

# A Morphological Appraisal of Wild Species in Section *Arachis* of Peanuts<sup>1</sup>

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## ABSTRACT

The cultivated peanut, *Arachis hypogaea* L., is a member of section *Arachis nom. nud.* along with its tetraploid progenitor, *A. monticola* Krap. et Rig., four validly described diploid species, eight diploid species whose names have never been validly published, and a large collection of taxa discovered since 1975. Systematic relationships and possible species circumscriptors are assessed in section *Arachis* by means of numerical taxonomy. Seventy-three accessions were grown in the field and three randomly selected specimens of each accession were evaluated. Numerical techniques in the form of cluster and principal components analyses were used on 56 characters, including 20 reproductive, 30 vegetative, and six created variables. Most variation was observed for leaflet size and shape, followed by branching habits and flower size. Although grouping of accessions did not always conform to expectations based on published species descriptions, general relationships among taxa are evident from the analyses. A total of 20 to 25 species will likely exist in section *Arachis* based on the observed variability.

Key Words: *Arachis*, species, numerical taxonomy.

The genus *Arachis* comprises a large and diverse group of diploid and tetraploid taxa native to South America. Species were first described by Linnaeus in 1753 and monographs have since been published by Chevalier (1), Hoehne (7), and Hermann (6). Due to inadequate herbarium specimens and the lack of field collections from over the range of the genus, Gregory *et al.* (4) considered these works to be greatly deficient. Three different infrageneric classifications have also been published (5, 8, 9) wherein the genus was divided into sections. However, none of the sectional names have been validly published according to the International Code of Botanical Nomenclature (10). Although 70 or more species may exist in the genus (3, 18), only 22 species, one variety and one hybrid have been validly described. Names for at least 12 additional species are commonly found in the literature, but these names have never been validated with descriptors. Collections made in South America during recent years have nearly tripled the number of accessions maintained under cultivation (12), and the taxonomy of *Arachis* has become increasingly deficient and confusing.

Species of section *Arachis nom. nud. sensu* Gregory *et al.* (5) are of special interest because the cultivated peanut *A.*

*hypogaea* L. ( $2n = 4x = 40$ ) is a member of the group. Both annual and perennial species in this section are widely distributed east of the Andes and north of 35° south latitude in South America. The known distribution of section *Arachis* has been extended to more than 1000 km northwest in Bolivia, 1500 km to the northeast in Brazil, and 350 km north along the Atlantic coast since 1976 (11). Section *Arachis* is distinguished from other sections of the genus by having tap roots but no adventitious, roots or rhizomes, vertical pegs which do not grow in a horizontal direction after penetrating the soil, and flowers without prominent red veins (5, 10). Six species (*A. batizocoi* Krap. et Greg., *A. diogeni* Hoehne, *A. helodes* Martius ex Krap. et Rig., *A. hypogaea*, *A. monticola* Krap. et Rig. and *A. villosa* Benth. var. *villosa*) have been described and names for nine other species have been used (Table 1). Estimates of the number of species which eventually will be described in section *Arachis* have ranged from 15 to 20 by Stalker and Moss (18) and from 34 to 46 by Valls *et al.* (19).

The purpose of this paper is to present results from a morphological study of wild *Arachis* species referable to section *Arachis*. A large number of living accessions have been used in an attempt to better describe taxonomic relationships in section *Arachis* and to delimit groups which may eventually be recognized as species. It is hoped that the results from this analysis will lay the foundation for a more complete taxonomic synthesis of section *Arachis* in the future.

## Materials and Methods

Seventy-three wild peanut accessions belonging to section *Arachis* were transplanted in a field at the Sandhills Agricultural Research Station, NC in May 1986 (Table 2). Forty-three of these accessions were obtained from D. J. Banks, U.S. Curator at that time for *Arachis* species at Stillwater, OK in 1979 and 1981; 14 accessions were obtained in 1982 from C. E. Simpson of Texas A&M University, Stephenville, TX; and 14 accessions plus a small leaf (sl) mutant of 10038 were already maintained at North Carolina State University prior to recent introductions. Two additional collections (6536 and 7762) were obtained in Brazil during a collection expedition in 1984 by H. T. Stalker, C. E. Simpson, J. F. M. Valls, I. J. Godoy, and W. L. Werneck.

Three plants were randomly selected from each accession grown in the field and scored for 20 reproductive and 30 vegetative traits 90 to 95 days after planting. Data for the following traits were collected: presence or absence of flowers on the main stem; main stem and lateral branches erect or prostrate; length of main stem; length of longest lateral branch; relative amount of lateral branching; annual or perennial; length and width of main stem and lateral leaves and leaflets; shape of main stem and lateral leaflets (lanceolate = 1 to obcordate = 6); shape of the leaflet apex on main stem and lateral leaves (acuminate-abrupt = 1 to emarginate = 7); stipule length; petiole length of main stem and lateral leaves; internode length between leaflets on main stem and lateral leaves; numbers of trichomes on stems, upper and lower leaflet surface, leaflet margins and pegs; length and type

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Table 1. Taxonomic subdivision of section *Arachis nom. nud.* [after Gregory *et al.* (5) and Ressler (10)].

