THE CLUSTER ANALYSIS OF TWENTY-NINE EPIPALEOLITHIC SITES IN ISRAEL : A STUDY OF CLASSIFICATION STRATEGIES

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Introduction

This paper asserts that the key to archaeological interpretation is that process by which masses of raw data are sorted and grouped in order to provide and explicate meaningful relationships. Various approaches exist for accomplishing this end. Of late, the use of statistical tests to more clearly identity and isolate these relationships has increased in importance. An awareness of the analytical potential offered by statistical tests requires, I believe, a concentrated effort on the part of concerned workers to probe the results of their work in order to demonstrate what validity a particular test may have for a specific problem. Comparisons between orderings derived through statistical procedures and those arrived at through other methods can well hold the potential for providing important insights into questions that are of concern to us all.

The following paper discusses some of the results and implications of a series of tests run using an approach called "cluster analysis". Because of the increasing importance of techniques utilizing biological distance and since the term "cluster analysis" has been used for two very different approaches, the specific structure of the approach used here will be discussed in greater detail below. However, with the growing popularity of cluster analysis among both European and American archaeologists (e.g. Clements 1954; Cowgill 1968; and Hodson 1969 and 1970) analysis of results derived using this approach are certainly timely.

A small note of caution should also be sounded here. Although there are many advantages offered by using an approach that is statistical in nature to probe relationships within a data set, the highly experimental nature of these attempts cannot be over emphasized. While I personally feel that the potential offered to research by these methods is great, I would like to join Cowgill (1968:367) in warning that while statistical techniques have their obvious uses

> "... they are no panacea for our problems; they increase rather than decrease, the need for acute and critical exercise of common sense and vigilance against stupidity."

The cluster analysis program used for the examples and tests in this paper was written by the staff of the Taximetrics Laboratory at the University of Colorado (see Wirth, Estabrook and Rogers:1966; Rogers and Tanimoto:1960 and Estabrook and Rogers:1966). It was converted for use and modified by Carol Good of the Arizona State University Computer Center. The program was run on the CDC 6400 and the UNIVAC 1110.

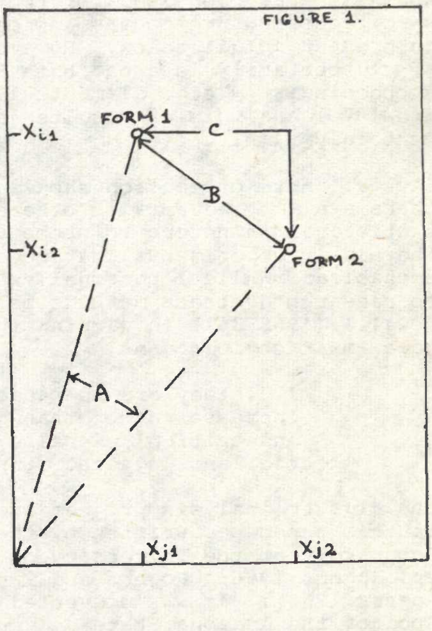
General Problems

Cluster Analysis offers the researcher a unique method for grouping individuals on the basis of some selected series of attributes into clusters that have the characteristic of very high internal similarity. Indeed, the approach is so designed that any individual within a derived group has a greater similarity to any other group member (based on a computed C- value) than that individual does to any individual not in the group. This in itself suggests that cluster analysis is a very strong tool for ordering of all sorts (e.g., chronological, typological, relational and technological ordering). There are, however, a number of questions revolving around the 'meaning' of the resultant taxa, and it is to this specific area that this paper is directed.

Using a series of 29 Epipaleolithic sites in Israel from which data were available, a comparison was made between the ordering of these sites into 'cultural' units using cluster analysis and the ordering made by the researcher who personally dealt with the sites and who used one of the other strategies open to the archaeologist; i.e., the procedure based in large part on the presence of the fossile directure felt to be indicative of a particular group. This comparison focused on the level of discrimination of the taxa produced by clustering techniques.

The Cluster Analysis Program

As noted above, the cluster analysis program is a method for grouping mutually similar objects on the basis of a set of attributes selected and observed for each object. Obviously, the strength of any analysis is directly related to the care with which the attributes are selected and observed as well as to the nature of the data used. That point being made explicit let us now move to a discussion in general terms of similarity measurement because of its integral relationship to all clustering approaches.



Boyce (1969) has suggested that a geometrical model serves as a useful analogue in explaining how different similarity computations operate. Two forms may be thought of as occupying a Euclidean space (Fig. 1) whose dimensions are the attributes on which the comparisons are based. For simplification, only two dimensions (attributes) are considered in the following model. The relative position of these points (forms) in space are, therefore, determined by the unique character values possessed by each of these forms.

The main importance of the illustration is to point out graphically that there are several 'distances' that may be used to locate the two forms in space and with respect to each other. In this manner, the relative closeness of the two forms to each other (i.e., the similarity) may be determined. The first method (represented by A) is a measurement of angular distance between the two forms. The second method (B) is a measurement of straightline distance between the forms, and method C is the so-called 'city block' distance.

Each of these three general methods has different formulae and computations upon which the similarity coefficient is based and, though the formulae themselves are not germane to the present level of this discussion, it should be pointed out that each of the particular methods of distance computation, while being sensitive measurements of some aspects of a form's location, are not responsive to changes along other axes. As an example, an angular measurement would fail to sense the difference between two forms lying at different points on the same diameter of measurement. The result would be that the two forms would be seen as the same. Conversely, linear distance measurement may fail to distinguish angular differences.

Hodson has already observed that pragmatic dictates may require that the researcher use the particular analytical tool available at their computer center (1970:302), but this does not relieve the investigator of the responsibility of acquiring the sophistication to deal with these issues; indeed, the value of cluster analysis (or of any statistical procedure) is apparent in that the processes, rationale, and underlying assumptions resultant from the structure of the particular technique <u>must</u> be made explicit. Moreover they must be kept foremost in the mind of the researcher as he structures his investigation, selects his attributes, and interprets his results.

Most readers are familiar with the fact that each statistical test has a number of constraints that must be met before the results of the test may be considered valid. In a wider sense, however, a statistical test may be seen as a model representing the system of relationships that exists within a data set. If for any reason the data cannot be assumed to also meet the structure of the statistical model, then its use, even accepting that the requirements of measurement level or other constraints are met, will produce spurious results. Most often the use of some statistical test by an archaeologist will envolve a 'canned' computer program, and the parameters of the input will prevent mistakes that violate test constraints. Such is not always the case for the more general but equally important requirements of the model represented. For this reason these assumptions for cluster analysis are listed here based on discussions in Wirth, Estabrook and Rogers 1966:59 and Clements 1954.

