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A PRELIMINARY STUDY OF THE ADAMS SITE BIFACES USING A DISCRIMINANT ANALYTICAL APPROACH

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ABSTRACT

Data relating to the analysis and typological classification of the Adams Site (15Ch90) biface collection are reexamined. The original descriptive artifact data are augmented by additional measurements, data are subjected to a discriminant statistical analysis. The resulting analysis produces statistically-derived typological categories and specimen assignments which agree with Sanders' (1983) classification at a rate of 89.66 percent. However, the discriminant procedure fails to identify specific artifact attributes which contribute most significantly to distinguishing successive biface reduction stages.

INTRODUCTION

The statistical multivariate analytical procedure known as discriminant analysis operates by distinguishing between two or more groups or cases by identifying a set of discriminating variables that measure characteristics on which the groups are anticipated to differ. These variables are then formed into a linear equation, or "discriminant function" (Klecka 1976:435). This paper presents the results of a discriminant analysis carried out on an assemblage of bifaces collected from the Adams Site (15Ch90), which is a single component, Paleoindian manufacturing and habitation site in Christian County, Kentucky. These bifaces have been previously studied and assigned to largely intuitive typological categories based upon the particular stages of biface reduction they represent (Sanders 1983). The purpose of this study is fourfold:

1. To statistically classify the Adams Site bifaces into mutually exclusive groups on the basis of physical characteristics;

2. To establish which characteristics are important for distinguishing among the groups;

3. To evaluate the accuracy of the statistical classification, and;

4. To quantitatively evaluate the accuracy of the implements' original typological classification.

THE ARTIFACTS AND THEIR ORIGINAL ANALYSIS

The subject biface collection consists of 116 complete and fragmentary artifacts which were surface collected from the Adams Site in 1976 and 1977. In this paper, the term biface is utilized to

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describe chipped stone implements which have been flaked from opposing surfaces. This definition includes specimens representing intermediate reduction stages as well as the finished products of flint knapping.

While the Paleoindian occupants at the Adams Site produced a wide range of bifacial tools, including side and end scrapers, burins, knives, and choppers, an important aspect of their manufacturing activities was the production of Clovis points. This assumption is based upon the large number of these projectile points which have been collected from the Adams Site over the years by amateurs, and more recently by professional archaeologists. This particular biface collection has provided a unique opportunity to document the complete sequence of Clovis point manufacture. In his analysis, Sanders (1983) traces the flow of material, Ste. Genevieve chert, from procurement of the locally available resource, through various blank and preform stages, concluding with the final fluting and edge grinding of the finished Clovis point.

Sanders (1983) adopted a modified version of Errett Callahan's (1979) 10 stage biface reduction model in developing his typological categories. Callahan's model was chosen for use because its carefully defined stages are based upon his numerous replication experiments. Sanders' somewhat more abbreviated model, consisting of seven progressive stages of manufacture (Figure 1) is described below.

Prior to a discussion of these manufacturing stages, it is necessary to define some terms. The term "blank" is utilized to represent an appropriately shaped piece of lithic material, showing little or no waste, and being large enough to produce a tool. The shape and form of the projected implement usually cannot be determined from the blank (Crabtree 1972:42). The term "preform" is utilized in this paper to indicate an unfinished form of the desired artifact, usually larger and lacking the usual characteristics of the completed tool (Crabtree 1972:85). The following discussion of a multistage biface reduction sequence is summarized from Sanders' (1983) analysis and report.

<u>Stage 0: Procurement of the Lithic Resource</u>

This stage represents the act of deliberate selection of a chert resource for the purpose of reduction and tool manufacture. However, because a chert nodule or tablet is not a bifacially-worked implement, all artifacts falling into this data category are not considered in the subsequent discriminant analysis.

<u>Stage I: Obtaining the Blank</u>

The next logical step in producing a tool entails the production or selection of a blank unit. Typically, these blank units consist of either unmodified, large flakes (spalls) detached from nodules or tablets, or biface cores. Sanders (1983:56) notes that the inhabitants of the Adams Site apparently preferred to utilize spalls as the starting point of the biface reduction sequence. Twenty spall specimens were recovered at 15Ch90, while only five biface cores were collected. Callahan (1979:66) has stated that the optimal size of a Clovis spall ranges from 10-13 cm in length, 7.5-10 cm in width, 13-25 mm in

