# THE TAXONOMY OF

# THE SHRUBBY SOPHORAS (FABACEAE) OF ARIZONA

by

Roger Edward McManus

---

A Thesis Submitted to the Faculty of the

DEPARTMENT OF ECOLOGY AND EVOLUTIONARY BIOLOGY

In Partial Fulfillment of the Requirements
For the Degree of

MASTER OF SCIENCE
WITH A MAJOR IN BOTANY

In the Graduate College

THE UNIVERSITY OF ARIZONA

1 9 7 6

STATEMENT BY AUTHOR

This thesis has been submitted in partial fulfillment of requirements for an advanced degree at The University of Arizona and is deposited in the University Library to be made available to borrowers under rules of the Library.

Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgment of source is made. Requests for permission for extended quotations from or reproduction of this manuscript in whole or in part may be granted by the head of the major department or the Dean of the Graduate College when in his judgment the proposed use of the material is in the interests of scholarship. In all other instances, however, permission must be obtained from the author.

SIGNED: Roger E. McManus

APPROVAL BY THESIS DIRECTOR

This thesis has been approved on the date shown below:

Charles T. Mason Jr.
CHARLES T. MASON, JR.
Professor of Ecology
and Evolutionary Biology

23 February 1976
Date

ACKNOWLEDGMENTS

I would like to express my sincere appreciation to Dr. Charles T. Mason, Jr. who suggested the problem, provided generous resources, and supplied numerous helpful suggestions on the research and the manuscript. My thanks to Steve McLaughlin who was my companion in the field and from whom I received many ideas. Gratitude is also expressed to Dr. Arthur Gibson, Dr. Robert W. Hoshaw, and Dr. Robert O. Kuehl for their suggestions and review of the manuscript.

Other people have contributed to the completion of this work. Caryl Busman assisted in the field work and was a welcome sounding board in the preparation of the manuscript. Lee Karpiscak drew the distribution map and the polygonal graph. Steve Bingham graciously provided his services in locating populations in the Pinaleno Mountains. The help of the staff and the use of the facilities of The University of Arizona Computer Center made the data analysis possible.

Much of the field work was conducted on private land. In all cases the owners were extremely cooperative. Herbarium material including type specimens were borrowed from herbaria listed in the text.

My wife Sandy deserves special credit for her encouragement and understanding.

TABLE OF CONTENTS

## LIST OF TABLES

## LIST OF ILLUSTRATIONS

## ABSTRACT

Woody sophoras from Arizona have been described as two species, two subspecies, and one species by various authors. Recently material from previously poorly collected populations and from newly discovered populations have become available. This new material has provided an opportunity to reevaluate the morphology of the group including those morphometric characters previously used to delineate taxa.

Collections were made from 10 locations and data were recorded for 30 continuous, discontinuous, derived, and ranked variables. Data were considered with all individuals together, as two regions, and as eight populations. Descriptive and inferential statistics were calculated with the Statistical Package for the Social Sciences at the Computer Center of The University of Arizona.

Ten variables were found to have significant results for the Chi Square, Student's T, and/or Analysis of Variance tests. Inspection of the descriptive statistics, however, did not provide any characters which could distinguish the regions or any group of populations. Consequently it is recommended that only one taxonomic species of woody Sophora from Arizona, S. arizonica Wats., be recognized. Many, but not all of the characters previously used for delineation of taxa were found to be correlated with size (age) of the flower.

# INTRODUCTION

Two fruticose species of Sophora, S. arizonica Wats. and S. formosa Kearn. & Peeb., have been described from Arizona. Traditionally authors have considered S. arizonica restricted to northwestern Arizona, whereas S. formosa has been found in southeastern Arizona.