1. The classification is based on the consideration of either all of the individuals in a population (an ideal not always realizable) or on as many individuals in the particular population as is possible, since the cluster formation occurs only within the context of the material immediately under study.

2. Classification clustering is based on a comparison of equally weighted attributes, since initially the researcher would be unable to make judgements concerning 'key' or fundamental attributes.

3. When presence/absence data are used, some shared basis of comparison is assumed, since otherwise a shared absence of a trait would be meaningless.

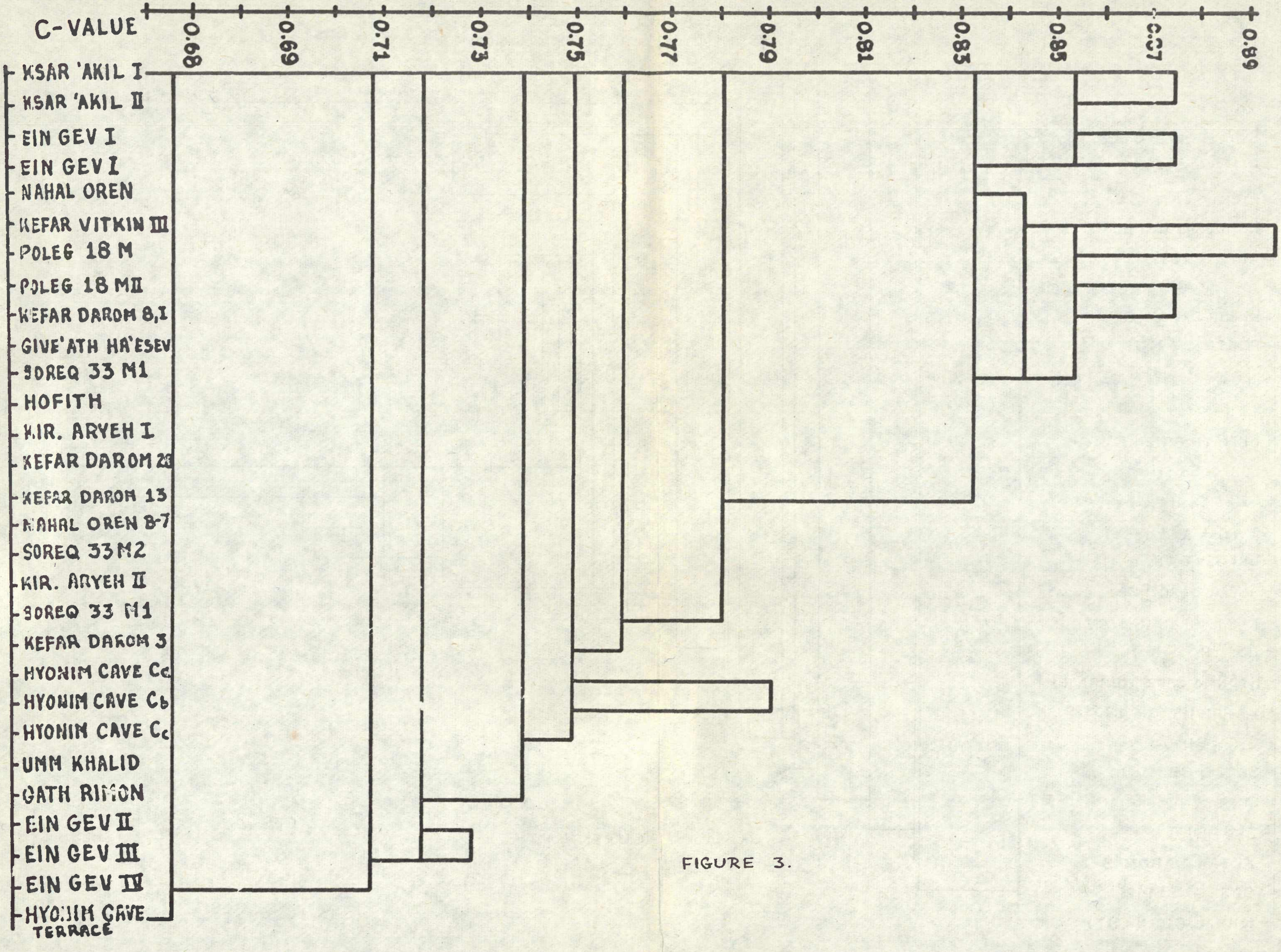
4. All objects are eventually classifiable.

5. A hierarchy is formed with larger groups subsuming smaller groups.

These parameters are, to a large extent, logically obvious. Concerning weighting of attributes, however, there is some controversy. The cluster programs generally allow for weighting, and the decision is one for the researcher to make. These methods of weighting can concern such manipulation of data as the use of assorted levels of measurement for different attributes. As has also been pointed out by Sokol and Sneath (1963:118), the selection of some attributes over others constitutes a type of weighting. In the final analysis, though, they conclude

> "...when many characters are employed, the statistical analysis of similarity is only slightly affected by weighting some characters (unless this weighting is extreme)."

Keeping in mind all of these issues that are normally considered before the initial run is made, let us now examine the actual flow of analysis that the specific program used



C-VALUE
0.68
0.69
0.71
0.73
0.75
0.77
0.79
0.81
0.83
0.85
0.87
0.89
KSAR 'AKIL I
KSAR 'AKIL II
EIN GEV I
EIN GEV I
NAHAL OREN
KEFAR VITKIN III
POLEG 18 M
POLEG 18 M II
KEFAR DAROM 8,I
GIVE'ATH HA'ESEV
SOREQ 33 M1
HOFITH
KIR. ARYEH I
KEFAR DAROM 23
KEFAR DAROM 13
NAHAL OREN B-7
SOREQ 33 M2
KIR. ARYEH II
SOREQ 33 M1
KEFAR DAROM 3
HYONIM CAVE Cc
HYONIM CAVE Cb
HYONIM CAVE Cc
UMM KHALID
GATH RIMON
EIN GEV II
EIN GEV III
EIN GEV IV
HYONIM CAVE TERRACE

FIGURE 3.