	Accession <sup>a</sup>
<b>Series <i>Annuae</i> Krap. et Greg. nom. nud.</b>	
1. <i>A. batizocoi</i> Krap. et Greg.	K 9484
2. <i>A. duranensis</i> Krap. et Greg. nom. nud.	K 7988
3. <i>A. ipaensis</i> Greg. et Greg. nom. nud.	GKBSPSc 30076
4. <i>A. spegazzinii</i> Greg. et Greg. nom. nud.	GKP 10038
5. <i>A. stenosperma</i> Greg. et Greg. nom. nud.	HLK 410
<b>Series <i>Perennes</i> Krap. et Greg. nom. nud.</b>	
6. <i>A. cardenasii</i> Krap. et Greg. nom. nud.	GKP 10017
7. <i>A. chacoense</i> Krap. et Greg. nom. nud.	GKP 10602
8. <i>A. helodes</i> Martius ex. Krap. et Rig.	GKP 9926
9a. <i>A. villosa</i> Benth. var. <i>villosa</i>	B 22585
9b. <i>A. villosa</i> var. <i>correntina</i> Burkart	GKP 9530-31
[ <i>A. correntina</i> (Burk.) Krap. et Greg. nom. nud.]	
10. <i>A. diogoi</i> Hochne	----
<b>Series <i>Amphiploides</i> Krap. et Greg. nom. nud.</b>	
11. <i>A. hypogaea</i> L.	----
12. <i>A. monticola</i> Krap. et Rig.	K 7264
13. <i>A. x batizogaea</i> Krap. et Fern. (experimental hybrid)	----

<sup>a</sup>Only the most commonly used accession number is listed with each species.

of trichomes (none = 0, single cell = 1, glandulated = 2); flower height, width, shape (standard almost flat = 1 to prominent bend at edges away from wings = 3) and color; hypanthium length and color; peg length; pod length, width, shape (round = 1 to long and narrow = 6), reticulation and beak size; seed length, width, color, reticulation, shape (round = 1 to long and narrow = 6) and weight; and flowering pattern on lateral stems (sequential vs. alternate pattern of reproductive nodes). In addition, the following six statistically created variables were evaluated: main stem and lateral leaf length/width ratios, main stem and lateral leaflet length/width ratios, and pod and seed length/width ratios. The three variables for the three plants of an accession were averaged for each trait, providing one value for each of the 56 variables measured for an accession. The data were standardized and numerical taxonomic techniques were applied using the SAS computer program for principal component and cluster analyses based on the unweighted pair group method with arithmetic averages (UPGMA) (14). Average taxonomic distance coefficients (15) were computed and accessions clustered by means of UPGMA, a sequential agglomerative, hierarchical, nonoverlapping technique. A second set of analyses were conducted with only those variables having eigenvalues greater than one to analyze that portion of the data which is most likely to have biological significance for separation of taxa. This analysis only used data from 15 of the 56 eigenvalues (2).

## Results

Origins for all accessions are listed in Table 2 along with USDA plant inventory (PI) numbers, collectors' names, and species names when they have appeared in the literature associated with a corresponding accession. In addition, accession numbers were plotted on a South American map to illustrate distributions (Fig. 1). Accession 30080 was previously published in error as 30097 (17). Taxa in the section are found in three major drainage systems including the Parana/Paraguay River system, which initiates in south-central and western Brazil and generally flows south; the

Madeira River, which flows north into the Amazon; and the north-flowing Araguaia River system in central Brazil. The three accessions of *A. stenosperma* Greg. et Greg. nom. nud., which were obtained from the eastern seacoast of Brazil, presumably originated from the Parana River drainage basin. All taxa were diploid  $2n = 2x = 20$  except for 7264, 30062 and 30063 which are tetraploid accessions of *A. monticola*.

Even though species in section *Arachis* have several common root, flower, and pegging characteristics, they are highly variable for most vegetative and reproductive traits. Conspicuous differences were noted among many taxa for leaflet shape and sizes, which ranged from short and narrow to long and round. Many taxa have an extensive amount of secondary branching, while others have only a few laterals. Several taxa had main stems reaching a few centimeters in height, whereas others were more than a half meter high. Similarly, flowers of many taxa had standards ranging 8 to 10 mm long, while in other species they were more than twice as long. Although flower color is an easily identifiable feature of peanuts, both yellow and orange types are found in many species, and even on different plants of the same accession, and should not be used as a major character to classify taxa.