Sophora arizonica was described by Watson (1876) who cited collections made by J. Bigelow labeled "White Cliff Creek and Cactus Pass." Bigelow had identified the specimens as S. speciosa (Scheele) Benth. (= S. secundiflora (Ort.) DC.). Unfortunately the type, stored in the Gray Herbarium (GH!), is one of three collections of five twigs by three different collectors from three different localities on three different dates mounted on the same herbarium sheet (Figure 1). One of the twigs is a flowering specimen collected by J. Lemmon in 1880 from the Santa Rita Mountains; this represents the only collection I have seen from the area. Three other twigs, all in late flowering condition, are apparently an E. Palmer collection of 1876 from "Cottonwood Creek 75 miles west of Prescott." A fifth twig matches the condition described by Watson (1876:135), "only fruiting specimens found, January." I here designate the Watson (Jan., 1854) specimen stored in the Gray Herbarium as lectotype. Two packets of seeds and fruits, of uncertain origin, collected by Bigelow are attached at the top of the sheet. One packet is labeled "Bill Williams Fork" which is at the junction of the Bill


Figure 1. The Gray Herbarium type specimen of Sophora arizonica Wats.

Williams and Colorado Rivers. A sterile specimen of the type collection was examined from the New York Botanical Garden (NY!).

A specimen from a collection made by B. Maguire, number 10993, in 1935 was designated as the type for S. formosa by Kearney and Peebles (1939). Maguire collected specimens with flowers and fruits from the northern slopes of Frye Mesa in the Pinaleno Mountains. The holotype is housed at the U. S. National Herbarium (US!) and isotypes are in herbaria at The University of Arizona (ARIZ!), University of California (UC!), Harvard University (GH!), and New York Botanical Garden (NY!).

Table 1 summarizes the differences between S. arizonica and S. formosa cited in Kearney and Peebles (1939, 1964) and Benson and Darrow (1954). In addition, Kearney and Peebles (1939:482-483) noted: "All the petals are relatively broader, in S. formosa, the leaflets of that species are usually longer, broader, and more obtuse, and the pubescence is denser and more persistent on the upper leaf surface and pods."

Kearney and Peebles (1939:483) acknowledged a close relationship between S. arizonica and S. formosa: "Both species give the impression of being relict forms, suggesting that they may have had a common ancestor of much wider distribution." The status of S. formosa was qualified by Benson and Darrow (1954:201): "Recognition of S. formosa as a species distinct from S. arizonica may, of course, become dubious if additional material is discovered." Both S. arizonica and S. formosa were included in the genus Calia Berland. (= Sophora L.) by Yakovlev (1967). Yakovlev (1968) reduced C. formosa (Kearn. & Peeb.) Yakovl. to a subspecies of C. arizonica (Wats.) Yakovl., retaining the separation on

Table 1. Summary of characters used by Kearney and Peebles (1939, 1964) and Benson and Darrow (1954) to distinguish S. arizonica and S. formosa.

| | Kearney and Peebles | | Benson and Darrow | |
|---|---|---|---|---|
| Character | S. arizonica | S. formosa | S. arizonica | S. formosa |
| Flower length (mm) | 22 | 16 | 20-24 | 14-17 |
| Banner Shape | Obovate-oblong | Ovate | (Widest above the middle) | (Widest below the middle) |
| Banner Length (mm) | 18-20 | 14-18 | 19-23 | 17-20 |
| Banner Length - Width Ratio | 0.67 as wide as long | 0.8 as wide as long | | |
| Keel Blade-Claw Relationship | Blade 2.5 x longer than claw | Blade 1.5-2.0 x longer than claw | | |
| | Claw 0.5 length of blade | Claw 0.5-0.6 length of blade | Claw 0.5 length of blade | Claw 0.5 length of blade |
| Vexillar Teeth Length (mm) | 1-1.5 | 2.5-3 | | |
| Seed Length (mm) | 9.9 | 9.2 | | |
| Seed Width (mm) | 7.4 | 6.5 | | |
| Leaflet Width (mm) | 10 | 12 | | |

the basis of the greater degree of pubescence on the leaflets of ssp. formosa. He found no differences in the length of perianth parts as postulated by Kearney and Peebles (1939, 1964) and suggested the observations may have reflected an analysis of flowers of unlike ages. Only one species of shrubby Sophora, S. arizonica, is recognized as native to Arizona by Rudd (1972). Isely (letter dated 13 August 1974, Iowa State University, Ames, Iowa) regards the Arizona shrubs and what is now known as S. gypsophila var. guadalupensis Turner & Powell as "3 poorly marked varieties of one species."