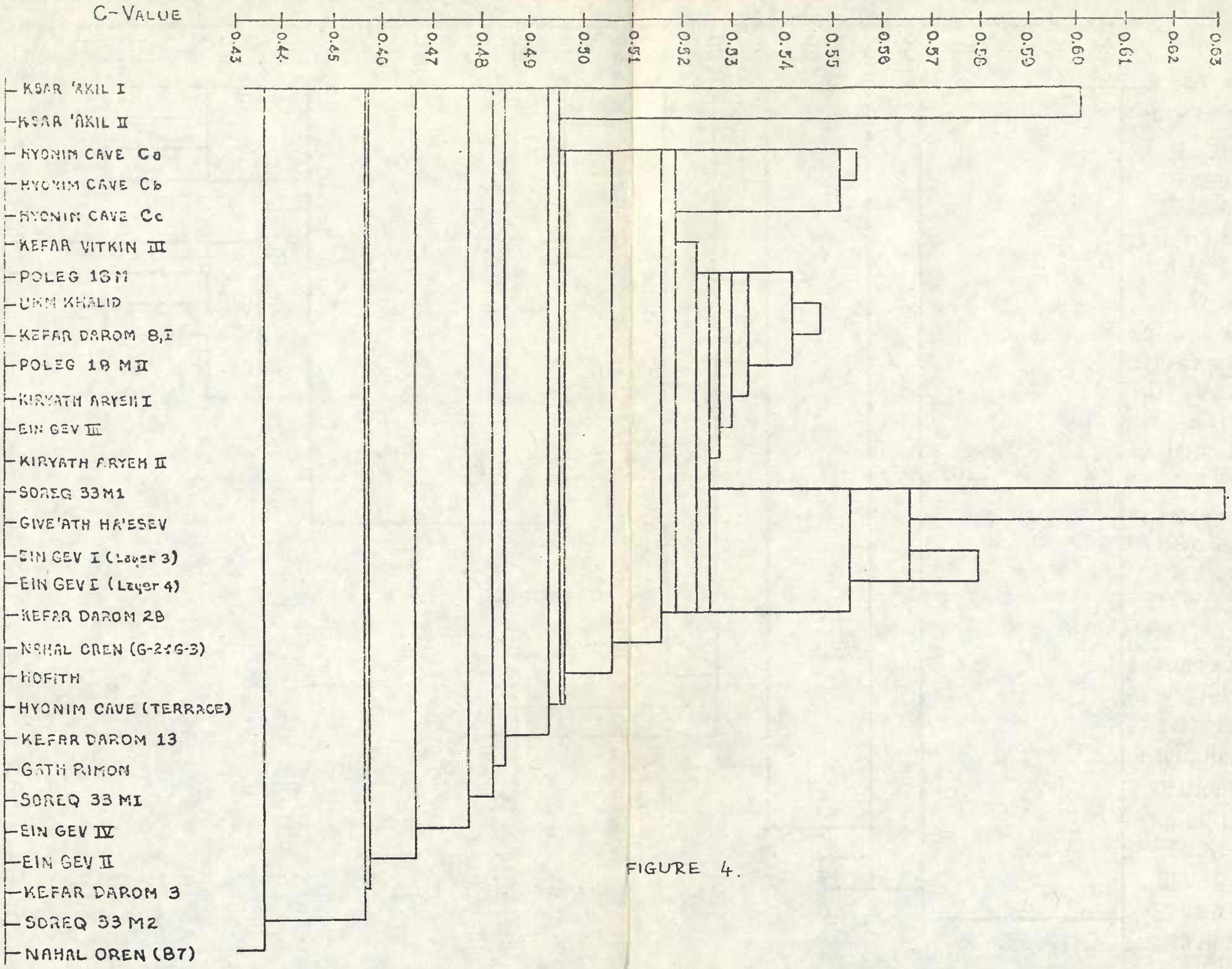
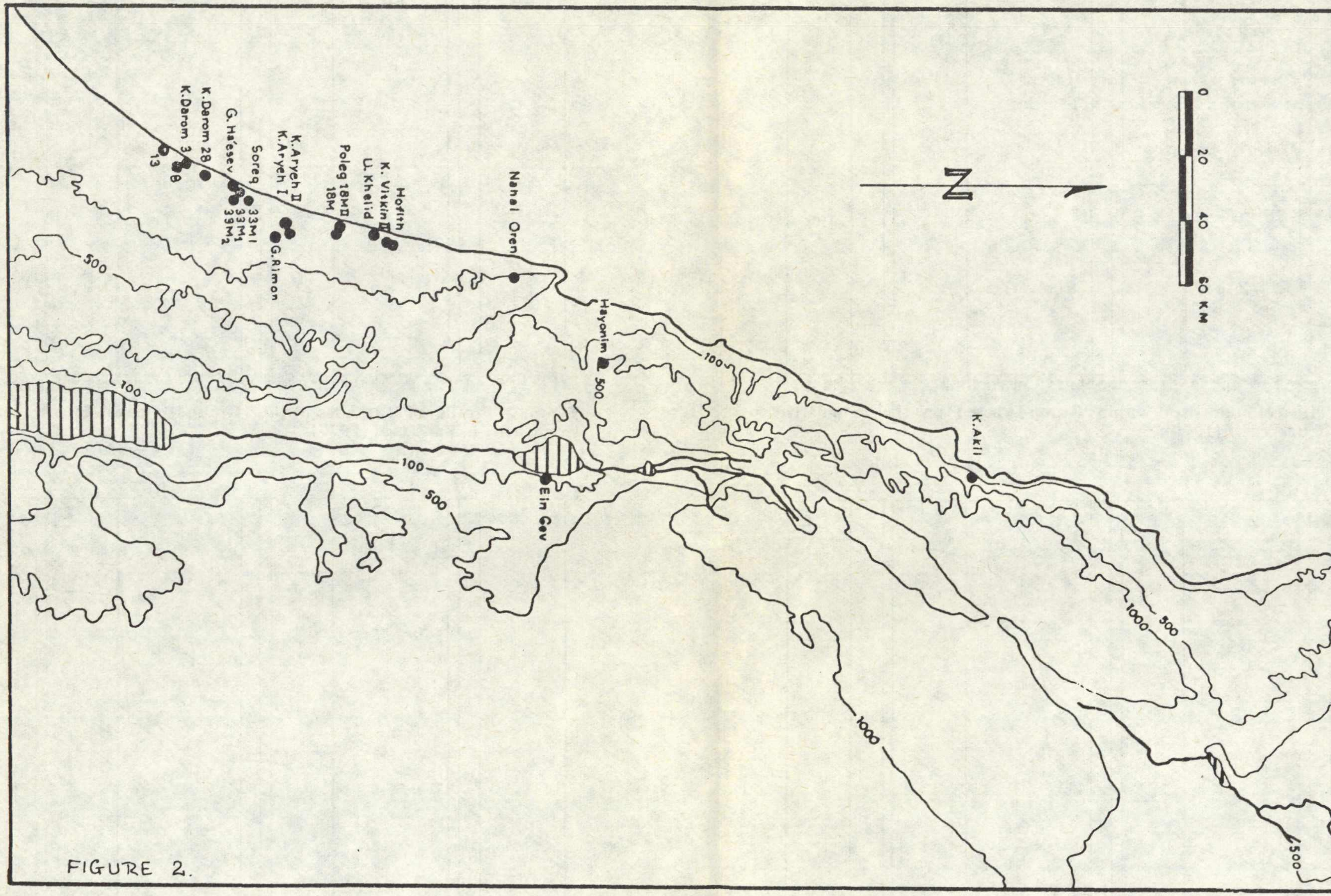