The first two principal components accounted for only 28% of the total variation, which indicates that the characters measured in the study may not represent traits of taxonomic significance or that there are few traits of taxonomic significance. However, the large leaf types, including *A. batizocoi* had high positive values for the first principal component and accessions of the small leafed species *A. correntina* (Burk.) Krap. et Greg. nom. nud. had negative values. In the middle of the two extremes was a large group of taxa with more or less continuous variability for leaf size. Although several accessions formed distinctive groups, the number of species in the section was nearly impossible to determine from principal component analysis.

The phenogram from the cluster analysis of 56 traits showed two major groups of species in the section. The smaller cluster of taxa comprised only four accessions (30091, 30098, 30099, and 30100) of a yet undescribed species. These four accessions have been collectively designated as having a D genome (16). The second major group consisted of the remaining 69 accessions. Although the phenogram may have value to indicate relative morphological similarities among taxa, it could not be considered a trustworthy predictor of species taxonomy because many accessions within previously described species did not cluster together.

A second analysis, using eigenvectors greater than one as proposed by Goodman (2), appeared to eliminate much of the randomness for separation of taxa. The 73 accessions were plotted on the first two principal component axes (Fig. 2), which accounted for 20 and 15% of the variation, respectively. Accessions were separated into groups corresponding to known species based on expectations from reports in the literature and previous experience with *Arachis* germplasm. Traits of most importance for component one were leaf and leaflet length and width of both mainstem and lateral leaves, and pod width and annual vs. perennial growth habit. The most important vectors for component two included flower width and shape, hypanthium length, and pod length. Similar to the first analysis which used all traits, the *A. batizocoi* and *A. sp.* accessions 30091, 30098, 30099, and 30100 associated as a group toward the high positive

Table 2. *Arachis* accessions morphologically observed with corresponding collectors, U.S. plant inventory numbers, species names when they had previously been associated with accessions in the literature, and locations of collections.<sup>a</sup>