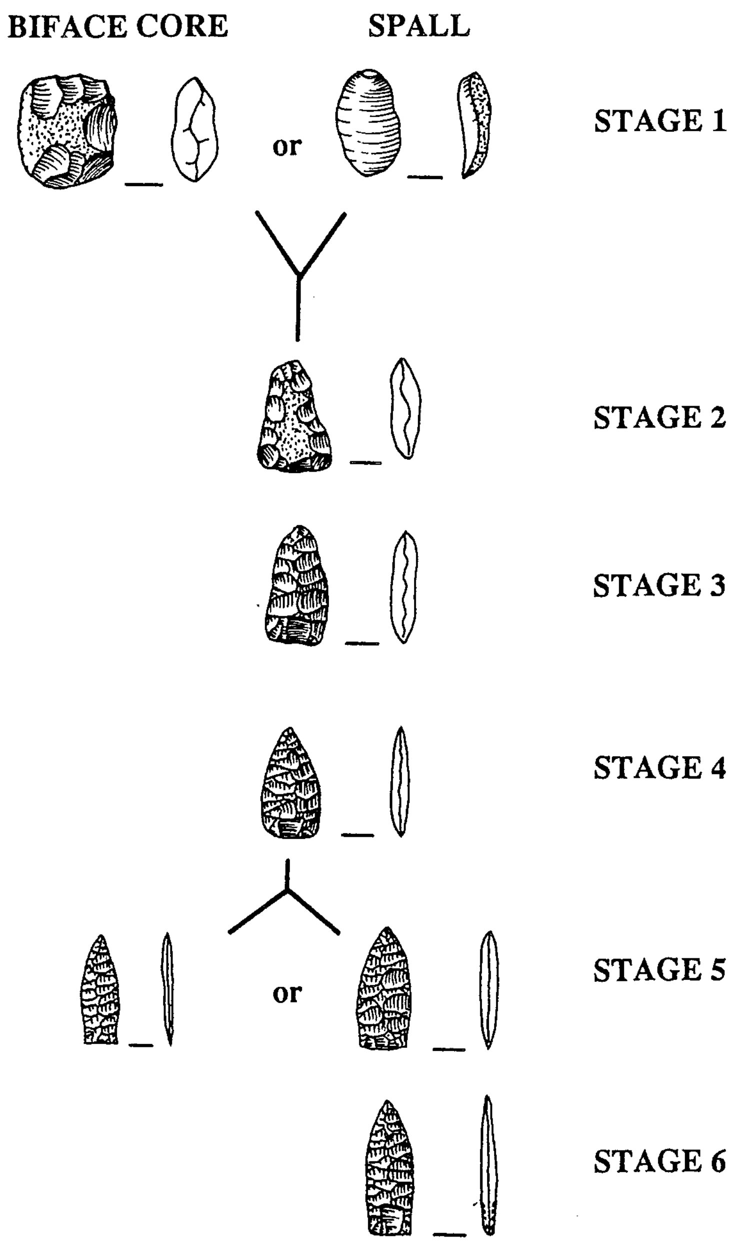

Figure 1. Six Stage Biface Reduction Model (after Sanders 1983).

thickness, and 170-255 grams in weight. Adams Site spalls tend to be shorter, narrower, and thicker than these ideal measurements, which are based upon Callahan's extensive replication experiments. However, these spalls may not represent optimal blanks. Sanders (1983:79) has stated that all but one of these spalls were probably discarded as unsuitable for biface manufacture, due to their extreme degree of curvature and extensive amount of cortex. Again, for reasons stated above, spalls and cores have not been included in the subject discriminant analysis.

Stage II: Initial Edging of the Blank

During Stage II, the selected blank unit is initially edged by detaching flakes which span less than half the biface width. The resulting flake scar intervals are wide and unevenly spaced. Stage II biface transverse sections are hexagonal, irregular, or lenticular. Callahan (1979:10) observes that Stage II specimens have "roughly centered edge-angles of between 55°-75° ... and a width/thickness ratio of 2.0 or more." Based upon the presence of deep flake scars and numerous step fracture terminations and collapsed edges on the Adams Site blanks, it is probable that these bifaces were produced by hard hammer percussion techniques (Sanders 1983:57).

Stage III: Primary Thinning of the Blank

This particular reduction stage entails the primary thinning of the blank unit to produce a biface which is lenticular in cross section. Flakes are removed from the edge up to, or slightly beyond, the biface center, meeting or overlapping thinning flake scars from the opposite margin. Flake scar edge intervals appear to be closer and more regularly spaced than evidenced in Stage II bifaces. Sanders (1983:57) observes that Stage III implements demonstrate flake scars with feather edge terminations, low incidence of gouging, and a decrease in the prevalence of crushed and collapsed edges. He interprets these biface features as hallmarks of the billet percussion technique. Adams Site Stage III bifaces are more regular in appearance, with pointed tips, straight to excurvate lateral edges, and straight or rounded bases. Callahan (1979:10) characterizes this category of bifacially worked specimens as having a width/thickness ratio of between 3.0-4.0, and with aligned, centered edge angles of 40° to 60°.

Stage IV: Secondary Thinning of the Clovis Preform

This stage in the biface reduction process involves the removal of lateral thinning flakes past the biface center, undercutting and removing the opposing flake scars. This action removes the preform's median ridge and produces a biface with a flattened cross section. A Stage IV biface shows detailed billet percussion work; flake scar intervals are close and regularly spaced. All surface irregularities have been eliminated, and edge platforms are centered in relation to the median plane. These Clovis preforms typically have pointed tips, excurvate sides, and rounded bases. Callahan (1979:10) records width/thickness ratios greater than 4.0, and edge angles between 25° and 45° for Stage IV bifaces.

Stage V: Final Shaping of the Clovis Preform

Reduction of the biface preform continues during this stage as billet flaking and pressure retouch are combined to reduce width and give the implement its final shape. In the case of bifacially worked tools not requiring fluting, Stage V represents the end of the reduction sequence.

Stage VI: Fluting and Finishing the Clovis Preform

Further reductions in width are achieved at this point by fluting both faces of the Clovis point preform. Finishing techniques include the application of lateral pressure retouch and lateral/basal grinding. Incidences of multiple fluting of one or both faces are represented in the Adams Site assemblage. While most of the specimens appear to have been fluted by direct billet percussion, a small number of the Adams Site Clovis specimens show evidence of the punch technique of flute removal (Sanders 1983:59).

Stage VII: The Finished Clovis Fluted Point

Stage VII represents the end of the biface reduction sequence, culminating in a finished fluted Clovis projectile point. Finished specimens collected from the Adams Site are mostly broken and rejected points. Understandably, successful Clovis projectile points would have been highly curated by Paleoindian inhabitants, and would be relatively rare items of occurrence at archaeological sites.