C-VALUE
0.43
0.44
0.45
0.46
0.47
0.48
0.49
0.50
0.51
0.52
0.53
0.54
0.55
0.56
0.57
0.58
0.59
0.60
0.61
0.62
0.63
KSAR 'AKIL I
KSAR 'AKIL II
HYONIM CAVE Ca
HYONIM CAVE Cb
HYONIM CAVE Cc
KEFAR VITKIN III
POLEG 18 M
UMM KHALID
KEFAR DAROM 8,I
POLEG 18 M II
KIRYATH ARYEH I
EIN GEV III
KIRYATH ARYEH II
SOREQ 33 M1
GIVE'ATH HA'ESEV
EIN GEV I (Layer 3)
EIN GEV I (Layer 4)
KEFAR DAROM 28
NAHAL OREN (G-2 & G-3)
HOFITH
HYONIM CAVE (TERRACE)
KEFAR DAROM 13
GATH RIMON
SOREQ 33 MI
EIN GEV IV
EIN GEV II
KEFAR DAROM 3
SOREQ 33 M2
NAHAL OREN (B7)

FIGURE 4.


K.Darom 3
K.Darom 28
13
8
G. Ha'esev
Soreq
33M I
33M1
39M2
K.Aryeh II
K.Aryeh I
G.Rimon
Poleg 18M II
18M
U. Kheid
K. Viskin II
Hofsh
Nahal Oren
Hayonim
Ein Gev
K.Akil
N
0
20
40
60 KM
500
100
1000
FIGURE 2.

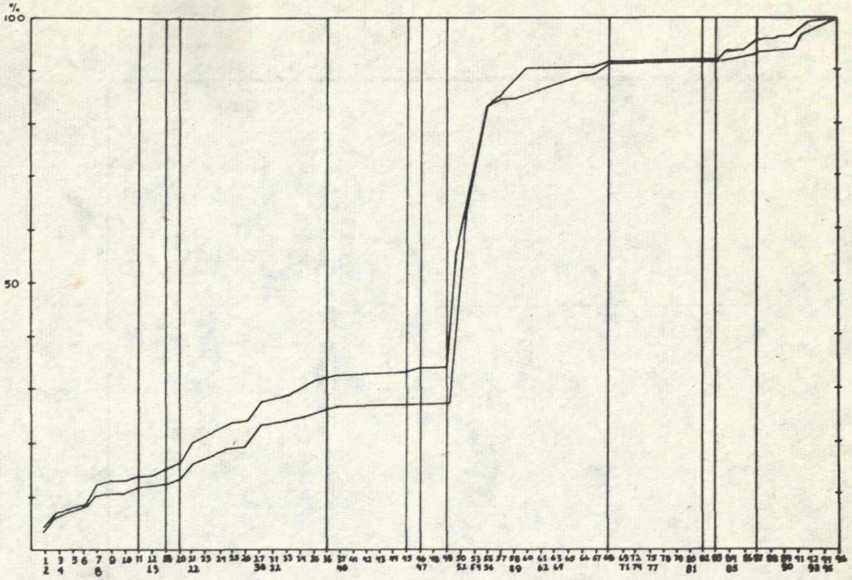


Figure 5. Profile of the sites within Group I based on the cumulative frequencies in Bar-Yosef (1970).

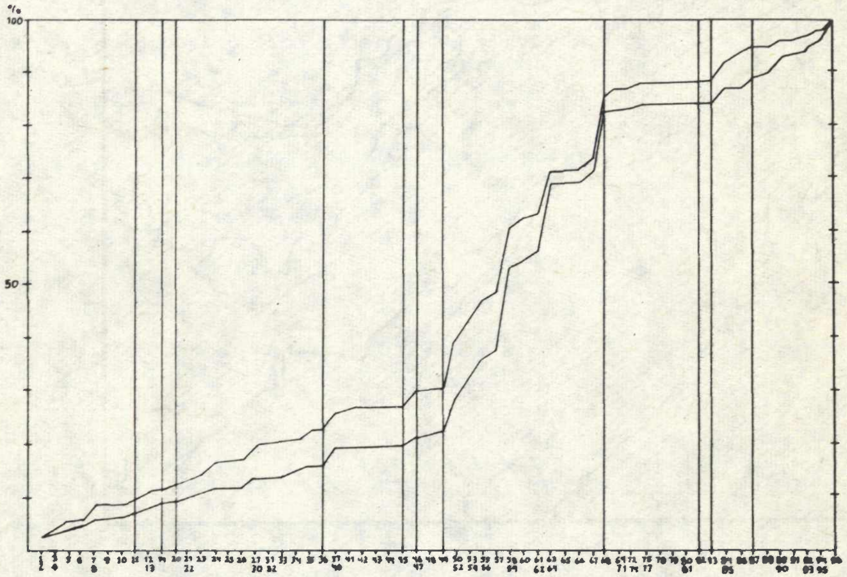


Figure 6. Profile of the sites within Group IIa based on the cumulative frequencies in Bar-Yosef (1970).

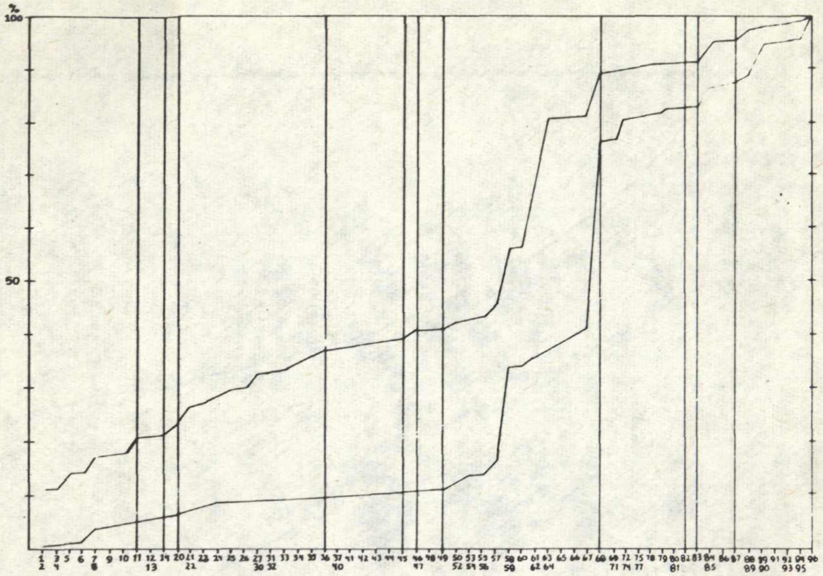


Figure 7. Profile of the sites within Group IIb based on the cumulative frequencies in Bar-Yosef (1970).