Acc.	Coll. <sup>b</sup>	PI	Species	State	Country	Long.	Lat.
408	HLK	338279	<i>A. stenosperma</i>	Parana	Brazil	48°44'	25°24'
409	HLK	337308	<i>A. stenosperma</i>	Parana	Brazil	48°44'	25°24'
410	HLK	338280	<i>A. stenosperma</i>	Parana	Brazil	48°31'	25°31'
6326	VSGr	476043	<i>A. sp.</i>	Mato Grosso	Brazil	56°04'	15°52'
6331	VSGr	476045	<i>A. helodes</i>	Mato Grosso	Brazil	56°44'	16°20'
6352	VSGr	476109	<i>A. sp.</i>	Mato Grosso	Brazil	57°47'	15°56'
6536	VKRSv	497551	<i>A. sp.</i>	Goias	Brazil	48°36'	09°29'
7264	K	219824	<i>A. monticola</i>	Jujuy	Argentina	65°24'	24°07'
7762	VSStGdW	--	<i>A. sp.</i>	Mato Grosso	Brazil	52°29'	15°34'
7830	K	261871	<i>A. correntina</i>	Corrientes	Argentina	58°46'	27°33'
7897	K	261868	<i>A. correntina</i>	Corrientes	Argentina	--	--
7988	K	219823	<i>A. duranensis</i>	Salta	Argentina	63°43'	22°19'
9484	K	298639	<i>A. batizocoi</i>	Cordillera	Bolivia	63°14'	20°50'
9530	GKP	262808	<i>A. correntina</i>	Corrientes	Argentina	58°46'	27°33'
9548	GKP	262881	<i>A. correntina</i>	--	--	--	--
10017	GKP	261874	<i>A. cardenasii</i>	Santa Cruz	Bolivia	59°46'	18°20'
10038L	GKP	262133	<i>A. spegazzinii</i>	Salta	Argentina	65°32'	24°47'
10038S	GKP	--	<i>A. spegazzinii</i>	--	--	--	--
10602	GKP	276235	<i>A. chacoense</i>	Concepcion	Paraguay	57°59'	22°17'
22585	Bu	298636	<i>A. villosa</i>	Federacion	Argentina	57°57'	30°56'
30001	GK	468141	<i>A. sp.</i>	Mato Grosso	Brazil	57°45'	17°40'
30005	GK	468142	<i>A. diogeni</i>	Mato Grosso	Brazil	57°40'	17°47'
30006	GK	468150	<i>A. sp.</i>	Mato Grosso	Brazil	57°30'	18°08'
30008	GK	468152	<i>A. sp.</i>	Mato Grosso	Brazil	56°39'	19°02'
30011	GK	468154	<i>A. sp.</i>	Mato Grosso	Brazil	57°29'	19°11'
30017	GK	468159	<i>A. sp.</i>	Mato Grosso	Brazil	55°57'	20°21'
30029	GK	468144	<i>A. helodes</i>	Mato Grosso	Brazil	56°28'	16°00'
30030	GK	468145	<i>A. helodes</i>	Mato Grosso	Brazil	56°53'	16°07'
30034	GK	468167	<i>A. sp.</i>	Mato Grosso	Brazil	57°18'	16°08'
30035	GK	468168	<i>A. sp.</i>	Mato Grosso	Brazil	57°15'	16°05'
30060	GKBSpSc	468197	<i>A. sp.</i>	Jujuy	Argentina	65°07'	24°22'
30061	GKBSpSc	468198	<i>A. sp.</i>	Jujuy	Argentina	65°12'	24°16'
30062	GKBSpSc	468196	<i>A. monticola</i>	Jujuy	Argentina	65°23'	24°07'
30063	GKBSpSc	468199	<i>A. monticola</i>	Jujuy	Argentina	65°24'	24°04'
30064	GKBSpSc	468200	<i>A. sp.</i>	Jujuy	Argentina	65°07'	24°23'
30065	GKBSpSc	468201	<i>A. sp.</i>	Salta	Argentina	63°53'	23°04'
30067	GKBSpSc	468202	<i>A. sp.</i>	Salta	Argentina	63°56'	23°03'
30068	GKBSpSc	468203	<i>A. sp.</i>	Salta	Argentina	63°56'	22°51'
30069	GKBSpSc	475844	<i>A. sp.</i>	Tarija	Bolivia	63°33'	21°48'
30070	GKBSpSc	475845	<i>A. sp.</i>	Tarija	Bolivia	63°38'	21°53'
30071	GKBSpSc	475846	<i>A. sp.</i>	Tarija	Bolivia	63°45'	21°41'
30072	GKBSpSc	475847	<i>A. sp.</i>	Tarija	Bolivia	63°44'	21°41'
30073	GKBSpSc	468319	<i>A. sp.</i>	Tarija	Bolivia	63°33'	21°44'
30074	GKBSpSc	468320	<i>A. sp.</i>	Tarija	Bolivia	63°27'	21°26'
30075	GKBSpSc	468321	<i>A. sp.</i>	Tarija	Bolivia	63°27'	21°18'
30076	GKBSpSc	468322	<i>A. sp.</i>	Tarija	Bolivia	63°24'	21°00'
30077	GKBSpSc	468323	<i>A. sp.</i>	Chuguisaca	Bolivia	63°13'	20°37'
30078	GKBSpSc	468324	<i>A. sp.</i>	Chuguisaca	Bolivia	63°08'	20°45'
30079	GKBSpSc	468325	<i>A. batizocoi</i>	Santa Cruz	Bolivia	63°28'	20°17'
30080	GKBSpSc	468326	<i>A. batizocoi</i>	Santa Cruz	Bolivia	63°36'	19°44'
30081	GKBSpSc	468327	<i>A. batizocoi</i>	Santa Cruz	Bolivia	63°41'	19°40'
30082	GKBSpSc	468328	<i>A. batizocoi</i>	Santa Cruz	Bolivia	63°36'	19°43'
30084	GKBSpScZ	468330	<i>A. sp.</i>	Santa Cruz	Bolivia	63°18'	17°19'
30085	GKBSpScZ	468331	<i>A. sp.</i>	Santa Cruz	Bolivia	63°28'	17°23'
30088	GKSSc	468333	<i>A. sp.</i>	Santa Cruz	Bolivia	63°05'	15°44'
30089	GKSSc	468334	<i>A. sp.</i>	Santa Cruz	Bolivia	63°06'	15°43'
30091	GKSSc	468336	<i>A. sp.</i>	Santa Cruz	Bolivia	62°05'	16°29'
30092	GKSSc	468337	<i>A. sp.</i>	Santa Cruz	Bolivia	62°14'	16°36'
30093	GKSSc	468338	<i>A. sp.</i>	Santa Cruz	Bolivia	62°13'	16°35'
30098	GKSSc	468341	<i>A. sp.</i>	Santa Cruz	Bolivia	61°00'	16°33'
30099	GKSSc	468342	<i>A. sp.</i>	Santa Cruz	Bolivia	61°01'	16°36'
30100	GKSSc	468343	<i>A. sp.</i>	Santa Cruz	Bolivia	61°02'	16°10'
35001	GKSPScGb	475873	<i>A. sp.</i>	Santa Cruz	Bolivia	63°18'	17°19'
36003	KSBScC	475883	<i>A. sp.</i>	Salta	Argentina	--	--
36019	KSSc	475998	<i>A. cardenasii</i>	Santa Cruz	Bolivia	59°45'	18°21'
36020	KSSc	475999	<i>A. cardenasii</i>	Santa Cruz	Bolivia	59°44'	18°21'
36027	KSSc	476006	<i>A. sp.</i>	Santa Cruz	Bolivia	60°29'	17°43'
36029	KSSc	476008	<i>A. sp.</i>	Santa Cruz	Bolivia	60°45'	17°49'
36031	KSSc	476010	<i>A. sp.</i>	Santa Cruz	Bolivia	60°45'	17°50'
36032	KSSc	476011	<i>A. cardenasii</i>	Santa Cruz	Bolivia	60°47'	17°58'
36035	KSSc	476014	<i>A. cardenasii</i>	Santa Cruz	Bolivia	60°50'	17°57'
36036	KSSc	475887	<i>A. sp.</i>	Salta	Argentina	65°43'	24°02'
Manfr. #8	--	300976	<i>A. correntina</i>	--	--	--	--

