1992) in Germany, and Anderson-Gerfaud and Willcox (Anderson-Gerfaud *et al.*, 1991) in the Mediterranean region of France. Experiments concerning agriculture in the New World were carried out by Koda (this chapter), who found, through analysis of use-traces, that certain of the wooden paddle-shaped objects from historic contexts in Peru were used to harvest ears of maize, cultivate fields or dig irrigation ditches, recalling similar tools for the latter two uses from Denmark and New Guinea (Steensberg, 1986).

Particular agricultural techniques can correspond to certain cultures, cultivars, climates, regions, and periods – for examples see Skakun, this chapter, concerning sickles and threshing tools, and Sigaut (*in* Cauvin (Ed.), 1991) concerning harvesting operations and tools, and Sigaut (*in* Anderson (Ed.), 1992) and Hillman (1984) concerning practical factors influencing choice of techniques. Harvesting plants by cutting stems with a tool dates (with sporadic examples) from the Paleolithic, but later in time, with an evolution of plant exploitation towards agriculture, this operation plays a different rôle in its new context. It may concern different plants than earlier, and operate on a much different scale (much more plant material harvested or processed at a given time), increasing complexity, intensity and standardization of operations and treatments. These factors may be reflected in tools which become increasingly standardized and better adapted to performing certain operations according to the techniques opted for by a particular human group.

A technique or activity can point to other links in the *chaîne opératoire*. For example, certain « harvesting knives » from the Horgen (Neolithic) in Switzerland show traces indicating use to strip seed heads from plants in the field, pressing stems against the thumb and pulling upward on the stems (Anderson-Gerfaud *et al.*, 1991) ; as only grain was taken in this operation the straw was either left standing in the field or harvested separately by uprooting or by using a sickle ; this technique recalls harvesting of seed heads by pulling them off using *mesorias* (Sigaut, *in* Cauvin (Ed.), 1991). A similar operation – removing seed heads from stems by pulling them against a tool – was identified for the Neolithic of Ganj Dareh

(Iran). However, experimentation and distribution of the various wear traces, described elsewhere (Stordeur, Anderson-Gerfaud, 1985), showed these abundant tools, made from scapula, were not used *in the field* to pull grain off the plant like the Horgen knives cited earlier, but rather to treat cereals which had already been harvested with stems . These were pulled against the tool as it was held motionless against a hard, curved surface (branch, bone, etc.). In this case other parts of the *chaîne opératoire* can be imagined : long stems needed for the use of this tool implies stems and grain were harvested together, and possible sickles, querns and other groundstone tools and storage structures also found at the site add to the impression of an organized, intensive sequence of treatments of cereal products, despite the site's dating to the beginning of known agricultural practice in the Zagros region. Experimentation with both of the techniques described above, using various grasses and both wild and domestic cereals, shows they appear to function far better for semi-solid rachised domestic cereals, as opposed to either wild grain or for free-threshing cereals such as bread wheat (because of seed loss), which agrees with the kinds of cereals found in the sites with these tools. On the contrary, the threshing sledge or *tribulum*, attested by Chalcolithic flakes from Bulgaria and whose use is described from ethnography (Skakun, this chapter and see Ataman *in* Anderson (Ed.), 1992), would appear to be most effective for free-threshing grain types and process plants whose stems and seed heads were harvested in the same operation. The beginnings of plant cultivation worldwide, whether cultivation of wild crops and domestication were indigenous, or agricultural technology arrived with domestic grain through diffusion (see articles by Korobkova and Skakun, this chapter), involve change in the kind of plant used and differences in plant morphology between domestic and wild plants which cause grain to stay on the domestic plant rather than fall to the ground at ripeness as for wild plants, as well as perhaps differences in how tightly the grain is enclosed in its enveloping glumes. These morphological features may be reflected by changes in harvesting and processing techniques.