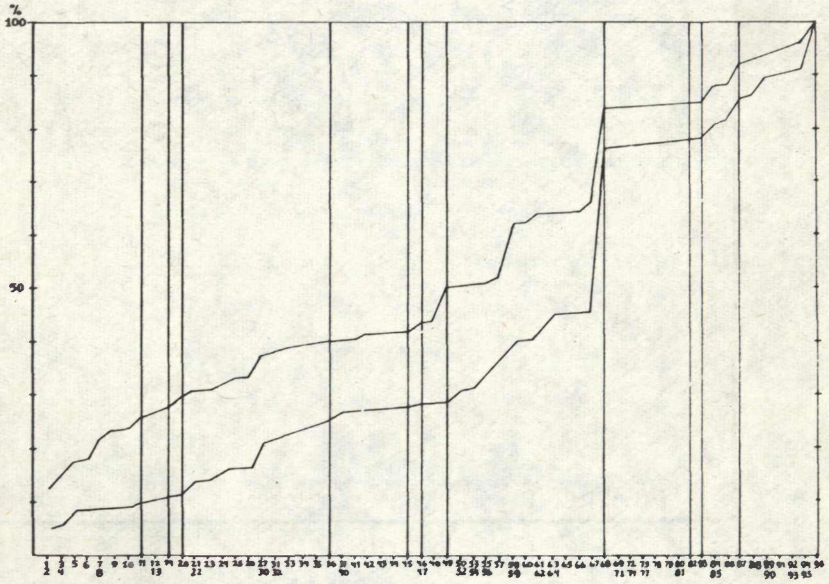


Figure 8. Profile of the sites within Group IIc based on the cumulative frequencies in Bar-Yosef (1970).

for the following analyses takes. As mentioned above, the actual clustering is built around the calculation of a similarity (or C-) value for each of all possible pairs of objects in the study. The first pair is taken as it occurs in the data input and a comparison of the values for the first attribute for both objects is made. These values are entered into the machine using any or all of the thirty-five alphameric characters (i.e. the numbers 1 through 9 and the letters A through Z), and with zero being reserved for missing data. This alphanumeric data can be treated as nominal or ordinal data depending on the requirements of the researcher and as programmed by him in the data deck instructions.

After the values have been compared, a correlation coefficient is computed (range between 0 and 1) and assigned to the first attribute for the pair. A coefficient is computed for all attributes for the pair. The formula is modified in such a way that, when the attributes for a pair are both zeros, a zero value is assigned rather than a 'perfect match' (which would normally result in a 1). Once this computation has been performed for all attributes for the pair, the coefficients are then summed and the mean value is determined and assigned as the similarity value for the pair.

Since the value for each attribute can be no larger than 1 and no less than 0, each attribute is confined within equal limits and is, therefore, equally weighted. Some selected attribute or attributes may be weighted if the researcher so decides. This may be done on the basis of the number of ordered states assigned for each attribute (or the number of ordered and nominal attributes for each object) on the character cards used in the instructions when the data is run. The fewer the ordered states, as an example, the greater will be the weight of the particular attribute or attributes.

In the following study two runs were made on the same data; one in which the data were assigned 35 ordered states and one in which the data were treated on a presence/absence basis (i.e. the data were assigned two nominal states). Estabrook and Rogers (1966:791) have reviewed the implications of weighted data and have suggested that these be kept in mind during the attribute selection procedure. Any weighting will also, of course, influence the interpretation of the results. It should be mentioned that, ideally, there should be no overlap between what is being described by two separate attributes. While less precise definitions of an attribute may be suited for general anthropological work, more exact definitions (e.g. Clarke 1968:181ff) of meaning are important for this type of analysis.

On the basis of C-values then, clusters are formed using the so-called single link method (see Hodson 1970 for a detailed discussion of the several clustering methods, advantages and disadvantages of their use, and for further references of pertinent discussions). A large amount of data are provided as both printed output and as a 'skyline' plot produced on a CALCOMP Plotter. The researcher must then attempt to determine the meaning (in anthropological terms) of the resulting relationships.

The Study

Data used in this study are from Bar-Yosef (1970) and concern the Epipaleolithic microlithic cultures in Palestine. To summarize the data briefly, the Epipaleolithic sites envolved (Fig. 2) fall temporally within the period from 18,000/15,000 B.P. to ca. 8000 B.P. Technologically and typologically the materials are assigned to Stage VI (Kebaran) of the Neuville typology (Bar-Yosef 1970:2). Stage VI also includes assemblages called Natufian because of the preponderence of microlithic tools found associated with these sites.

In Palestine, there appears to be a progression from the Kebaran cultures through to the Natufian marked technologically by an increasing dependence on the use of geometric microliths; or at least an increase in their importance as a stylistic element. This period is also characterized by increasing localized assemblage variation. Intermediate levels are represented by Kebaran Geometric A and Kebaran Geometric B assemblages. The Kebaran proper is well bracketed stratigraphically between the Natufian and the earlier 'Aurignacian' materials. The same is not true, however, for the Geometric A and B assemblages. One of the reasons for this is explained by the sites used in this paper in that many are coastal sites represented by surface collections and, indeed, appear to have little or no stratigraphy being found on top of and partially imbedded in a <u>terra</u> <u>rosa</u> soil, partially covered by a fine sand (A. Ronen, Pers. Comm. 1970). The issue is to determine how these groups are related to the others in time and space.

Bar-Yosef (1970) has demonstrated that, since the microlithic component of Kebaran assemblages varies from 50-70% of the retouched tools, that this class of implements is the most sensitive indicator of change. On this basis, the 29 sites used here were ordered both culturally and temporally by him.

It was felt that Bar-Yosef's careful and rather detailed classification could be used as a sounding board for other alternative techniques, and that an analysis of the relationships between groups derived using cluster analysis and Bar-Yosef's units might reveal important points about the clustering procedure. Consequently, several tests were designed using the above data. Two of the tests used all of 96 tool types in the classification process; one based on the presence/absence of the types (nominal) and the other clustered on the occurrance by percentage of all 96 types (ordinal). Dr. Bar-Yosef (Pers. Comm. 1971) has noted that many of the site collections are not characerized by random samples, even in the sense in which many archaeologists use the term. The effect of this on the data is discussed below, and is not

TABLE 1. Industrial division of the 29 Epipaleolithic sites (after Bar-Yosef 1970).