<sup>a</sup>Only species names published with corresponding accession numbers are listed.<sup>b</sup>Abbreviations for collectors' names are as follows: B = D. J. Banks, Bu = A. Burkart, C = L. Coradin, G = W. C. Gregory, Gb = R. W. Gibbons, Gd = I. J. Godoy, Gr = A. Gripp, H = R. O. Hammons, K = A. Krapovickas, L = W. R. Langford, P = P. Pietrarello, R = V. R. Rao, S = C. E. Simpson, Sc = A. Schinini, St = H. T. Stalker, Sv = G. P. Silva, V = J. M. Valls, W = W. L. Werneck, Z = H. Zurita.

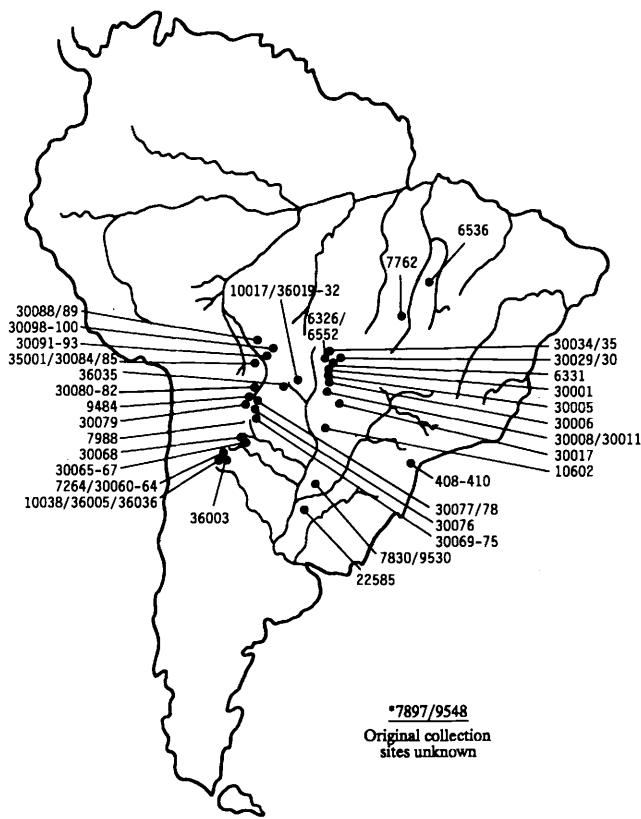


Fig. 1. South American map showing approximate collection locations of section *Arachis* accessions.

values of axis 1. Plants of this unnamed species have longer main stems and much longer lateral branches as compared to other peanut species, as well as large elliptic leaves, highly

reticulated pods and large seeds which approach the size of small-seeded cultivated varieties. *Arachis correntina* accessions grouped at the other extreme of axis 1. Narrow leaf types—for example, *A. diogoi* and *A. chacoense* Krap. et Greg. *nom. nud.*—were found at the high positive values of axis 2 whereas the more rounded leaf types of *A. duranensis* Krap. et Greg. *nom. nud.* and *A. cardenasii* Krap. et Greg. *nom. nud.* had negative values. Although outliers were observed for several accessions of a few species (for example, accession 9530 of *A. correntina* and 30029 of *A. helodes*), good taxonomic groupings of accessions into known species groups is possible as shown in Fig. 2.

The phenogram which used the 15 eigenvalues greater than one (Fig. 3) to estimate Euclidean distances differed from the first one both in clustering accessions within major groups and for increasing the relative distance between clusters. Four (versus two) major clusters of taxa emerged from the second analysis. The first cluster was represented by a single accession, 30076, which will likely be described as the species of *A. ipaensis*. A second major group was represented by the four D-genome entries (30091, 30098, 30099, and 30100). *Arachis chacoense* and *A. diogoi* accessions clustered together in a third group, and the remaining large cluster had the other 63 accessions.

The largest cluster of 63 entries will probably be divided into many species and possibly represents several complexes of species. First, an *A. correntina-villosa* subgroup contains accessions 9530, 9548, Manfredi #8, and 22585. Within the large group, two additional subgroups were represented by *A. duranensis* and *A. cardenasii* accessions, but also contain several named taxa which are morphologically unique, such as *A. monticola* and *A. batizocoi*. Based on the grouping of known taxa—such as *A. monticola* (7264, 30062, 30063), *A. stenosperma* (408, 409, 410), and *A. batizocoi* (9484, 30079,