One unusual amino acid, y-aminobutyric acid, was found to be present in S. arizonica and absent in S. formosa by Izaddoost (1973). This amino acid was also present in such diverse species of Sophora as S. nuttalliana B. L. Turner and S. japonica L. Northington (unpublished manuscript dated 12 January 1975, Texas Tech University, Lubbock, Texas) found individuals from the northwestern and southeastern parts of Arizona have identical chromatograms for flavonoids, but can be distinguished by morphometric characters.

Recently collections of shrubby sophoras have been made in Arizona from locations which were represented by little or no herbarium material. The availability of additional material provided an opportunity to reevaluate the characters used to delineate taxa in the complex.

## MATERIALS AND METHODS

Plant materials collected by myself and others on various field trips in 1974 and 1975 were used for examination and as sources of data. To insure individual plants were represented once in statistical calculations a field number was assigned to each plant except in designated mass collections where one twig for each individual was collected. Specimens were examined and annotated from the following herbaria designated by standard herbarium abbreviations (Holmgren and Keuken, 1974): A, ARIZ, ASC, ASU, CAS, DS, GH, NY, UC, US. A representative set of collections used for data in this study will be deposited in the Herbarium of The University of Arizona (ARIZ) and additional specimens will be distributed.

Two regions and eight populations were selected for comparing variables. The Northwest region included the Cottonwood, Hualapai, Knight Creek, and Aquarius populations; the Southeast region included the Pinaleno, Mattie Canyon, Dry Canyon, and Swisshelm populations. The Pinaleno population was represented by plants from three locations: Bear Springs, Ash Creek, and Frye Mesa, all of which are found on the northern slopes of the Pinaleno Mountains. Figure 2 shows the general locations of shrubby sophoras in Arizona. These locations include all the sites verified by me; however, herbarium labels examined indicate other sites may exist.