These seven stages describe a biface reduction sequence which is in essence a continuum. Flint knapping is a linear, subtractive process, and from beginning to end the proposed implement is in a continuous transition state (Collins 1975:16). The transition is completed when the implement is finished and ready for hafting and/or use. Alternatively, the transition sequence can be terminated when the unfinished implement is discarded, or put to some other use than the intended projectile point.

In his analysis of the Adams Site bifaces, Sanders describes seven major reasons for artifact discard or rejection: step fractures which prevent bifacial thinning, deeply hinged terminations, fracture, overshots, longitudinal splitting, excessively thick biface edges, and raw material flaws (Sanders 1983:60-63). It must also be suspected that some preliminary stage bifaces were coopted for other uses due to the opportune need for a particular tool type. Of the 116 bifaces studied, only five specimens were considered to be successful executions. Four of these successful forms were removed from the continuing reduction process and utilized as other tool types (choppers, side scrapers, drills, and knives). However, Callahan (1974:25) emphasizes that the presence of use wear on early stage biface implements does not necessarily mean that the permanent termination of reduction was intended. At any point during the reduction process, the implement could be utilized for incidental functional activities, and then returned to the reduction process. Sanders (1983:82-125) also observes various degrees of end wear and edge modification on 29 of the unsuccessfully executed Adams Site bifaces. Apparently, the prehistoric residents at the Adams Site were learning to profit from their mistakes.

Sanders' (1983) macroscopic analysis of the Adams Site bifacially worked artifacts employs the seven above-referenced categories of progressive reduction stages. In determining the assignment of individual bifaces to particular classes, he recorded several metric and non-metric observations. Measurements of maximum length, width, and thickness were recorded with vernier calipers, and rounded to the nearest millimeter. Artifact weights were recorded on electronic digital display scales and rounded to the nearest tenth of a gram. Specimens weighing more than 200 grams were weighed on a U.S. Postal Service scale. Edge angles were measured on the most representative area of each lateral with a goniometer. The angle was read by overlaying the goniometer to a sheet of polar coordinate graph paper calibrated in degrees. For fluted specimens, obverse and reverse maximum length and width measurements were recorded. These raw data appear in Appendix Two of Sanders' (1983) thesis, "The Manufacturing of Chipped Stone Tools at a Paleo-Indian Site in Western Kentucky."

Additional more subjective, unpublished observations were noted by Sanders (n.d.) for each biface as follows: overall shape, blade edge shape, basal edge shape, transverse and longitudinal section shape, treatment of lateral and basal edges, type and form of flaking, chert type, and heat treatment. On the basis of these continuous and nominal data, he assigned the 116 Adams Site bifaces to the categories indicated below.

Stage	Specimen Number
II	1,2,3,4,5,6,7,8,9,10,12,14,16,45,46,47,48,49,55,74,76,89, 90,98,104,108,109,111,114,115,116 (n=31)
III	11,13,15,17,18,22,24,26,51,52,56,59,60,63,64,69,73,78,82, 83,84,86,93,94,96,105,106,107,110,112 (n=30)
IV	19,20,21,23,25,27,29,32,34,37,50,54,58,61,65,66,67,70,71, 77,79,80,81,85,87,88,91,92,97,99,101,103 (n=32)
V	28,57,62,68,72,113 (n=6)
VI	30,31,33,35,36,38,39,40,41,53,95,100,102 (n=13)
VII	42,43,44,75 (n=4)

DISCRIMINANT ANALYSIS: BACKGROUND INFORMATION

The first direct archaeological application of the discriminant analysis method apparently was Graham's study of South Britain handaxes (Graham 1970). Using all handaxes recovered from 38 sites as a sample of a homogeneous population, he derived canonical variates indicating the physical attributes which discriminated best between sites. This particular multivariate method functions optimally in situations where units have already been divided into recognized groups, such as the Adams Site bifaces. Discriminant analysis discovers and emphasizes these attributes which distinguish among such known groups, and permits the assignment of similar, unclassified units to groups using this knowledge (Doran and Hodson 1975:209).

The steps involved in executing a discriminant analysis utilizing the SPSS^X statistical program, DISCRIMINANT, are described by Norusis (1985: 73-122). The initial step is to determine which variables will be most successful in predicting assignment to a particular group. While continuous variables with a multivariate normal distribution are the most reliable predictors, dichotomous, or discrete, variables may also be utilized. Most evidence suggests that the linear discriminant function performs reasonably well with combinations of continuous and discrete variables (Norusis 1985:109).

Following the identification of the predictor variables, or attributes, appropriate cases must be selected for use in the statistical analysis. Norusis (1985:76) recommends that cases which are missing information for any of the predictor variables be excluded from the analysis. However, if the sample population presents numerous cases with missing data, then the discriminant analysis will be based upon a small subset of this population, possibly resulting in extremely biased estimates. To address this problem, the program DISCRIMINANT allows the inclusion of cases with missing data, compensating for the missing values by substituting group means.

Once the cases have been selected and appropriate attribute data have been measured and encoded for each case, DISCRIMINANT proceeds to analyze all of the variables simultaneously. A linear combination, or series of combinations, is formed measuring observed intergroup variation. This linear equation serves as a basis for assigning cases to groups. The linear functions are called discriminant coefficients and maximize the ratio of between-groups to within-groups sum of squares. Utilizing these coefficients, a discriminant score is computed for each case by multiplying the coefficients by the values of the variables and summing the products. The discriminant scores are used in assessing the probability of group membership through the application of Bayes' Rule. Simply stated, Bayes' Rule permits the calculation of probability of group membership based upon prior probabilities of group membership (Freund 1970: 103). This predicted group can then be compared to the actual group that has already been assigned, and statements can be made concerning the validity of the previously defined categories.