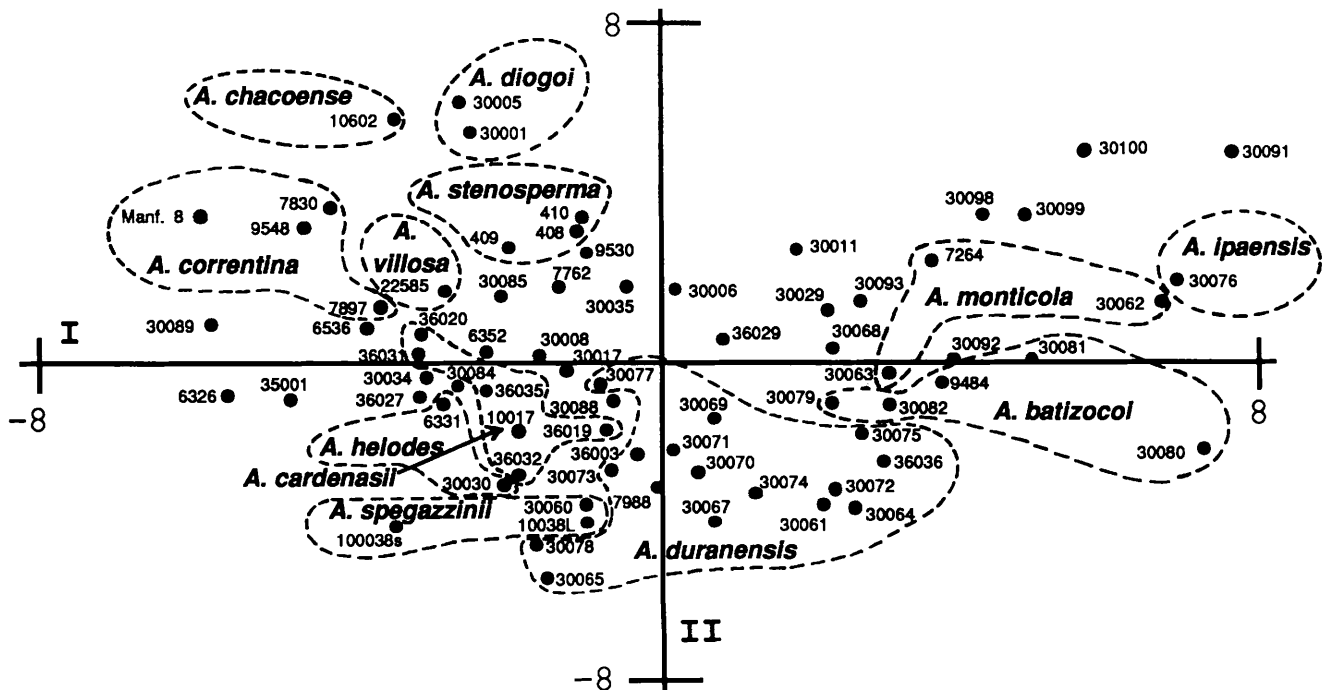


Fig. 2. Projection of 73 section *Arachis* accessions onto the first two principal components extracted from a correlation matrix of characters associated with character loadings with a value greater than 1 in the original principal component analysis. Broken lines circle accessions which the author believes represent single named species and additional accessions may be added to species groups when species descriptors become available.

30080, 30081, 30082)—accessions with a distance value of 0.8 or less could be considered as belonging to similar morphological species. Although most accessions belonging to known species clustered together, several members of *A. helodes* remained separated due to differences in leaf sizes among accessions. Further, a clear grouping of accessions of *A. duranensis* or *A. cardenasii* was not evident from the numerical analyses.

