in Luristan. In Ethnoarchaeology: The Implications of Ethnography for Archaeology, edited by C. Kramer, 192-218. Columbia University Press, New York.

Kintigh, K.W. and A.J. Ammerman 1982 Heuristic approaches to spatial analysis in archaeology. American Antiquity 47:31-63.

Kramer, C. 1979 An archaeological view of a contemporary Kurdish village: domestic architecture, household size and wealth. In Ethnoarchaeology: The Implications of Ethnography for Archaeology, edited by C. Kramer, 139-63. Columbia University Press, New York.

Lees, S.H. 1979 Ethnoarchaeology and the interpretation of community organization. In Ethnoarchaeology: The Implications of Ethnography for Archaeology, edited by C. Kramer, 265-76. Columbia University Press, New York.

Murray, P. 1980 Discard location: the ethnographic data. American Antiquity 45:490-502.

Orton, C. 1982 Stochastic processes and archaeological methods of spatial analysis. Journal of Archaeological Science 9:1-23.

Schiffer, M.B. 1972 Archaeological context and systemic context. American Antiquity 37:156-65.

Schiffer, M.B. 1976 Behavioral Archaeology. Academic Press, New York.

Sumner, W. 1979 Estimating population by analogy: an example. In Ethnoarchaeology: The Implications of Ethnography for Archaeology, edited by C. Kramer, 164-74. Columbia University Press, New York.

Sweet, L. 1979 Tell Toqaan: A Syrian Village (Museum of Anthropology, Anthropological Paper 14). University of Michigan, Ann Arbor.

Watson, P.J. 1979 Archaeological Ethnography in Western Iran (Viking Fund Publications in Anthropology 57). University of Arizona Press, Tucson.

Whallon, R. 1973 Spatial analysis of occupation floors I: the application of dimensional analysis of variance. American Antiquity 38:266-78.

Whallon, R. 1974 Spatial analysis of occupation floors II: the application of nearest neighbor analysis. American Antiquity 39:16-34.

Winter, M. 1976 The archaeological household cluster in the Valley of Oaxaca. In The Early Mesoamerican Village, edited by K.V. Flannery, 25-31. Academic Press, New York.

Yellen, J.E. 1977 Archaeological Approaches to the Present: Models for Reconstructing the Past. Academic Press, New York.

Address: Department of Anthropology and Sociology
University of Queensland,
St. Lucia,
Queensland 4067,
Australia

THE ETHNOARCHAEOLOGY OF CROP PROCESSING: SEEDS OF A MIDDLE-RANGE METHODOLOGY

Glynis Jones

In recent years, there has been a growing interest in the study of past agricultural practices from the archaeologically recovered charred remains of crop plants. It is no longer considered sufficient to provide a list of the species from each site, area or archaeological period and attempts are being made to understand some of the techniques used for the cultivation of crops. What is lacking is a sound methodology for linking archaeologically recovered plant remains to past human agricultural activities. This problem has been emphasised in a wider archaeological context by Clarke (1973), Schiffer (1976) and Binford (1977) who have stressed the need for the development of, respectively, 'interpretive theory', 'behavioural archaeology' and 'middle-range theory' or 'middle-range research' (Binford 1981) for relating past human dynamics to contemporary static observations. Though the distinction between general and middle-range theory is not always clear, it does have some utility as a framework for the critical examination of some problems of archaeological method. In this paper, therefore, ethnoarchaeology will be used as a means of generating a middle-range methodology for the interpretation of archaeological plant remains (see also Hillman 1973, 1981).

Only some of the aspects of middle-range research distinguished by Clarke and Schiffer will be discussed here (see Figure 1). In the first place, only the predepositional correlates, i.e. the relationship between agricultural practices and the plants themselves, will be considered. A further distinction can be made between the husbandry practices applied to crops in the field and the processing sequence to which they are subjected after harvest. The former are best tackled by reference to ecological rather than ethnographic models and so will not be considered here. I will be concerned, then, only with the problem of crop processing (see Figure 1), which provides a suitably compact study that can be used to illustrate some of the more general benefits and problems of using ethnoarchaeology to generate a middle-range methodology.