It is important to note that the magnitude of discriminant coefficients in no way reveals the importance of individual variables. Because the variables in a linear equation are correlated, the value of the coefficient of a particular variable depends upon the other variables included in the function. Positive or negative coefficients are not significant, since absolute values are utilized in computations (Norusis 1985: 90-91). A more appropriate method of assessing the contribution of a single variable to the discriminant function is to examine the correlations between the function values and variable values.

DISCRIMINANT ANALYSIS RESULTS: THE ADAMS SITE BIFACES

With these basic concepts in mind, a specific discriminant analysis was designed for the Adams Site biface collection. For the purposes of this analysis, the term group refers to individual biface reduction stage categories. The selection of variables, in this case artifact attributes, to use as predictors of group membership proved problematical. As Read (1974:225) points out in his discussion of typological derivations, that for a given set of artifacts, "there should be a unique typology, if we knew what variables to measure." Since no archaeologist has been able to unquestionably identify one set of attributes as universally significant in terms of defining typological categories, one must speculate concerning which attributes are important in assigning bifaces to particular reduction stages.

In establishing the list of predictor attributes, it seemed reasonable to utilize the continuous and discrete measurements already available from Sanders' 1983 analysis. These data were supplemented by new measurements recorded during a reexamination of the Adams Site artifact assemblage. Some existing categories of data have been excluded from the discriminant analysis (chert type, heat treatment, and flaking form) because the data lacked sufficient variation to provide significant input. New measurements and computations were recorded for each biface by the author of this paper, with assistance from Thomas Sanders, and include width/thickness ratio, average edge angle, cortex presence/absence, and percussion type. A complete list of the attributes utilized as predictors of bifacial reduction stage are given below. It must be mentioned that an obvious and expected attribute, maximum artifact length, had to be eliminated from consideration due to the high percentage (75%) of broken bifaces in the Adams Site collection. While it can be argued that artifact weight should be excluded for the same reason, an admittedly arbitrary decision was made to retain the weight measurements.

Predictor Variables (abbreviations in parentheses)

1. Maximum width (WIDTH)
2. Maximum thickness (THICK)
3. Width/Thickness ratio (W.T.)
4. Weight (WEIGHT)
5. Average edge angle (AV.ANGLE)
6. Cortex (CORTEX)
7. Overall shape: bipointed (SHAPE1), trianguloid (SHAPE2), elliptical (SHAPE3), undetermined (SHAPE4)
8. Blade edge shape: excurvate (BLADE1), straight (BLADE2), parallel (BLADE3), recurvate (BLADE4), incurvate (BLADE5)

9. Basal edge shape: square (BASE1), convex (BASE2), pointed (BASE3), concave (BASE4)

10. Transverse section shape: biconvex (TRANS1), plano convex (TRANS2), rhomboid (TRANS3), flattened (TRANS4), median ridged (TRANS5), biconcave (TRANS6), concave/convex (TRANS7)

11. Longitudinal section shape: biconvex (LONG1), plano convex (LONG2), rhomboid (LONG3), flattened (LONG4), concave/convex (LONG5)

12. Treatment of lateral edges: dulling (LAT1), grinding (LAT2), visible edge wear (LAT3), no visible edge wear (LAT4)

13. Treatment of basal edge: beveled (BASAL1), thinned (BASAL2), fluted (BASAL3), dulled (BASAL4), ground (BASAL5), striking platform (BASAL6), no treatment of basal edge (BASAL7)

14. Percussion type: hard hammer (HARD), billet (SOFT)

These metric and parametric data were encoded into a computer file. An intermediate step was undertaken to convert the discrete data to binary codes of 0 or 1, representing the presence or absence of traits. I elected to execute a direct, forced-entry discriminant analysis in which all variables, including those with missing data, are analyzed simultaneously.

As stated earlier in this paper, 75% of the Adams Site biface collection are fragmentary specimens. It is patently impossible to obtain a full set of measurements for incomplete specimens, so values for certain parameters were recorded as missing data. Normally, discriminant statistical procedures do not operate on cases with missing variable values, and such cases are eliminated from the test population. However, the exclusion of biface specimens with missing data from this particular study would have reduced the sample size to an unacceptably low number. To compound this problem, 100% of Sanders' (1983) Stages IV, VI, and VII biface collection consist of broken specimens. Also, in certain cases it seems undesirable to eliminate attributes with missing measurements from the list of predictor variables. Attributes such as basal edge shape and basal treatment obviously can be expected to contribute significantly to the identification of particular reduction stages. Therefore, all specimens with missing variable information were used for this discriminant analysis.

Because this statistical procedure has been designed to discriminate among six groups of cases (biface reduction stages II-VII), the SPSS^{X} program DISCRIMINANT accordingly produced five canonical functions. A list of standardized canonical discriminant coefficients, calculated for each variable and function, appears in Table 1.

As discussed previously, an examination of individual coefficient values does not provide a positive indication of which attributes are most successful at predicting group membership. To make this determination, it is necessary to interpret the pooled within-groups correlations between discriminating variables and canonical discriminant

Table 1. Standardized Canonical Discriminant Function Coefficients.