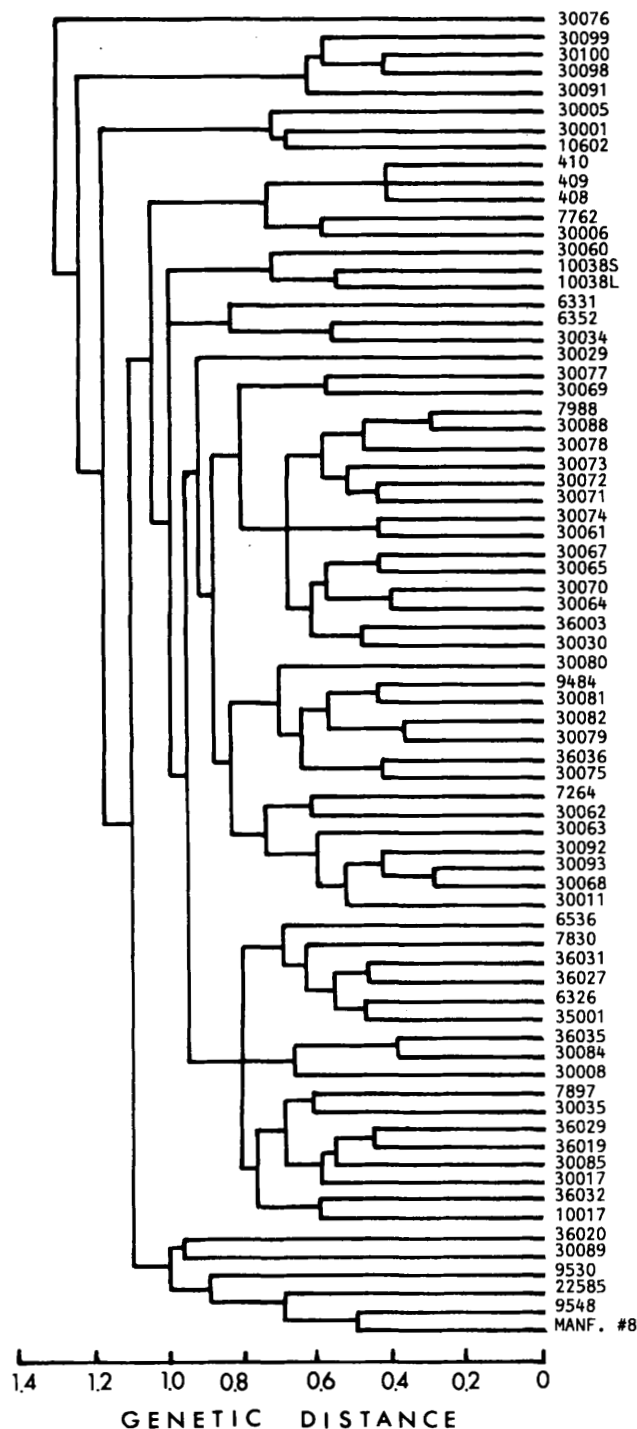


Fig. 3. Phenogram from cluster analysis of 73 section *Arachis* accessions based on taxonomic distance coefficients using characters associated with 15 principal components greater than 1.

## Discussion

*Arachis* species were separated primarily based on measurements of mainstem and lateral leaves and leaflets, pod length and width, and flower width and shape. The shapes of leaflets, seed traits, stipules, trichomes, pod veination and shape, and general growth habit were of minor value for distinguishing taxa. Surprisingly, mainstream leaflet shape had a low correlation with leaf ( $r = 0.07$ ) and leaflet ( $r = 0.05$ ) length or length/width ratio ( $r = 0.00$ ). Correlations were similar for lateral leaflet measurements. Further, mainstem and lateral leaflet shapes had a correlation near zero ( $r = 0.03$ ), which means that leaves on the mainstem and lateral branches must be analyzed independently. The conclusion drawn from these analyses is that relatively few traits will separate taxa in the section.

Confidence can be placed in the numerical analyses of *Arachis* taxa for grouping accessions into species groups when selected data were restricted to eigenvalues greater than one because most accessions of known species clustered together. This is opposed to highly random associations of taxa when 56 characters were evaluated. Although the principal component and cluster analyses grouped morphologically similar accessions, principal component analyses manifested more definitive relationships among accessions of *A. cardenasii* and *A. duranensis* than did cluster analysis. On the other hand, the cluster analyses separated several accessions which were obvious misfits in species groups in Figure 2. For example, *A. ipaensis* Greg. et Greg. nom. nud. (30076) and *A. monticola* (30062) accessions were removed from the apparent close association (Fig. 3). Several outliers still existed, however, including accessions of *A. helodes* (30029, 30030, and 6331), and accessions of *A. correntina* (9530).

One species which had accessions consistently associated during all analyses was *A. batizocoi*. This is a cytologically unique species and the only one in the genus identified with a B genome (18). The four accessions 9484, 30079, 30081, and 30082 clustered more closely together than the fifth accession (30080) which appeared to be significantly different. The accession 30080 had previously been reported as accession 30097 in the literature (17) because of a misidentification of seed. Field observations indicated that plants of 30080 are smaller and have fewer branches than the other members of the species, which may account for its separation during the numerical analyses. Cytological studies of *A. batizocoi* also indicate that the accession 30080 differs from other *A. batizocoi* collections in having a more asymmetrical karyotype (17).

Although cluster analyses grouped accessions with morphological similarities, taxa in *Arachis* which look alike do not always equate with biological species. Even species assigned to different sections of the genus are often misidentified as the other parallel species, especially when complete herbarium specimens are not available (13). Analogous situations may also occur in section *Arachis* as illustrated by *A. stenosperma* accessions (408, 409, and 410) which have a distribution on the eastern Brazilian seacoast, whereas accessions 7762 and 30006 were found in central and south-central Brazil, respectively. Although these five accessions look very similar, they are probably different biological species.

A limited number of hybridization and cytological

experiments [for reviews, see (13, 18)] indicate the most taxa in the section will hybridize and are cytogenetically similar. Exceptions are *A. batizocoi* and the unnamed species associated with accessions 30091 and 30098-100 which have asymmetrical chromosomes and produce sterile progenies when crossed with other species. The large group of taxa collected during the past 10 to 15 years must now be hybridized and the  $F_1$ s analyzed to more conclusively indicate species relationships.