Part of the research devoted to understanding the transition from simply gathering to the cultivation of wild plants, involves experiments harvesting wild cereals, using sickles and other techniques, in their various natural environments, thought to be among those which prehistoric humans exploited, in Anatolia (Harlan 1967 ; Hillman, Davies, *in* Anderson (Ed.), 1992) and the southern Levant (Unger-Hamilton, *in* Anderson (Ed.), 1992). The actual beginning of cultivation of cereals in their wild form is in fact difficult to prove archaeologically at the present time. Current studies reason that annual cultivation of wild cereals would have had to occur over a more or less long period in a few areas of the Levant, where the first domestic cultivars appear in Southwest Asia, because the domestication process involves fixing (unconscious) selection (by sowing) of « domestic-type » plants which are naturally very rare in a wild cereal population (*ibid.* and Zohary, *in* Harris, Hillman (Ed.), 1989). Various estimations have been made of the length of time needed for cultivation to bring about domestication in different situations (Hillman, Davies, *in* Anderson (Ed.), 1992 ; Willcox, *in* Cauvin (Ed.), 1991). The latter estimates are based upon experimental cultivation of wild wheat and barley from southwest Asia in a Mediterranean climate in southern France, at Jalès (Anderson-Gerfaud *et al., op cit.*), measuring effects of different harvesting techniques and recording use-traces produced on the corresponding tools. Interestingly, the last three studies cited above indicate sickle harvesting is one of the techniques which can produce selection towards domestication – if combined with certain cultivation practices. Comparison of these experimental tools with Natufian and Neolithic tools from various Levantine sites having wild cereal remains shows some archeological tools correspond to experimental harvest of wild cereals fairly near the ground, cutting handfuls of stems at a time ; these plants, which ripen unevenly, would have been harvested at about a « green » stage of maturity. These data suggest : stems grew fairly densely ; green harvest (which leaves particular traces different from ripe harvest, due to measurable difference in stem humidity in the two cases, (Anderson, *in* Anderson (Ed.), 1992)), would have caused a minimum of grains to spill, and germination tests on equivalent modern grains indicate that the grains harvested at this stage would already have been viable, contrary to popular notion. However, grain which inevitably spilled on the ground even when harvest occurred at the green stage would grow into a field of wild cereals for years afterwards. This implies that sowing did not need to take place annually as long as cereals cultivated were of « wild » type (an option no doubt attractive to a sedentary human population, but which unfortunately reverses the effects of any unconscious selection for the domestic-type cereals). Also complicating the picture of this early cultivation is that experiments indicate wild cereals do not need nor thrive on working of the soil. Soil-working tools are as of yet unknown in these contexts, and experimental tools used to harvest wild grasses, cultivated wild cereal and domestic cereal show that striae present on harvesting tools from the Natufian and early Neolithic of the Near East are better interpreted simply as due to their proximity to the soil during use and intensity of use, rather than as showing the soil was tilled. This stage recalls more recent examples of cultivation of wild grasses in North America (Shipek, *in* Harris, Hillman (Ed.), 1989) which did not produce complete domestication, where the soil was not prepared and sickles were used for harvest.

If we move towards the other end of the *chaîne opératoire*, precise use-trace studies of groundstone tools capable of showing pounding and grinding of particular plant materials are only beginning ; new experimental, historic and ethnographic data concerning use of these difficult-to-analyse tools include Schoumacker (this vol.) ; Meurers-Balke and Lüning, and Grégoire (*in* Anderson (Ed.), 1992), and several papers in Harris and Hillman (Ed.), 1989. Infra-red spectrometry (Mc Laren *et al.*, 1990), along with new field and genetic studies of plants, has been successful in identifying the precise plant type from partial (including ground) grain residues, illustrating promise held by co-operation between archeologists and microwear analysts, botanists, geneticists and chemists for better understanding uses of groundstone (and, eventually, other) tools.

The research presented in this chapter includes experimental, ethnographic and archeological analyses of tools of wood, antler, bone, and various lithic materials which were used for a gamut of pland food-producing activities from soil preparation to grinding of grain and processing of tubers ; it constitutes an important contribution to our present knowledge and future perspectives for retracing the history of agriculture in the archeological record.

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