One of the main reasons for studying crop processing is that it acts as a 'filter' on archaeological plant material and must, therefore, be controlled in any further interpretation of this material. This 'taphonomic' (cf. Efremov 1940 and Figure 1) role of crop processing studies was stressed by Dennell (1972) who noted that the effect of crop processing activities, and therefore of archaeological context, on the composition of archaeobotanical samples should be taken into account before any attempt is made to reconstruct a prehistoric crop economy. For instance, husbandry practices, such as choice of soil, tilling methods, time of sowing, fallowing, rotation, irrigation and so on all have an effect on the weeds which grow in cultivated fields and so are potentially detectable by archaeobotanical analysis of weed seeds.

However, only some of these weeds will be in seed at harvest time and not all of them will necessarily be harvested. Furthermore, weed seeds will be removed at different stages of crop processing and so it is useful to distinguish samples resulting from these different stages. It is then possible, when analysing weed seeds from different samples for the purposes of understanding crop husbandry, to compare like with like (Jones 1981).
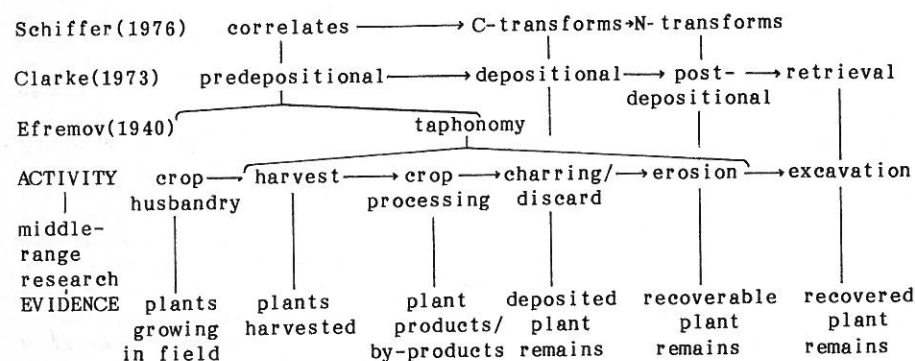

Figure 1: The archaeological investigation of crops.

The problem, then, is one of inference -- how can we identify archaeological samples resulting from different stages in the crop processing sequences applied to them? For this we must inevitably resort to the present since only here is the link between activity and material observable (Hillman 1973, 1981:126-7; Binford 1981:25-30; Hodder 1982:11-12). There are, undoubtedly, problems with analogies between the past and the present since similarity between the present and the past in one respect or context does not necessarily imply similarity in another (Binford 1981:27-8; Hodder 1982:12-14). In this study, however, uniformitarian assumptions about people have been avoided and assumptions are made only about plants and their behaviour under certain physical conditions. This relationship is causal and relevant (cf. Binford 1981:ch.2) and so this type of analogy is of the 'relational' rather than the 'formal' kind (cf. Hodder 1982:16-24). It is also important, of course, to take account of the context within which these analogies apply (Hillman 1981:126-38; Hodder 1982:24-7) and it will be argued below that crop processing analogies are relevant in a broad context. Lastly, by the use of relational analogy, it is possible to predict the effects of some hypothetical processing stages.

There are two possible sources of present-day analogies for crop processing -- these are the experimental and ethnographic approaches (Hillman 1981). The experimental approach has the advantage that it is repeatable and can be closely controlled, and it is also theoretically possible to try out an infinite range of processes and combinations of processes. The ethnoarchaeological approach has the advantage that the techniques are performed by experienced operators and that the range of alternative methods is bound by a different cultural context than that of the observer and is, therefore, often wider, in practice, than that which can be thought up by the observer. What the ethnographic approach loses in experimental control and repeatability, it gains in experience and cultural independence (cf. Hodder 1982:29-31). Ideally, a combination of the two is desirable -- existing present-day practices can be observed ethnographically and experimentation, using some of the skills learnt ethnographically, can be used to explore the possibilities of techniques not practised today. This paper, however, is concerned only with ethnographic models of crop processing.