KEBARAN	MIXED	GEOM. A	GEOM. B	NATUFIAN
Ksar 'Akil I & II	Ein Gev III	Kiryath Aryeh I	Poleg 18M	Hyonim Cave (Terrace)
Ein Gev I & II	Kefar Darom 28	Gath Rimon	Ein Gev IV	
Kiryath Aryeh II	Soreq 33MI	Hofith		
Kefar Darom 3,8 & 13	Kefar Vitkin 3	Soreq 33M		
Hyonim Cave Ca-Cc				
Umm Khalid				
Give'ath Ha'esev				
Poleg 18 MII				
Soreq 33M_1 & M_2				
Nahal Oren G_2-G_3				
Nahal Oren B2-7				

TABLE 2. Division of the 29 Epipaleolithic sites based on the Presence/Absence clustering.

GROUP Ia	GROUP Ib	GROUP Ic	GROUP IIa	GROUP IIb	GROUP III
Ksar 'Akil I & II	Nahal Oren G_2 - G_3	Soreq 33 M_1	Hyonim Cave Ca-Cc	Kefar Darom 13 & 3	Hyonim Cave (Terr)
Ein Gev I (3 & 4)	Kefar Vitkin III	Hofith		Nahal Oren B-7	
	Poleg 18M & 18 MII	Kiryath Aryeh I		Kiryath Aryeh II	
	Kefar Darom 8	Kefar Darom 28		Soreq 33M_1 & M_2	
	Give'ath Ha'esev			Umm Khalid	
				Gath Rimon	
				Ein Gev II, III & IV	

TABLE 3. Division of the 29 Epipaleolithic sites based on the ordinal level clustering.

GROUP I	GROUP IIa	GROUP IIb	GROUP IIc	GROUP III
Ksar 'Akil I & II	Hyonim Cave Ca-Cc	Poleg 18M & 18 MII	Soreq 33 M_1	Hofith
		Umm Khalid	Kefar Darom 28	Hyonim Cave (Terrace)
		Kefar Darom 8	Ein Gev I (3 & 4)	Kefar Darom 13 & 3
		Kiryath Aryeh I & II	Give'ath Ha'esev	Gath Rimon
		Ein Gev III	Nahal Oren G_2-G_3	Soreq 33 M_1 & M_2
		Kefar Vitkin III		Ein Gev II & IV
				Nahal Oren B-7

negligible. However, since this paper focusses on the cluster analysis itself, and is not an attempt to contribute to an understanding of the Epipaleolithic in Israel, and since the results do point out some important considerations for archaeologists using clustering techniques, this series of sites is used.

The two final cluster runs were centred around attempts to first of all test the potential that cluster analysis has for seriation and this run used only those tool categories that Bar-Yosef considered to be the most sensitive indicators of change. The last run used R- mode clustering to isolate the more important tool types occurring within the 29 sites used for this analysis and compared the results against an R-mode correlation matrix.

Based then on Bar-Yosef's analysis, focussing principally on the microlithic content of the assemblages, the resulting industrial divisions of the sites are shown in Table 1.

<u>Presence/Absence Cluster Analysis</u>

The first test run utilized only presence/absence data; a tool was scored as either present (P) or absent (A) in the list of 96 tool types used by Bar-Yosef. Without going into detail, it should be pointed out that this constitutes the nominal level of data scaling.

Comparing the results of this run (Fig. 3, Table 2) with Bar-Yosef's ordering of the same material (Table 1) reveals several points. Generally, some cross-cutting of the established boundaries is noted. Even though the one Natufian example was well segregated from all of the other sites (Hyonim Cave Terrace), the other categories did not fare as well at first glance. The Geometric variants A and B were somewhat mixed through the rest of the cluster groups. The only exception to this is cluster Group Ic, in which two of the Geometric A sites and two of the Mixed industries of Bar-Yosef occur. The Kebaran industries are grouped mostly within the IIa and IIb groups, although some are scattered through the subgroups of Group I.

During the time period spanned by these sites, variation in tool content as well as the relative frequency of selected tool types is fairly common. As a result of this variation any ordering into 'cultural' units using these parameters will, naturally, result in some degree of temporal ordering. While part of the above ordering may be somewhat spurious as a result of poor collections and low tool counts, another factor operating in the cluster groups is certainly that of the time/technological variation; the result is that several of the groups formed by clustering reflect a crude and partial temporal ordering. The implications for possible use of cluster analyses for seriation noticed here are explored later in the paper.

Ordinal Level Cluster Analysis

The second cluster analysis used the percentage of occurrence of the 96 tool categories utilized by Bar-Yosef (1970). The material was clustered on the basis of the same attributes as the first test (the tool categories), but was intended to more nearly replicate Bar-Yosef's approach in that not only the occurrence of a particular tool has importance, but the frequency of its occurrence as well. This approach does differ from that of Bar-Yosef's in that all tool categories are considered and all are equally weighted.

The resultant 'skyline' plot is shown in Figure 4. Taking the C-value of .49 as an arbitrary marker, the sites may be separated into two large groups: those having a C-value below .49 (Hofith to Nahal Oren B-7) and those which have a C-value above .49 (Nahal Oren G_2-G_3 to Ksar 'Akil I). This latter group further separates into two major groups; one of only two sites (Ksar 'Akil I and II), the other having three sub-groups within it. The resultant configuration is shown in Table 3.