	FUNC 1	FUNC 2	FUNC 3	FUNC 4	FUNC 5
WIDTH	-1.14841	0.54182	-0.95693	0.89867	-0.17704
THICK	-0.39760	1.17485	1.34375	-1.24176	-0.66823
W.T	0.91648	0.70739	0.91622	-1.13722	-0.59536
WEIGHT	1.02457	-1.27406	-0.15740	0.23282	0.63101
AV.ANGLE	-0.33240	-0.40093	0.13003	0.05670	-0.37602
CORTEX	-0.06470	0.05821	0.16228	0.00531	0.32037
SHAPE1	-0.14891	0.13942	0.26171	-0.30528	-0.30823
SHAPE2	-0.12345	-0.01071	0.31813	-0.15640	0.07178
SHAPE3	-0.40554	0.10648	0.31284	-0.32444	0.05071
BLADE1	0.37115	-0.23285	-0.08701	0.59661	-0.18419
BLADE2	0.39693	-0.41104	-0.11760	0.27955	0.02174
BLADE3	0.35759	0.19492	0.30401	0.35628	-0.16324
BLADE4	-0.01224	-0.01308	0.06594	-0.13859	0.44741
BLADE5	-0.01560	-0.14182	-0.15494	0.00815	0.15601
BASE1	0.12052	0.29662	-0.35200	-0.36056	0.05885
BASE2	-0.01852	0.28730	-0.57923	-0.27692	-0.40539
BASE3	0.11489	0.15105	-0.30736	0.03202	0.16217
BASE4	0.09834	0.28878	0.15531	-0.09856	-0.32683
TRANS1	0.36264	-0.74008	-0.39509	-0.01401	0.30543
TRANS2	0.17987	-0.15610	-0.21462	0.28832	0.30432
TRANS3	-0.07025	-0.31807	-0.20453	-0.07087	0.03594
TRANS4	0.14657	-0.00570	0.37071	0.37314	-0.04418
TRANS5	0.07325	-0.06355	-0.17958	0.02932	0.03229
TRANS6	0.03488	-0.62098	0.01019	0.08843	-0.14817
LONG1	0.14234	0.87190	-0.37592	0.24525	-0.24853
LONG2	0.26397	0.28807	-0.57648	0.43600	-0.20470
LONG3	-0.11284	0.33164	0.37131	-0.01189	0.00000
LONG4	0.37929	0.31834	-0.38125	0.41737	0.24687
LAT1	0.00628	0.51788	0.09534	-0.33353	1.32894
LAT2	0.13275	-0.55329	-0.26018	-0.42860	0.45173
LAT3	-0.30241	0.82594	0.12151	-0.64124	1.17477
LAT4	-0.15021	0.90295	0.02227	-0.51113	1.68840
BASAL1	-0.27120	-0.09842	0.08943	0.28037	-0.04478
BASAL2	-0.00012	-0.02284	0.26642	0.36226	0.12691
BASAL3	0.45579	-0.43987	-0.04327	0.35647	-0.03626
BASAL4	0.16474	0.30255	0.70214	0.31322	-0.23952
BASAL5	0.21903	0.47137	0.18961	0.55592	0.31862
BASAL6	0.05977	-0.29831	-0.12728	0.26213	0.15132
BASAL7	-0.12850	-0.20558	-0.27064	0.39878	0.15819
HARD	-0.08399	0.16116	0.04163	-0.05679	-0.15488

functions. These data are presented in Table 2. Important contributing variables are ordered by size of correlation within function and are indicated by asterisks.

The results of this discriminant analysis indicates that the first three functions are statistically significant, based upon the chi-squared tolerance level of 0.0005. However, the pooled within-groups correlations between variables and functions cannot be interpreted at this time beyond a gross level because the investigator did not obtain pooled within-groups correlation matrices. This matrix data would reveal highly correlated individual variables. If two variables are highly correlated, then their contribution to specific functions are shared (Norusis 1985: 92). Without this information, it is not possible to identify with any accuracy those individual attributes which contribute most significantly to discriminating among biface reduction stages.

The most interesting and revealing part of this discriminant analysis is apparent when one examines the end product of the statistical procedure: the assignment of individual biface specimens to statistically-derived reduction stages. The chart provided in Table 3 references specimen numbers (case sequence numbers), originally assigned reduction stages (actual group), and the highest probability groupings. Artifacts which the program determines have been mistakenly classified by Sanders' (1983) analysis are indicated with asterisks. Out of a total of 116 biface implements, DISCRIMINANT agreed with Sanders' reduction stage assignments on all but 12 cases. This represents an accuracy rating of 89.66 percent.

A graphic representation of the discriminant analysis grouping assignments appears in Figure 2, which is an all-groups scatterplot for reduction stages II-VII plotted around group centroids, indicated by asterisks. DISCRIMINANT has utilized symbols 1-6 to depict reduction stages II-VII. When several specimens are located at the same plotting location, only the symbol of the last case is printed. The numbers plotted are the original group assignments. From examining the scatterplot, the misclassified specimens are readily observed.

The final product of this discriminant analysis is a breakdown of actual group membership and predicted group membership figures. The chart shown as Table 4 demonstrates that Sanders' 1983 biface reduction typological categories have been very successful in identifying artifact Stages II, III, V, and VII, and somewhat less successful in classifying Stages IV and VI.

CONCLUSIONS

The results of this discriminant analysis appear to largely conform with earlier observations and interpretations concerning biface reduction stages. However, the use of statistics has imparted a numerical credibility to what are essentially intuitive typological categories. This study would seem to indicate that intuitive typologies can be highly accurate when utilized by trained, experienced archaeologists. However, it is important to stress that an impressionistic taxonomy developed by one individual is very difficult

Table 2. Pooled Within Groups Correlations Between Discriminating Variables and Canonical Discriminant Functions (Variables ordered by size of correlation within function).