Because taxonomic information is unavailable regarding the number of species in section *Arachis* and the amount of intraspecific variability, numerical taxonomic techniques offered an approach to evaluate the structure of section *Arachis* in the absence of definitive species information. Broadly defined groups were distinguished and the clustering of accessions represents an initial step in defining systematic relationships in section *Arachis*. An obvious problem exists in *Arachis* whereby many apparent species are represented by only one accession. Included among the characteristics which best differentiate taxa in the group are leaf size, narrow vs. broad leaves, flower types, and annual vs. perennial habit. Twenty to 25 species are expected to be named in section *Arachis* from taxa already in germplasm collections. In addition, the known distribution of taxa in the section is continuing to be expanded, and additional species are expected to be found.

### Literature Cited

- Chevalier, A. 1933, 1934, 1936. Monographie de Arachide. Rev. Bot. Appl. et Agr. Trop. 13:689-789; 14:565-632, 709-755, 833-864; 16:673-871.
- Goodman, M.M. 1972. Distance analysis in biology. Syst. Zool. 21:174-186.
- Gregory, W. C., and M. P. Gregory. 1976. Groundnut, *Arachis hypogaea* (leguminosae—Papilionatae), pp. 151-154. in N. W. Simmonds (ed.), Evolution of Crop Plants. Royal Botanic Gardens, Kew.
- Gregory, W. C., A. Krapovickas, and M. P. Gregory. 1980. Structures, variation, evolution and classification in *Arachis*, pp. 469-481. in R. J. Summerfield and A. H. Bunting (eds.), Advances in Legume Science, Vol. 1. International Legume Conference, Royal Botanic Gardens, Kew.
- Gregory, W. C., M. P. Gregory, A. Krapovickas, B. W. Smith, and J. A. Yarbrough. 1973. Structures and genetic resources of peanuts, pp. 47-133. Peanuts—Culture and Uses. Amer. Peanut Res. Educ. Assoc., Stillwater, OK.
- Hermann, F. J. 1954. A synopsis of the genus *Arachis*. USDA Agr. Monograph No. 19. 26 p.
- Hoehne, F. C. 1940. Leguminosae-Papilionadae. Genero *Arachis*. Flora Brasiliica 25(II) 122:1-20.
- Krapovickas, A. 1969. Evolution of the genus *Arachis*. Seminario Avanzado de Genetica Agricola para America Latina, Maracay, Venezuela SAGA/B (d):1-4.
- Krapovickas, A. 1973. Evolution of the genus *Arachis*, pp. 135-151. in R. Moav (ed.), Agricultural Genetics: Selected Topics. Natl. Council. Res. Develop., Jerusalem.
- Ressler, P. M. 1980. A review of the nomenclature of the genus *Arachis* L. Euphytica 29:813-817.
- Simpson, C. E. 1984. Plant exploration: Planning, organization, and implementation with special emphasis on *Arachis*, pp. 1-20. in D. M. Kral (ed.), Conservation of Crop Germplasm—An International Perspective. CSSA Spec. Publ. No. 8. Crop Sci. Soc. Amer., Madison, WI.
- Simpson, C. E., and D. L. Higgins. 1984. Catalog of *Arachis* germplasm collections in South America, 1976-1983. Texas Agri. Expt. Sta. Bull. MP1570. 79 p.
- Smartt, J., and H. T. Stalker. 1982. Speciation and cytogenetics in *Arachis*, pp. 21-49. in H. E. Pattee and C. T. Young (eds.), Peanut Science and Technology. Amer. Peanut Res. Educ. Soc., Yoakum, TX.
- Sneath, P. H. A., and R. R. Sokal. 1973. Numerical Taxonomy. W. H. Freeman and Co., San Francisco.
- Sokal, R. R. 1961. Distance as a measure of taxonomic similarity. Syst. Zool. 10:70-79.
- Stalker, H. T. 1985. Cytotaxonomy of *Arachis*, pp. 65-79. in J. P. Moss (ed.), Proc. International Workshop on Cytogenetics of *Arachis*. Oct. 31-Nov. 2, 1983. International Crops Research Institute for the Semi-Arid Tropics, Patancheru, A.P., India.
- Stalker, H. T., J. S. Dhesi, and D. C. Parry. 1990. An analysis of the B genome species *Arachis batizocoi* (Fabaceae). Plant Syst. Evol. (in press).
- Stalker, H. T., and J. P. Moss. 1987. Speciation, cytogenetics, and utilization of *Arachis* species. Adv. Agron. 41:1-40.
- Valls, J. F. M., V. R. Rao, C. E. Simpson, and A. Krapovickas. 1985. Current status of collection and conservation of South American groundnut germplasm with emphasis on wild species of *Arachis*, pp. 15-35 Proc. International Workshop of Cytogenetics of *Arachis*, Oct. 31-Nov. 2, 1983. International Crops Research Institute for the Semi-Arid Tropics, Patancheru, A. P., India.

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