The ethnographic work discussed here was carried out on the Aegean island of Amorgos and all the samples collected were from crops cultivated by traditional methods (see also Jones, in press). The crops included bread and macaroni wheats, six-row hulled barley, oat, pea, lentil, common vetch and grass pea, all of which were processed for dry storage. The processing sequence applied to these crops is complex and very similar to that described by Hillman (1981) for free-threshing cereals and pulses in Turkey. Only the major stages in the sequence will be described here (Figure 2). The by-products of these stages are relatively long-lived and, partly for this reason, are the most likely to be exposed to fire and so to the possibility of preservation by charring.
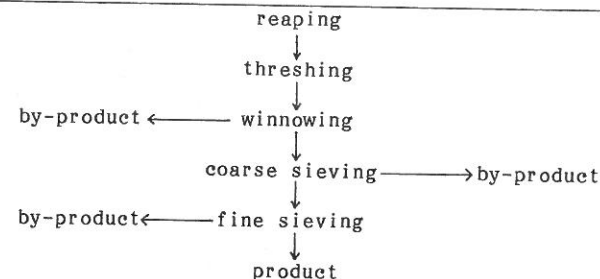

Figure 2: Simplified crop processing sequence.

Cereals were reaped with a sickle and pulses either uprooted or, reaped with a scythe. Threshing was accomplished by trampling with the hooves of animals driven around a circular threshing floor. This serves merely to release the grain from chaff and seeds from pods -- no separation of crop or weed components is involved. The next stage in the process was the separation of the chaff and straw (leaf stem and pod in the case of pulses) from the grain by winnowing. This was done by tossing the threshed crop into the air with a winnowing fork; light chaff and straw were carried aside by the breeze and the grain and

heavier chaff and straw fragments fell straight downwards.

.Coarse sieves, which allow grain to pass through them while retaining large straw fragments, weed heads, unthreshed ears, etc., were used on the partly winnowed crop, on rakings from the top of the grain pile and on the fully winnowed grain. At this stage, the light chaff and straw (the winnowing by-product) were stored as animal fodder and the heavy chaff and straw (the coarse sieve by-product) were fed to working animals. Both these by-products were sampled as they could be burnt accidentally during storage or as fuel (Hillman 1981). The grain was stored for human food to be further processed as needed.

This later processing involved the use of fine sieves which retain the grain but allow small weed seeds, etc., to pass through them. The by-product of this fine sieving was fed to chickens and the product was further cleaned by hand to remove the remaining weed seeds, etc. Both the fine sieve product and by-product were sampled as the former may be accidentally charred in storage and the latter thrown onto household fires where domestic fowl are absent. A total of 216 samples was taken from the four major products and by-products for eight different crops.

Some comment should be made on the cross-cultural and archaeological applicability of this sequence. It is clear from ethnographic and ethnohistoric accounts and also on a priori grounds that crop processing can only be achieved practically in a limited number of ways, given a traditional technology (Hillman 1981). Though the details may vary and, in particular, the implements used, the processing stages remain essentially the same and so, more importantly, do their effects on composition. Thus, the effect of winnowing is to separate the light component of the threshed crop from the heavy component, regardless of whether it is performed with a fork, a basket or by hand. Similarly, sieves, regardless of how they are made, must be of very specific mesh sizes if they are to achieve the separation desired. It is difficult to envisage a method of separating chaff from grain which would not involve wind as the agent of separation and yet would not take more energy than is provided by the food being cleaned. Likewise, to remove every small weed seed without the use of sieves would be prohibitively time-consuming. Moreover, the sequence of processes is unlikely to vary much. For example, it would be extremely difficult to sieve before winnowing as an unwinnowed crop is very bulky.