	FUNC 1	FUNC 2	FUNC 3	FUNC 4	FUNC 5
THICK	-0.44044*	-0.04115	0.10242	0.04343	-0.04064
W.T	0.41401*	0.25850	-0.04916	-0.23187	-0.29699
AV.ANGLE	-0.37861*	-0.17250	0.24217	0.04108	-0.12478
WEIGHT	-0.30375*	-0.01195	0.04262	0.04577	-0.01897
HARD	-0.30340*	0.06833	-0.17424	0.16934	-0.11311
SOFT	0.30340*	-0.06833	0.17424	-0.16934	0.11311
CORTEX	-0.25847*	-0.05995	0.14462	-0.05945	0.01428
SHAPE3	-0.24986*	-0.08762	0.21754	-0.12582	0.03511
LONG3	-0.16505*	-0.05788	0.14370	-0.08311	0.02319
TRANS3	-0.13937*	-0.04887	0.12134	-0.07018	0.01958
LONG4	0.13294*	-0.01702	0.02657	0.01824	-0.04502
BASAL7	-0.09886*	-0.01735	0.05222	-0.05751	-0.01645
LONG5	-0.08748*	-0.01721	0.03377	0.01635	0.01367
BLADE5	-0.06777*	-0.02377	0.05900	-0.03413	0.00952
LAT2	0.09082	-0.42128*	-0.04440	-0.05589	-0.14595
LAT4	0.01132	0.15122*	-0.13153	0.09772	0.14930
TRANS7	0.05502	0.09877*	0.00273	0.07294	-0.01450
BASAL6	-0.00193	0.07676*	0.02717	0.06776	-0.00514
BASAL4	0.08348	0.06445	0.35280*	0.20082	-0.03807
TRANS1	0.01102	0.04954	-0.26166*	-0.21163	-0.00183
BASE4	0.03441	-0.08280	0.20451*	0.05479	-0.10997
LAT1	0.06776	0.05720	0.18620*	-0.01221	0.05731
TRANS4	0.03680	0.02627	0.18166*	0.13681	0.00288
BLADE3	0.05857	0.05177	0.16783*	-0.00642	-0.08673
SHAPE4	0.03979	0.02762	-0.15440*	-0.05092	0.09953
BASE3	-0.02985	0.03282	-0.08745*	0.08471	-0.02690
BASAL5	0.06289	-0.02283	-0.03110	0.31444*	0.09398
SHAPE2	0.10006	-0.02928	0.11274	0.19594*	-0.00172
BLADE1	-0.02995	0.05426	-0.15016	0.16307*	0.03484
BASAL1	0.05112	0.00627	0.07641	0.15318*	-0.00532
BASAL2	-0.03914	0.05046	0.12585	0.14741*	0.05662
LONG2	0.04700	-0.02532	-0.00954	0.14285*	0.10592
LONG1	-0.04143	0.07947	-0.10423	-0.12793*	-0.08823
TRANS2	-0.04219	0.03751	0.05717	0.10930*	0.07700
LAT3	-0.08857	0.04058	0.07749	-0.09203*	-0.02927
BLADE4	-0.02549	-0.02802	-0.01391	-0.12825	0.37581*
WIDTH	-0.25041	0.20213	-0.14745	0.07186	-0.33313*
BASAL3	0.13554	-0.08566	0.09030	0.21346	-0.24968*
TRANS6	0.08916	-0.20576	0.20207	0.07933	-0.24560*
TRANS5	-0.04704	-0.01178	-0.03599	0.02955	0.22173*
BASE2	-0.05378	0.12854	-0.13036	0.09057	-0.19054*
SHAPE1	0.00136	0.07410	-0.12580	-0.11194	-0.15919*
BASE1	-0.01728	0.02506	0.15091	-0.04829	0.15284*
BLADE2	-0.02575	-0.09556	0.06184	-0.01372	-0.09780*

Table 3. Biface Specimen Group Assignments Utilizing Statistically Derived Reduction Stages.

