

patterns and practices for the efficient collection of new maize races and populations and the interpretation of maize evolution.

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3. Multivariate and quantitative studies of maize systematics and genetics.

In conjunction with Drs. S. G. Stephens and M. M. Goodman, several aspects of maize systematics are being investigated. A series of genetic studies is aimed toward understanding the genetic basis of several of the morphological traits used so frequently in determining racial interrelationships. A classification of maize races is being attempted by using different multivariate techniques. Many new morphological characters are being evaluated. Although no method seems to exist for selecting a small set of characters which would classify material almost as well as the full set, it is hoped that eventually there will be a reduction in the number of variables needed. Probably different subsets will be needed for defining maize groups and races within each geographical region and within each major subdivision of the species. A reduced set of variables accounting for most of the variation present in the maize to be studied would greatly aid research into maize evolution by allowing much larger samples to be studied.

Although several hundred maize races and subraces have been described, there has been little success in determining their interrelationships. A study of variables can be more carefully and easily made when the data are obtained from a "balanced" sample of objects, "balanced" in that all the major trends of evolution are sampled. Therefore tentative groupings of races are being described, perhaps 40 for the present species Zea mays. Many races will be unique, intermediate or too variable to be properly ascribed to a group. A more careful grouping of races should be possible when the variables have received more study.

During my doctoral work an attempt was made to use factor analysis for classifying. It was not fully satisfactory, but factor analysis helps greatly in more meaningful selection and characterization of variables.

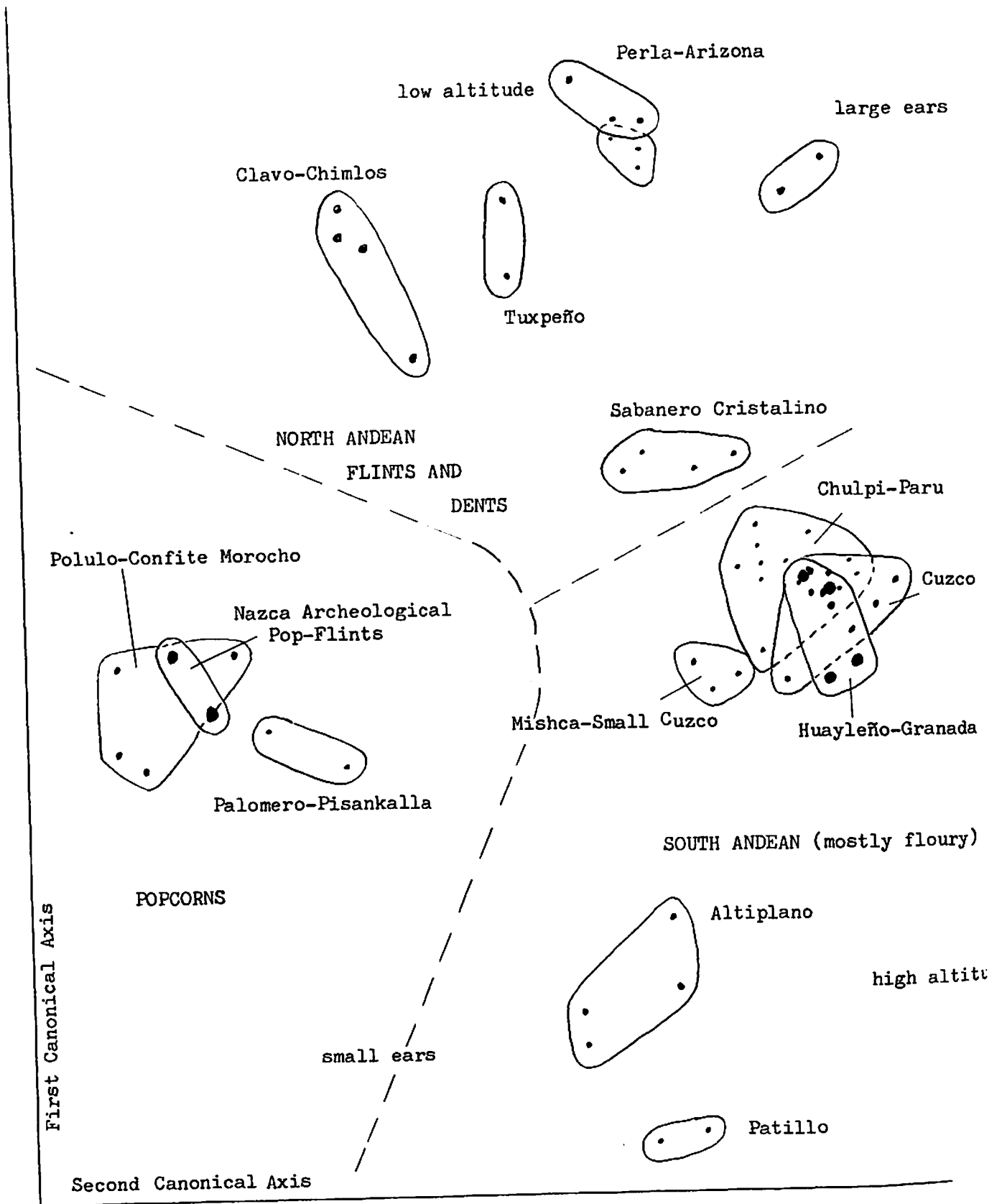
M. Goodman at this campus is continuing study of principal components of maize, the effects of the environment on variables and