Interestingly, the inhabitants of Amorgos themselves classify the by-products of processing not according to the stage from which they were derived but according to their composition, as this determines their different uses as winter fodder, immediate fodder for work animals, chicken feed and so on. Coarse sievings, for example, are locally referred to as kondala, literally meaning 'straw nodes'. Such amalgamations of by-products as occur are usually between those of similar composition, which is encouraging news for the archaeobotanist interested primarily in the effect of crop processing on composition. Mixing between similar products and by-products from different crops is also

more likely than is mixing of products and by-products from different stages.

Depositional mixing at the refuse disposal stage remains a possibility but mixing between by-products of different stages, if not of different crops, should still be detectable. Thus the absence of mixing cannot be assumed but it is possible to demonstrate empirically whether or not it has occurred. Mixed samples should have characteristics intermediate between two or more by-products. It is difficult to see how, for instance, the mixing of any combination of products and by-products could imitate a fine sieve by-product. Only the intermediate products of processing stages could be satisfactorily replicated by mixing, in the correct proportions, the product and by-product to which they give rise. However, archaeological context may still permit distinction between them, and the situations in which such mixing would have occurred are likely to be comparatively rare.

The products and by-products of each crop processing stage differ in the proportions of crop seeds, chaff and straw (pods and stems for pulses) and weed seeds (Hillman 1973, 1981; Dennell 1974, 1978). Both cereal and pulse seeds occur on archaeological sites but, whereas the charred remains of cereal chaff and, to a lesser extent, straw are encountered frequently, the equivalent components for pulses, i.e. fragments of pods and stems, are rarely found. In order to find some method of differentiating between the products and by-products of different stages of crop processing applicable to both types of crop, it was decided to concentrate on the evidence from crop and weed seeds.

Discriminant analyses (Klecka 1975) were carried out taking the four major products and by-products as the predefined groups to be discriminated and using square roots of the percentages of weed seeds as the discriminating variables (a transformation to normalise the distribution of each variable). The purpose of the discriminant analysis is to reduce the discriminating variables to three composite discriminant functions which maximise the statistical separation of the four predefined groups. A varimax rotation of the discriminant functions was performed to facilitate interpretation. The 'loadings' of discriminating variables can be taken as a measure of their contribution to each function. The eigenvalues of the discriminant functions are cited as a measure of the functions' relative ability to separate groups of samples, and Wilk's lambda, at the start of each analysis, is cited as a measure of the discriminating power of the variables used. The higher the eigenvalues, the greater the functions' ability to separate groups, and the lower Wilk's lambda, the more discriminating power there is in the variables. Another measure of the discriminating value of the functions is given by their ability to reclassify the samples correctly.

The discriminant functions derived from the analysis had very high eigenvalues and Wilk's lambda was low at the start of the analysis; 93.5% of samples were correctly reclassified (see Table 1:A). Thus the four products and by-products can be very successfully discriminated on

Variables Used	Eigenvalues of Discriminant Functions			Wilk's Lambda at Start of Analysis	% of Samples Correctly Reclassified
	1st	2nd	3rd		
A weed species	8.05	3.55	1.22	0.011	93.5
B weed seed categories	4.55	1.80	0.32	0.049	83.8

Table 1. Discrimination of crop processing groups

the basis of weed seeds alone. However, the explanatory power of a solution depends on the interpretability of the discriminant functions. It is, therefore, worth examining the varimax rotated solution of the latter analysis in relation to weed seed characteristics and crop processing groups.

On the first function, which separates fine sieve products positively and winnowing and coarse sieve by-products negatively, large-seeded weeds load high positively and weeds with seeds commonly remaining in 'heads' or with appendages load high negatively. On the second function, which separates off fine sieve by-products positively, small-seeded weeds load high positively and big or headed weed seeds load high negatively. On the third function, which primarily separates winnowing by-products negatively and coarse sieve by-products positively, weeds whose seeds remain in 'heads' load high positively and free, light weed seeds load high negatively. The loadings of the weed seeds are, therefore, consistent with the processing groups used in the analysis.

How could this method of analysis be applied archaeologically? It is highly unlikely that two separate case studies, whether archaeological or ethnographic, will yield exactly the same range of weed species, but this does not preclude the use of ethnographic models in the interpretation of archaeological samples. In fact, such models can be made widely applicable, both temporally and geographically, by considering weed characteristics rather than individual species.