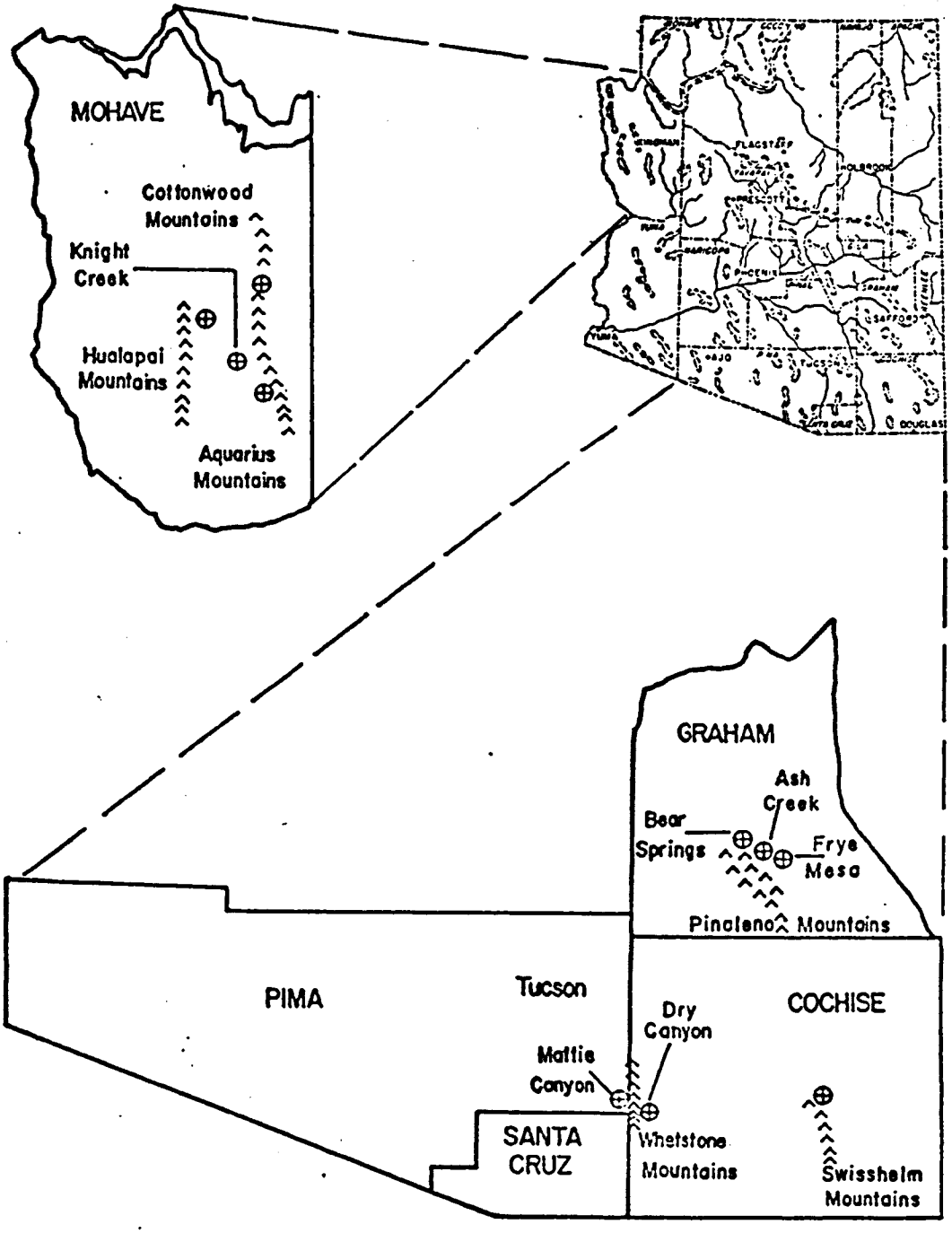


Figure 2. Distribution of shrubby Sophoras in Arizona.

Continuous, discontinuous, ranked (from a coded attribute) and derived (from ratios) variables were chosen to represent the morphology. Variation in leaf morphology was described by nine variables. Continuous variables included leaf length, stipule length, length of the leaf axis, maximum leaflet length, median leaflet width, and leaflet apex and base angles. There was one discontinuous variable, number of leaflets, and one derived variable, leaflet length-width ratio. To define an angle, a perpendicular line was first drawn through the midvein at a point one quarter of the length of the leaflet from the respective apex or base. The angle was then defined by the point of the apex or base and the interception of the perpendicular line with the leaflet margins.

Variation in flowers, fruit, and seed morphology was described by 21 variables. Continuous variables included raceme length, flower length (tip of wings to bracteoles), calyx length (tip of sepals to bracteoles), calyx vexillar teeth length, calyx mid-tooth length (of abaxial teeth), banner length, banner width, keel blade length, keel claw length, wing blade length, wing claw length, bracteole length, seed length, seed width, seed depth, minimum fruit width (at constriction), and maximum fruit width. In addition were three derived variables, banner length-width ratio, keel blade-claw ratio, wing blade-claw ratio, and one ranked variable, banner shape. Banner shape was coded as "2" for obovate and "1" for ovate, circular, or elliptic.

Data were recorded from leaves at the third node below the inflorescence. Terminal leaflets were representative of the Hualapai population for the variable terminal leaflet length using a testing

procedure described by Schefler (1969:63-66) with L.S. $\alpha = 0.05$. Leaflet data were taken from the dominant terminal leaflet. Data were recorded from flowers, fruits, and seeds which appeared mature and undamaged.

Linear measurements were made to the nearest 0.5 mm except for seed dimensions, which were obtained with a micrometer to the nearest 0.001 mm. Many variables had less than 30-300 units within their ranges contrary to what is considered desirable by Sokal and Rohlf (1969). For many of these variables, units smaller than 0.5 mm would represent superfluous accuracy. Angles were recorded at the nearest 0.5 degrees.