CASE SEQNUM	MIS VAL	SEL	ACTUAL GROUP		HIGHEST PROBABILITY GROUP	P(D/G)	P(G/D)	2ND HIGHEST GROUP	P(G/D)
1			2		2	0.2630	1.0000	3	0.0000
2			2		2	0.4454	1.0000	3	0.0000
3			2		2	0.1395	1.0000	3	0.0000
4			2		2	0.0976	0.5868	3	0.4131
5			2		2	0.3650	0.9945	3	0.0055
6			2		2	0.4673	0.9968	3	0.0032
7			2		2	0.3085	1.0000	3	0.0000
8			2		2	0.5308	1.0000	3	0.0000
9			2		2	0.4212	1.0000	3	0.0000
10			2		2	0.7368	0.9999	3	0.0001
11			3		3	0.3801	0.9965	2	0.0033
12			2		2	0.7512	0.9988	3	0.0012
13			3		3	0.5005	0.9811	4	0.0097
14			2		2	0.0066	0.9213	3	0.0787
15			3		3	0.8941	0.9990	4	0.0010
16			2		2	0.8001	1.0000	3	0.0000
17			3		3	0.9728	0.9659	4	0.0341
18			3		3	0.4248	0.9950	4	0.0046
19			4		4	0.8968	0.9616	3	0.0383
20			4		4	0.6272	0.8516	3	0.1478
21			4		4	0.8623	0.9848	3	0.0151
22			3	**	4	0.7617	0.6275	3	0.3681
23			4		4	0.5431	0.8663	3	0.1337
24			3		3	0.3837	0.8622	4	0.1378
25			4		4	0.7418	0.9911	3	0.0082
26			3		3	0.1479	0.9981	4	0.0012
27			4		4	0.8502	0.7145	3	0.2849
28			5		5	0.8856	0.9985	4	0.0015
29			4	**	6	0.7014	0.9694	4	0.0284
30			6		6	0.9550	0.9997	4	0.0003
31			6		6	0.9463	0.9995	4	0.0005
32			4	**	6	0.3273	0.5741	4	0.4258
33			6		6	0.5502	1.0000	4	0.0000
34			4		4	0.4640	0.9511	6	0.0463
35			6		6	0.3624	1.0000	4	0.0000
36			6		6	0.5738	0.7002	4	0.2641
37			4		4	0.7264	0.9934	5	0.0046
38			6		6	0.6772	1.0000	4	0.0000
39			6		6	0.8352	0.9965	4	0.0035
40			6	**	4	0.9480	0.9895	6	0.0082
41			6	**	5	0.7597	0.9703	4	0.0254
42			7		7	0.9196	1.0000	5	0.0000
43			7		7	0.8907	1.0000	5	0.0000
44			7		7	0.7466	1.0000	5	0.0000
45			2		2	0.3005	1.0000	3	0.0000
46			2		2	0.5297	1.0000	3	0.0000
47			2		2	0.0048	1.0000	3	0.0000
48			2		2	0.7414	1.0000	3	0.0000
49			2		2	0.6106	1.0000	3	0.0000
50			4		4	0.7195	0.9985	3	0.0007
51			3		3	0.2446	0.9438	4	0.0561
52			3		3	0.2929	0.9920	2	0.0076
53			6		6	0.3721	1.0000	4	0.0000
54			4		4	0.1812	0.9997	3	0.0002
55			2		2	0.0505	0.6306	3	0.3596
56			3		3	0.0534	0.9994	2	0.0006
57			5		5	0.9537	1.0000	4	0.0000
58			4		4	0.7270	0.8045	3	0.1225
59			3		3	0.8150	0.9995	4	0.0005
60			3		3	0.9912	0.9702	4	0.0298
61			4		4	0.8827	0.8644	3	0.1353
62			5		5	0.2186	0.9999	4	0.0001
63			3		3	0.7318	0.9924	4	0.0072
64			3	**	4	0.9486	0.9971	3	0.0025
65			4	**	3	0.8233	0.6549	4	0.3422

Table 3 (continued).

66	4		4	0.3473	0.9977	6	0.0012
67	4		4	0.0232	0.9936	3	0.0049
68	5		5	0.6196	0.6896	4	0.2756
69	3		3	0.8911	0.9895	4	0.0099
70	4	**	5	0.6916	0.9224	4	0.0773
71	4		4	0.6875	0.7780	5	0.1695
72	5		5	0.9361	0.9929	4	0.0069
73	3		3	0.3131	0.9132	5	0.0719
74	2		2	0.1780	1.0000	3	0.0000
75	7		7	0.8921	1.0000	5	0.0000
76	2		2	0.0813	1.0000	3	0.0000
77	4		4	0.6090	0.9989	5	0.0008
78	3		3	0.0518	0.8422	4	0.1578
79	4		4	0.7122	0.8557	3	0.0884
80	4		4	0.6733	0.9968	5	0.0029
81	4		4	0.9548	0.9897	3	0.0100
82	3		3	0.6734	0.9884	4	0.0116
83	3		3	0.5935	0.5142	4	0.4852
84	3		3	0.0717	0.9966	4	0.0034
85	4		4	0.3781	0.5383	3	0.4606
86	3		3	0.2815	0.9883	4	0.0117
87	4	**	3	0.7001	0.6710	4	0.3290
88	4	**	6	0.8696	0.9773	4	0.0226
89	2		2	0.6407	1.0000	3	0.0000
90	2		2	0.9766	0.9999	3	0.0001
91	4		4	0.3941	0.4952	5	0.3147
92	4		4	0.9147	0.9674	3	0.0307
93	3		3	0.5460	0.5535	4	0.4460
94	3		3	0.4707	0.9894	4	0.0106
95	6		6	0.3438	1.0000	4	0.0000
96	3		3	0.7935	0.9900	4	0.0100
97	4		4	0.6059	0.9982	3	0.0010
98	2		2	0.3585	0.9989	3	0.0011
99	4	**	3	0.3600	0.6693	4	0.3307
100	6		6	0.5723	0.7506	4	0.2490
101	4		4	0.3999	0.9948	6	0.0034
102	6		6	0.6661	1.0000	4	0.0000
103	4	**	6	0.4814	0.5875	4	0.4100
104	2		2	0.8783	1.0000	3	0.0000
105	3		3	0.6596	0.9953	2	0.0038
106	3		3	0.6414	0.9895	4	0.0067
107	3		3	0.5776	0.8734	4	0.1227
108	2		2	0.9307	1.0000	3	0.0000
109	2		2	0.1380	1.0000	3	0.0000
110	3		3	0.7303	0.9985	4	0.0009
111	2		2	0.4459	0.9999	3	0.0001
112	3		3	0.8648	0.9989	4	0.0011
113	5		5	0.7874	1.0000	4	0.0000
114	2		2	0.8459	1.0000	3	0.0000
115	2		2	0.9410	0.9999	3	0.0001
116	2		2	0.6446	1.0000	3	0.0000