Three characteristics of weed seeds seem to be most relevant to crop processing:
(i) Size of seed -- this is most relevant to fine sieving since small seeds tend to pass through the sieve and large seeds to be retained.
(ii) Tendency of seeds to remain in heads, spikes or clusters despite threshing or to retain large projections -- this is most relevant to coarse sieving since seeds in heads, etc., tend to be retained by the sieve while free seeds pass through.
(iii) Aerodynamic qualities of seeds, including density, shape and presence or absence of features such as wings or hairs -- this is most relevant to winnowing.

Weed seeds were therefore grouped into categories such as big, heavy and headed (BHH); small, free and light (SFL) and so on, so as to take account of these three characteristics simultaneously. The square roots of percentages of weed seeds in each category were summed for each sample, thus creating six new variables (there were no big, light seeds) for each sample, which were then used as the discriminating variables in a discriminant analysis of the four processing groups.
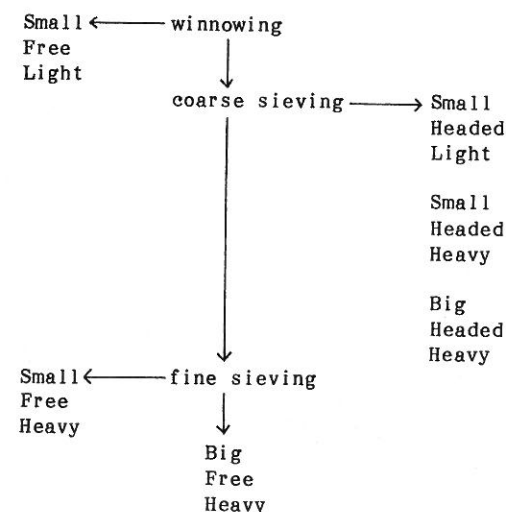

Figure 3. Processing sequence indicating effects on weed seed categories.

The result is that Wilk's lambda at the start of the analysis was low and three functions with high eigenvalues were extracted (see Table 1D); 83.8% of samples were reclassified correctly. This is even more satisfactory when one examines the way in which the six variables load on the three discriminant functions. Let us first consider what would be the expected effect of crop processing on these categories of weed seeds (see Figure 3). Clearly, small, free, light seeds (SFL) should, largely be removed by winnowing and so end up with the winnowing by-products. The seeds which tend to remain in heads (SHL, SHH and BHH), regardless of whether their seeds are light or heavy, big or small, should be removed by coarse sieving and remain with the coarse sieve by-products. Small, free, heavy seeds (SFH) would be mostly removed by fine sieving and so stay with the fine sieve by-products leaving big, free, heavy seeds (BFH) with the fine sieve products.

Weed Seed Category	Discriminant Function		
	1st	2nd	3rd
Big,Free,Heavy	-0.789*	0.094	-0.045
Small,Free,Heavy	-0.090	-0.795	0.112
Small,Free,Light	-0.002	0.001	0.784
Small,Headed,Light	0.333	0.476	0.066
Small,Headed,Heavy	0.338	0.335	-0.515
Big,Headed,Heavy	0.060	0.263	0.259

* loadings >0.75 underlined

Table 2: Loadings on discriminant functions using weed seed categories.

The results of the discriminant analysis are consistent with these expectations (see Table 2; Figure 4). Big, free, heavy seeds load high negatively on the first function which separates fine sieve products negatively from the by-products. Small, free, heavy seeds contribute most and negatively to the second function which separates fine sieve by-products negatively from other by-products and products. Lastly, the small, free, light seeds load high positively on the third function which separates winnowing by-products positively from the other groups. The weeds which remain in heads do not load high on any of the discriminant functions and coarse sieve by-products occupy a comparatively neutral position on all functions.