classification of maize races, especially those of the Amazon area and Central America.

Numerical taxonomy provides a means of classifying that many argue holds special promise. However, the more widely available techniques do not provide a method that indicates relationship in multidimensional space, a necessity for comprehending the nearly chaotic variety of maize races.

Preliminary results using canonical analysis have convinced S. G. Stephens (for Gossypium), M. Goodman and myself that this technique provides a useful portrayal of relationships. Therefore I will briefly describe early results of a canonical analysis of 57 ears from Peru, two from Ecuador and two archeological specimens from south coastal Peru (Fig. 1). The ears are typical specimens of races already described and of new races found in Peru. These are the specimens that seem to readily fit into groups that can be defined by numerical taxonomy using 117 variables and by a prior canonical analysis using six variables. Additional material which does not easily fit into one of the 15 groups is not used in the analysis. Figure 1 results from the input of 32 variables selected to represent all the factors described in my doctoral research, these variables also having high values on a standard F test (ratio of between to within group variance).

At least three loose divisions seem possible for the sample at hand--temperate popcorns, South Andean flours and North Andean flints. The groups are tentatively labeled Polulo-Confite Morocho (South Andean small-cob popcorns), Palomero-Pisankalla (conical-eared popcorns with white, pointed kernels, probably lately introduced), Nazca Archeological Pop-Flints (multi-rowed ears with small kernels), Clavo-Chimlos (elongate flints or dents), Tuxpeño (flinty dents from the tropical Caribbean area), Amagaceño (flints of middle altitude), Perla-Arizona (large-eared flinty dents), Sabanero Cristalino (small-eared flints of middle altitude), Cuzco (large-grained, eight-rowed types not exclusively South Andean; both floury and flinty), Mishca and Small Cuzco (similar to Cuzco but smaller, floury), Huayleño-Granada (small-eared flours of high altitude), Chulpi-Paru (large-eared, multi-rowed flours of high altitude), Altiplano (very small flours of very high altitude), Patillo (very small flints of



very high altitude) and an unlabeled potential group of large-eared, middle altitude flours from near Huánuco at the upper right of Fig. 1.

There are several limitations to Fig. 1, a plot based on the two most important canonical variables or axes. To properly separate the several groups in close proximity in the center of Fig. 1, at least two additional axes are needed since the distances between these groups are not well demonstrated with these two axes. By using the canonical axes here presented, one does not obtain satisfactory classification of new material unless it is closely related to one or more of the 15 groups.

Canonical analyses using other sets of variables, cob characters, characters predicted to be of "low value," and the six "best" variables, also give good separation of these groups, although the relative spacing is different. Not only does this help to corroborate the grouping presented, but it means that one can classify material using whatever variables are available.

The genetic studies are only being started. Following the suggestion of M. Goodman, the variabilities found in the F_2 generations of crosses between widely separated races will be compared with the phenotypic distances. At the same time the genetic inheritance of some important traits may be studied. It should also be possible to observe introgressive effects of one race on others.

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1. Chemical nature of the a_2 mutant.

About one kg. of a_2 and in a_2 seeds, after removal of pericarp, were defatted with petroleum ether and then extracted with cold methanol. The solvent was removed under reduced pressure and was treated with ether. Ether insolubles were separated by filtration and treated with distilled water. The aqueous solution was extracted repeatedly with ethyl acetate, and dried over anhydrous magnesium sulphate. The solvent is removed under cold conditions on a flash evaporator, which gave a