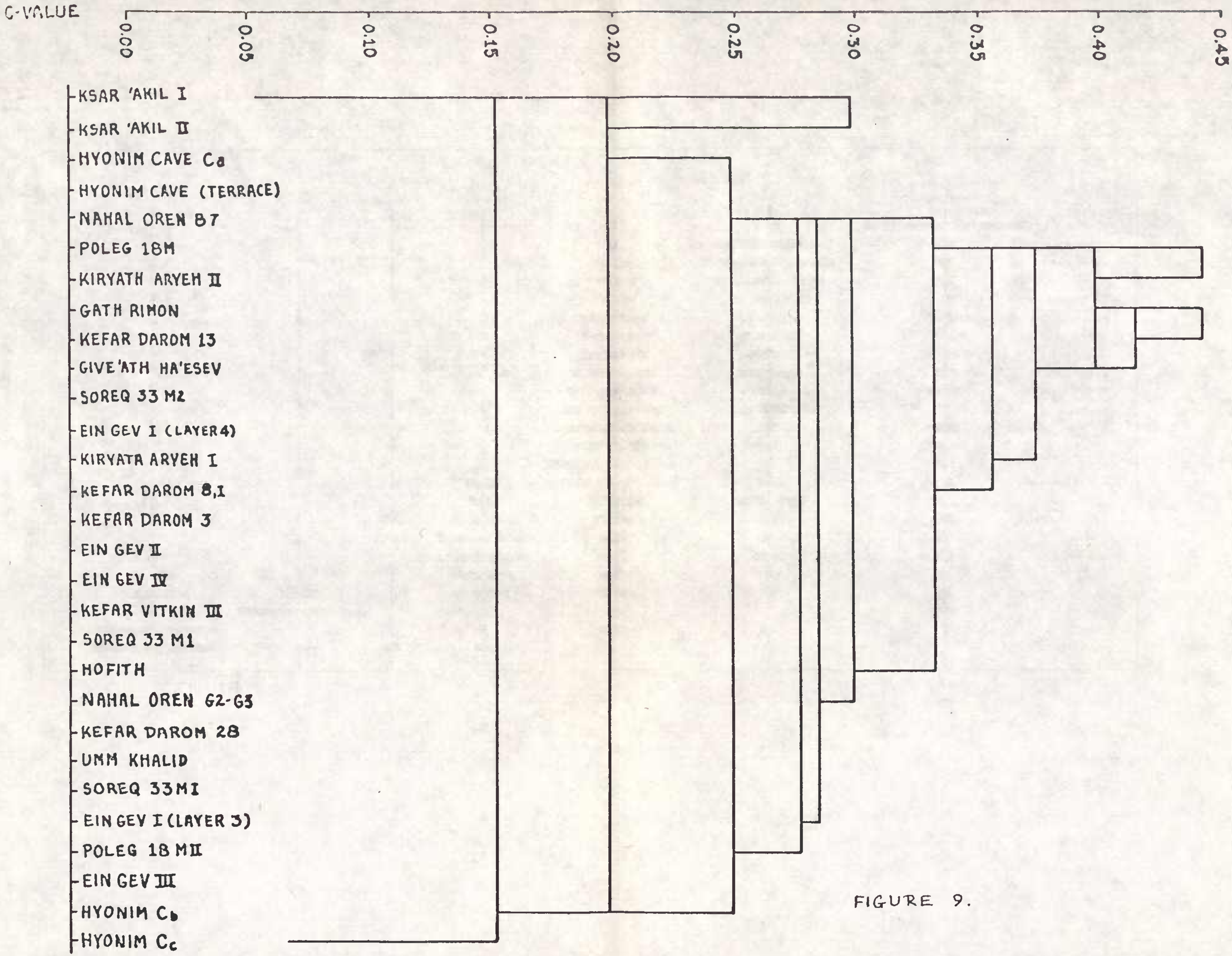
As is true with the first clustering, the group numbers indicate an hierarchy of similarity (i.e. Group I has a greater degree of internal similarity than does Group II, etc.). All of the groups have a high degree of internal similarity, being more internally similar than any site within a group would be to any site belonging to an outside group.

To represent the internal variance of the major groups having high C-values, profiles using the cumulative type percentages of each site within a group were prepared (based on Bar-Yosef 1970). These profiles provide a better picture of internal consistency than numbers would (Figs. 5-8). The cumulative percentage graphs define the boundaries of the highest and lowest percentages occurring within the group for each of the 96 tool types and any site member will fit within the boundaries of this profile.

As was true with the presence/absence clustering, the resultant categories cross-cut the standard groups, but to an even greater degree. The amount of missing data resultant from poor collection procedures as well as sample non-randomness are more apparent here, where attribute relative frequencies were utilized. Also, it seems that, for most of the sites in Group III, the most commonly shared trait is a low incidence of tools represented in the collection. The most valid groups are I and II and their sub-groups.

Seriation with Clustering

Using the tool categories considered by Bar-Yosef to be the most sensitive of temporal locus and relationship, and operating at the ordinal scale level of measurement, an attempt was made to ascertain the viability of cluster analysis for seriation. It appears, based on these results (Figs. 9 and 10



C-VALUE
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
KSAR 'AKIL I
KSAR 'AKIL II
HYONIM CAVE Ca
HYONIM CAVE (TERRACE)
NAHAL OREN B7
POLEG 18M
KIRYATH ARYEH II
GATH RIMON
KEFAR DAROM 13
GIVE'ATH HA'ESEV
SOREQ 33 M2
EIN GEV I (LAYER 4)
KIRYATA ARYEH I
KEFAR DAROM 8,1
KEFAR DAROM 3
EIN GEV II
EIN GEV IV
KEFAR VITKIN III
SOREQ 33 M1
HOFITH
NAHAL OREN G2-G3
KEFAR DAROM 28
UMM KHALID
SOREQ 33 MI
EIN GEV I (LAYER 3)
POLEG 18 MII
EIN GEV III
HYONIM Cb
HYONIM Cc

FIGURE 9.