So, ethnographically collected samples, from different stages in the crop processing sequence, can be distinguished statistically on the basis of weed seeds -- a development in the analytical theory of archaeobotany (cf. Clarke 1973). Moreover, characteristics of weed seeds can be used to differentiate between samples, thus contributing to the interpretive theory of archaeobotany (cf. Clarke 1973). The characteristics of weed seeds found archaeologically can be used both in direct comparisons with ethnographic samples and also to search for internal regularity amongst archaeological samples.

Each of the processing stages discussed relies on a single selective agent (wind or mesh size) to separate product and by-product. By using characteristics of weed seeds which are causally related to these agents, which vary little in time or space and which can be extrapolated to weed species not found in the original study, this ethnographic model of crop processing can be widely applied in the study of non-mechanised agriculture. No assumptions need be made about human actions and few about the weeds themselves.
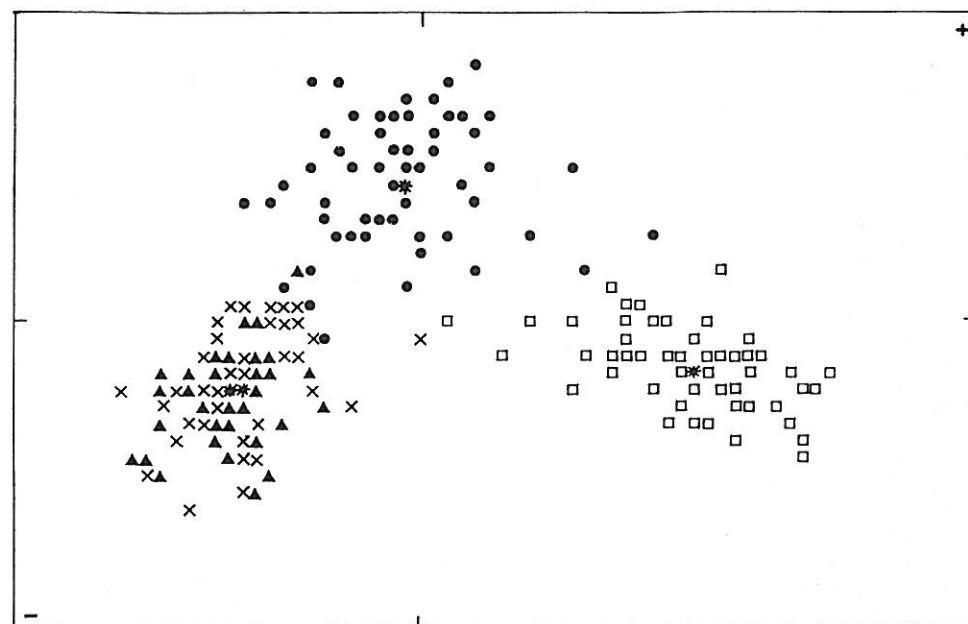
Figure 4: Discrimination of crop processing groups. (X winnowing by-product, ▲ coarse sieve by-product, ● fine sieve by-product, □ fine sieve product, ✳ group centroid.)

The fact that few practical ways of processing crops are available to the non-mechanised farmer increases the relevance of the ethnographic model making it applicable in a wide range of contexts. Thus the model will satisfactorily account for most samples while retaining the ability to identify sample compositions which cannot be ascribed to the known processing sequences. Moreover, if the main objective of the crop processing study is taphonomic, i.e. to ensure that the effects of crop processing on sample composition are not misinterpreted in terms of, say, husbandry practices, then it matters little if different processing techniques have the same effect on sample composition. Once the effects of crop processing have been isolated, it is of secondary importance to identify the particular technique or tools used.

References

Binford, L.R. 1977 General introduction. In For Theory Building in Archaeology., edited by L.R. Binford, 1-10. Academic Press, New York.

Binford, L.R. 1981 Bones: Ancient Men and Modern Myths. Academic Press, New York.

Clarke, D.L. 1973 Archaeology: the loss of innocence. Antiquity 47:6-18.

Dennell, R.W. 1972 The interpretation of plant remains: Bulgaria. In Papers in Economic Prehistory, edited by E.S. Higgs, 149-60. Cambridge University Press, Cambridge.