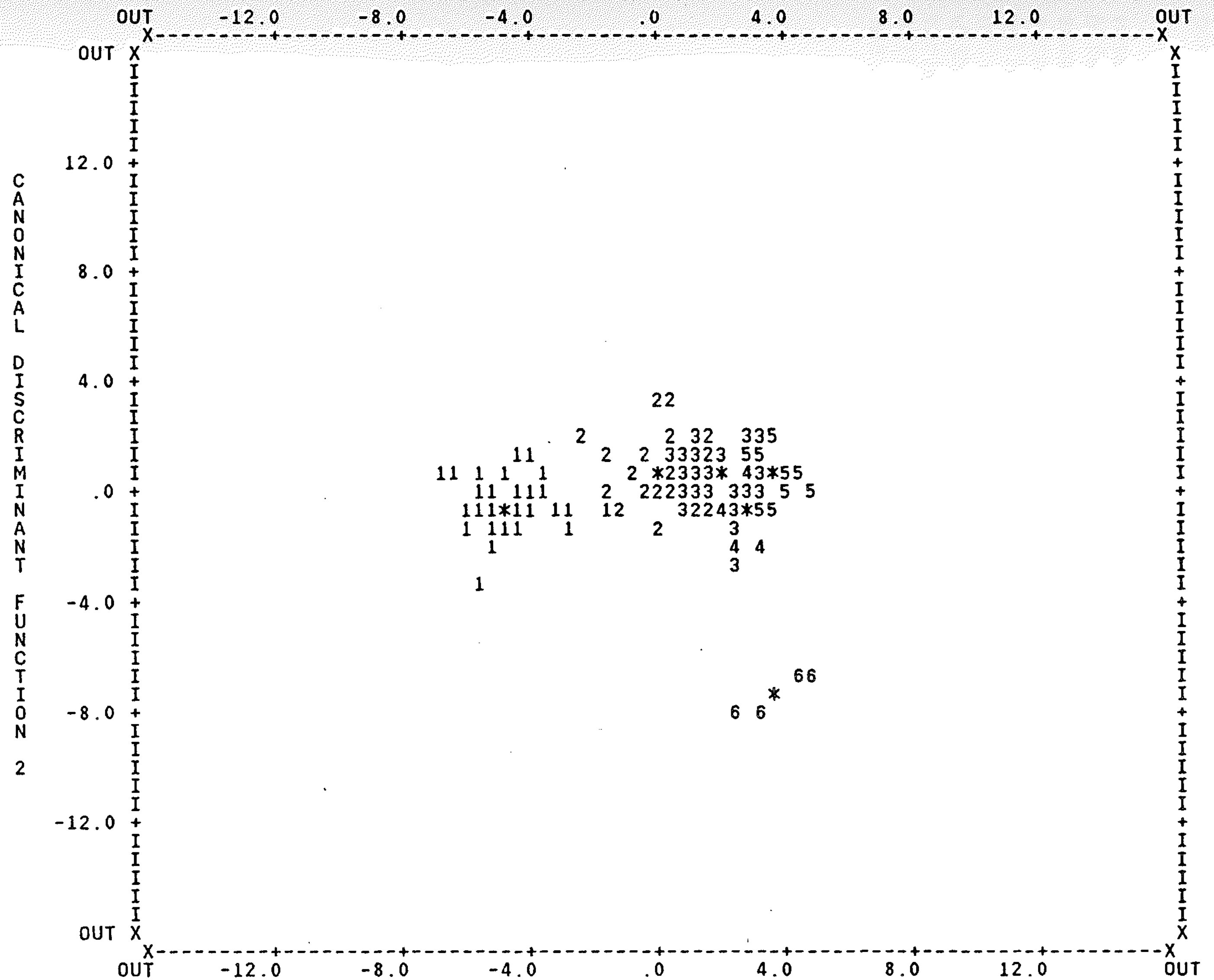

Figure 2. All- Groups Scatterplot- * Indicates a Group Centroid
Canonical Discriminant Function 1.

Table 4. Actual Group Membership Versus Predicted Group Membership.

ACTUAL GROUP		NO. OF CASES	PREDICTED GROUP MEMBERSHIP 2	3	4	5	6	7
GROUP	2	31	31	0	0	0	0	0
			100.0%	0.0%	0.0%	0.0%	0.0%	0.0%
GROUP	3	30	0	28	2	0	0	0
			0.0%	93.3%	6.7%	0.0%	0.0%	0.0%
GROUP	4	32	0	3	24	1	4	0
			0.0%	9.4%	75.0%	3.1%	12.5%	0.0%
GROUP	5	6	0	0	0	6	0	0
			0.0%	0.0%	0.0%	100.0%	0.0%	0.0%
GROUP	6	13	0	0	1	1	11	0
			0.0%	0.0%	7.7%	7.7%	84.6%	0.0%
GROUP	7	4	0	0	0	0	0	4
			0.0%	0.0%	0.0%	0.0%	0.0%	100.0%

PERCENT OF "GROUPED" CASES CORRECTLY CLASSIFIED: 89.66%

to transfer intact to other researchers. Consistent classification techniques, vital if data are to be comparable, are difficult to achieve. Statistical procedures such as discriminant analysis offer a method of obtaining more reliable and objective results from the use of particular typologies.

While the stated goals of this study have been realized, this research represents only a preliminary reexamination of the Adams Site biface collection. Future research will include a more intense examination of individual artifact attributes in an effort to more accurately identify those variables which contribute most to the delineation of reduction stages. This effort will entail the execution of a stepwise discriminant analysis, and the interpretation of pooled within-groups correlation matrices to identify highly correlated variables. It is anticipated that the ultimate conclusion of this study will successfully demonstrate how quantitative methodologies can enhance the understanding of cultural processes.