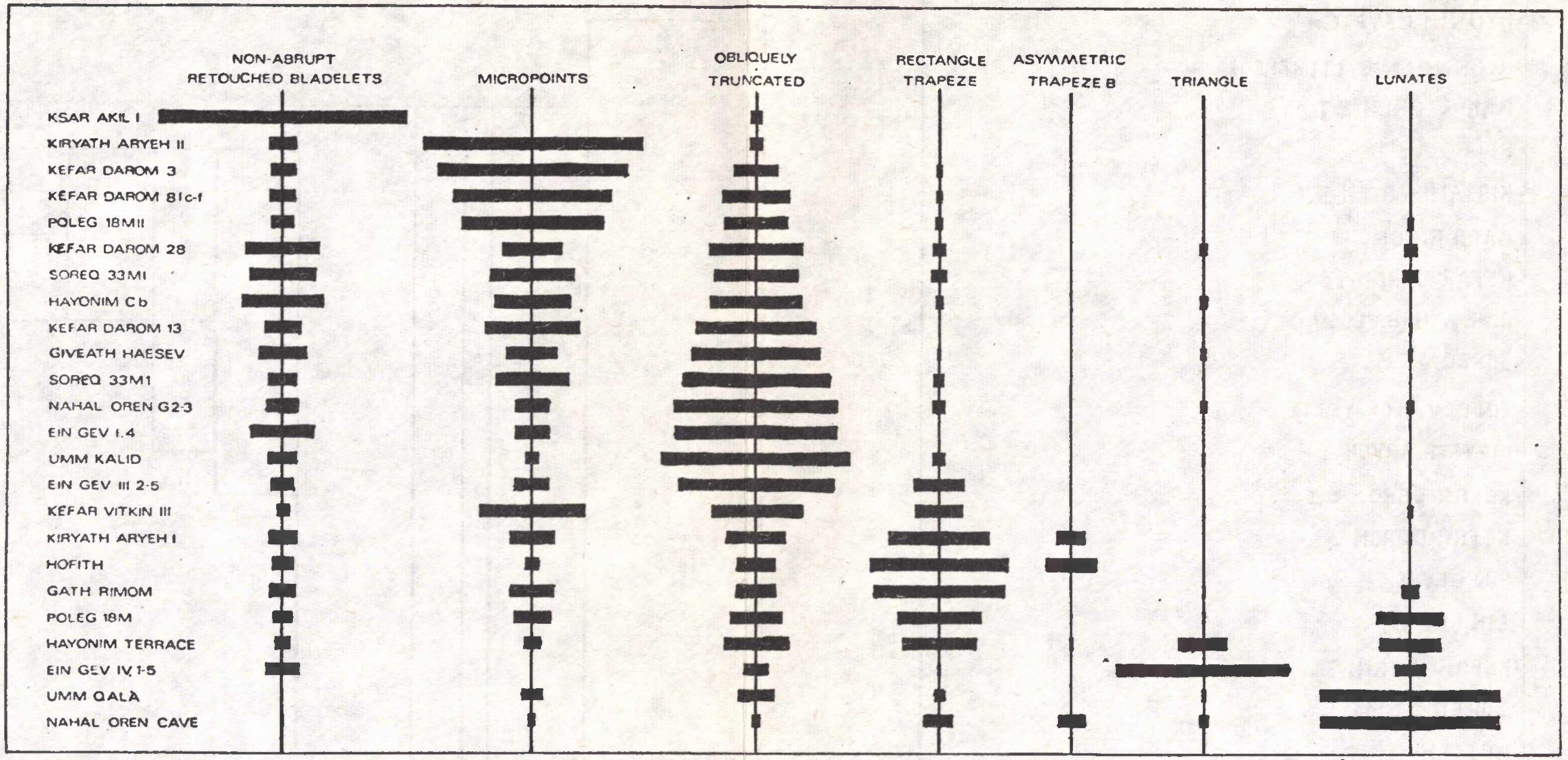

NON-ABRUPT RETOUCHED BLADELETS
MICROPOINTS
OBLIQUELY TRUNCATED
RECTANGLE TRAPEZE
ASYMMETRIC TRAPEZE B
TRIANGLE
LUNATES
KSAR AKIL I
KIRYATH ARYEH II
KEFAR DAROM 3
KEFAR DAROM 8Ic-f
POLEG 18MII
KEFAR DAROM 28
SOREQ 33MI
HAYONIM Cb
KEFAR DAROM 13
GIVEATH HAESEV
SOREQ 33M1
NAHAL OREN G2-3
EIN GEV I.4
UMM KALID
EIN GEV III 2-5
KEFAR VITKIN III
KIRYATH ARYEH I
HOFITH
GATH RIMOM
POLEG 18M
HAYONIM TERRACE
EIN GEV IV, 1-5
UMM QALA
NAHAL OREN CAVE

FIGURE 10.

for comparison) that only the poorest ordering in time results. Because of this, unless further work indicates to the contrary, single-link cluster analysis does not appear to offer any solutions. A possible exception to these results exists in that Dr.H.J.B.Birks of the University of Cambridge, School of Botany, reports good results in zonation of pollen using single-linkage criteria with material already stratigraphically constrained (Univ. of Cambridge Report 1973).

R-Mode Analysis

Thomas (1971:206) defines the differences between Q- and R-Mode data as follows:

> "A comparison of artifact complexes based upon artifact types is termed Q-mode, while assessment of groupings of artifact types (tool kits) across complexes is in the R-mode."

Re-casting the presently used data into the R-mode to possibly isolate meaningful tool clusters in the 29 sites used produced a large number of clusters, many of which had very high C-values. Without a detailed knowledge of the material itself, it was impossible to assess these clusters in any but a superficial manner. However, by independently checking these clusters by constructing a matrix (R-mode) using the well-known Pearson's R correlation coefficient, it became clear that most of these tool groupings can be supported statistically. Generally speaking, some of those tool categories considered most important by Bar-Yosef appear neither in the matrix or the clustering attempt. This may be explained in any of several ways; the most likely probably being the result of the poor collections represented. More important is the independent support that both of these tests give to most of the categories used by Bar-Yosef. More detailed work with better samples could prove very productive.

Conclusions

Analytical results were hampered by the serious sampling problems already mentioned. Sampling error influences any attempt to order the sites using cluster analysis, but cluster analysis provides a better assessment of the real effects that missing data can have on group formation. This is important, since no guidelines exist to determine how much missing data is allowable in clustering. The ideal situation, of course, would be to have no missing data, but if data are missing, the amount of missing data should be held to a minimum. It appears to be demonstrated that no greater number of 'zero' counts per object should be allowed than 10% of the total number of attributes scored; a figure of approximately 10% would seem, at least, to be on the right order of magnitude. This comment, of course, does not obtain for a 'presence/absence' clustering.

It is also apparent that cluster analyses conducted on data scaled on the ordinal level, while having a veryhigh internal group consistency, bear little resemblance to the groups formed by Bar-Yosef (1970). The divergence appears to reflect missing data and poor sampling procedures for the most part. Indeed, the presence/absence clustering procedure most closely replicates Bar-Yosef's group formation procedures.

Cluster analysis is, then, a technique of great importance in group formation and classification problems. Perhaps its greatest contribution lies in its ability to provide quickly a number of alternative ways of grouping the same set of data. It also allows for mixing data of both nominal and ordinal levels of scaling as well as for weighting some attributes over others (if this can be demonstrated to be justifiable). It is concluded, however, that no single approach will be sufficient and that the researcher will find himself resorting to mixed levels of data, weighted and unweighted attributes and much detailed interpretation of the results before a valid classification results.

It is most often the case that the ease of some particular method is stressed, but this is not the case with cluster analysis. Its advantages lie in the final quantification and accompanying replicability of the results - qualities seldom to be attained when a classification is mostly subjective in nature.

In classification in general, and specifically directed to this research with the Epipaleolithic of Israel, it is possible to know what one is dealing with in stylistic terms, but the question remains of what these traits mean in human terms, i.e. what underlying systems are these traits an expression of? It is apparent that the sub-divisions of Kebaran Geometric A and B relate to valid or at least descrete entities; however, the final convincing reconstruction will be not that some sites have one kind of point or tool type and some sites another, but rather that these tools reflect a style of <u>behaviour</u> characterizing a descrete and isolatable life-pattern; surely this is the eventual goal of all approaches.

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