Dennell, R. W. 1974 Prehistoric crop processing activities. Journal of Archaeological Science 1:275-84.

Dennell, R. W. 1978 Early Farming in South Bulgaria from the VI to the III Millennia B.C. (B.A.R. International Series 45). British Archaeological Reports, Oxford.

Efremov, J.A. 1940 Taphonomy: a new branch of paleontology. Pan-American Geologist 74:81-93.

Hillman, G. C. 1973 Crop husbandry and food production: modern basis for the interpretation of plant remains. Anatolian Studies 23:241-4.

Hillman, G. C. 1981 Reconstructing crop husbandry practices from charred remains of crops. In Farming Practice in British Prehistory, edited by R. Mercer, 123-62. Edinburgh University Press, Edinburgh.

Hodder, I. 1982 The Present Past: An Introduction to Anthropology for Archaeologists. Batsford, London.

Jones, G. 1981. Crop processing at Assiros Toumba: a taphonomic study. Zeitschrift für Archäologie 15:105-11.

Jones, G. in press Interpretation of archaeological plant remains: ethnographic models from Greece. In Plants and Ancient Man (Proceedings of the VI symposium of the International Work Group for Palaeoethnobotany, Groningen, 1983), edited by W. van Zeist and W.A. Casparie. Rotterdam.

Klecka, W. R. 1975 Discriminant analysis. In Statistical Package for the Social Sciences (second edition), edited by N.H. Nie, C.H. Hull, J.G. Jenkins, K. Steinbrenner, and D.H. Bent, 434-67. McGraw-Hill, New York.

Schiffer, M.B. 1976 Behavioral Archeology. Academic Press, New York.

Address: 42, York St.,
         Cambridge.

ARCHAEOLOGICAL EXCAVATION AND ETHNOARCHAEOLOGICAL INTERPRETATION: A CASE STUDY IN KENYA

Françoise Hivernel

Introduction

Later African prehistory has been characterised during recent decades by a strong commitment to culture historical reconstructions based on comparisons made at a descriptive level, of material culture and economic patterns. Similarities in terms of techniques used, pottery decoration, stone tool attributes, economies inferred from the presence or absence of varying traits and environmental factors have been used to fit archaeological sites into three main economic schemes: hunter-gatherers, pastoralists and agriculturalists. Distinctions based on stone tool morphology and 'style', presence/absence of pottery and decoration, have led to a further breakdown into discrete 'traditions'. This taxonomic exercise was based on the self-supporting hypothesis that whatever variations may have occurred in terms of economy and socio-cultural factors within past ethnic groups, part of these past ethnic groups could still be identified from archaeological remains alone, and were sufficient to provide valid assumptions on the past behaviour patterns of the group as a whole. The corollary which must have underlain such practices, although perhaps unconsciously, was that groups with different economies could coexist in a fairly delimited area without influencing each other, or influencing each other to such a small extent that it would be below the level of archaeological visibility. Culture areas and traditions were then built on the spatial distribution and absolute dating of the economically and technologically labelled archaeological sites. I do not wish to say that such entities do not exist, but merely question the basis on which they were built. To assess the value of such systems, one has to go back to the roots, i.e. the archaeological site itself and the way in which its information can be interpreted, especially in the light of our knowledge of present-day societies.

Archaeologists working in Africa seem to have paid little attention, until fairly recently, to the information gained through work such as Binford's (1972, 1978) pointing to the tremendous variation both in material culture and in economic components recoverable at the various camps created by one ethnic group. The real complexity in the variation of present-day economies and the underlying factors, be they environmental or socio-cultural, and the way in which they overtly or covertly affect and mould the various economies have begun to come to light through a number of recent studies such as Lee and DeVore (1976), Jochim (1976), Sahlins (1972) and Hodder (1982).

Interestingly enough, although more studies of this type are becoming available, little has been done so far to try to feed the information gained back into archaeological field practice. It is possible that ethnoarchaeology is still too young and that much more work needs