Variables were considered on three levels of organization: all individuals together, as regions, or as populations. Descriptive statistics for each variable at all three levels of organization were calculated using programs outlined in the Statistical Package for the Social Sciences (Nie, Bent, and Hull, 1970) and the SPSS Update Manual Version 5.8 (Vogelback Computing Center, 1974) at The University of Arizona Computer Center. The SPSS package was used for all statistical procedures in this study unless otherwise noted. Adequate sample sizes were calculated using a procedure outlined in Sokal and Rohlf (1969:246-249). Regions and populations required a sample size to provide an 80% certainty of detecting a 20% difference between the means at a 5% level of significance for both the Student's T Test and the Analysis of Variance (ANOVA). Sample sizes of the variable keel blade-claw ratio were accepted at a 25% difference when tested at the regional level of organization. A Chi Square Test was performed at the regional level for the variable, number of leaflets. Variables with regions that had adequate

sample sizes were checked manually for homoscedasticity with a procedure outlined in Sokal and Rohlf (1969:185-186). The Student's T Test was performed on those variables without significantly unequal variances. ANOVA tests were performed for all continuous variables using all populations with adequate sample sizes. SPSS provided a Bartlett's Test along with the results of the ANOVA. Results of ANOVA tests with significantly different variances were not recorded.

To test the hypothesis that many floral variables are correlated with floral size (age), scattergrams were plotted and Pearson's Coefficients of Correlation were calculated using all individuals for the following pairs of variables: flower length with banner length, banner width, banner length-width ratio, calyx vexillar teeth length, wing blade length, wing claw length, wing blade-claw ratio, keel blade length, keel claw length, and keel blade-claw ratio.

## RESULTS

Some of the descriptive and inferential statistics of the continuous and discontinuous variables are recorded in Appendix A. Table 2 presents a list of variables which have inferential statistical tests with significant results. Statistics representing ranked or derived variables should be interpreted with care as to meaning and statistical validity. The Chi Square, Student's T, and ANOVA tests have significant results for variables. Three variables, stipule length, wing claw length, and wing blade-claw ratio have significant results for both the Student's T and ANOVA tests. The variables, median leaflet width and wing blade-claw ratio, have regions with variances that were highly variable but not distinctly significantly different. Figures 3, 4, 5, 6, and 7 represent means, ranges, and standard deviations for all variables from Table 2 which have significant results with the Chi Square, Student's T, and/or the ANOVA tests. Except for wing blade-claw ratio, all of the variables compared to flower length using the Pearson's Coefficient of Correlation have significant correlations.

Table 2. Significant Results for the Inferential Statistical Tests for Variables with L.S. $\alpha = 0.05$.

| Statistical Test | Value | Slope | Variable |
|---|---|---|---|
| Chi Square | 64.550 | | Number of Leaflets |
| Student's T Test | 12.61 | | Stipule Length |
| | 1.85 | | Leaf Axis Length |
| | 3.04 | | Median Leaflet Width |
| | 3.04 | | Leaflet Length-Width Ratio |
| | 4.23 | | Wing Claw Length |
| | 3.41 | | Wing Blade-Claw Ratio |
| | 2.79 | | Seed Length |
| Analysis of Variance | 17.971 | | Stipule Length |
| | 3.248 | | Flower Length |
| | 2.441 | | Banner Length |
| | 3.390 | | Wing Claw Length |
| | 3.688 | | Wing Blade-Claw Ratio |
| Pearson's Coefficient of Correlation | .70 | .78 | Flower Length vs. Banner Length |
| | .22 | 2.41 | Banner Length-Width Ratio |
| | .36 | .60 | Banner Petal Width |
| | .25 | 1.30 | Vexillar Teeth Length |
| | .60 | .74 | Wing Blade Length |
| | .48 | 1.33 | Wing Claw Length |
| | .67 | 1.17 | Keel Blade Length |
| | .47 | 1.23 | Keel Claw Length |

Figure 3. Means, standard deviations, and ranges for variables of shrubby sophoras in Arizona. A. Number of Leaflets. B. Leaf Axis Length.

NW, Northwest region; SE, Southeast region; CO, Cottonwood population; HU, Hualapai population; KC, Knight Creek population; AQ, Aquarius population; PE, Pinaleno population; MC, Mattie Canyon population; DC, Dry Canyon population; SW, Swisshelm population.

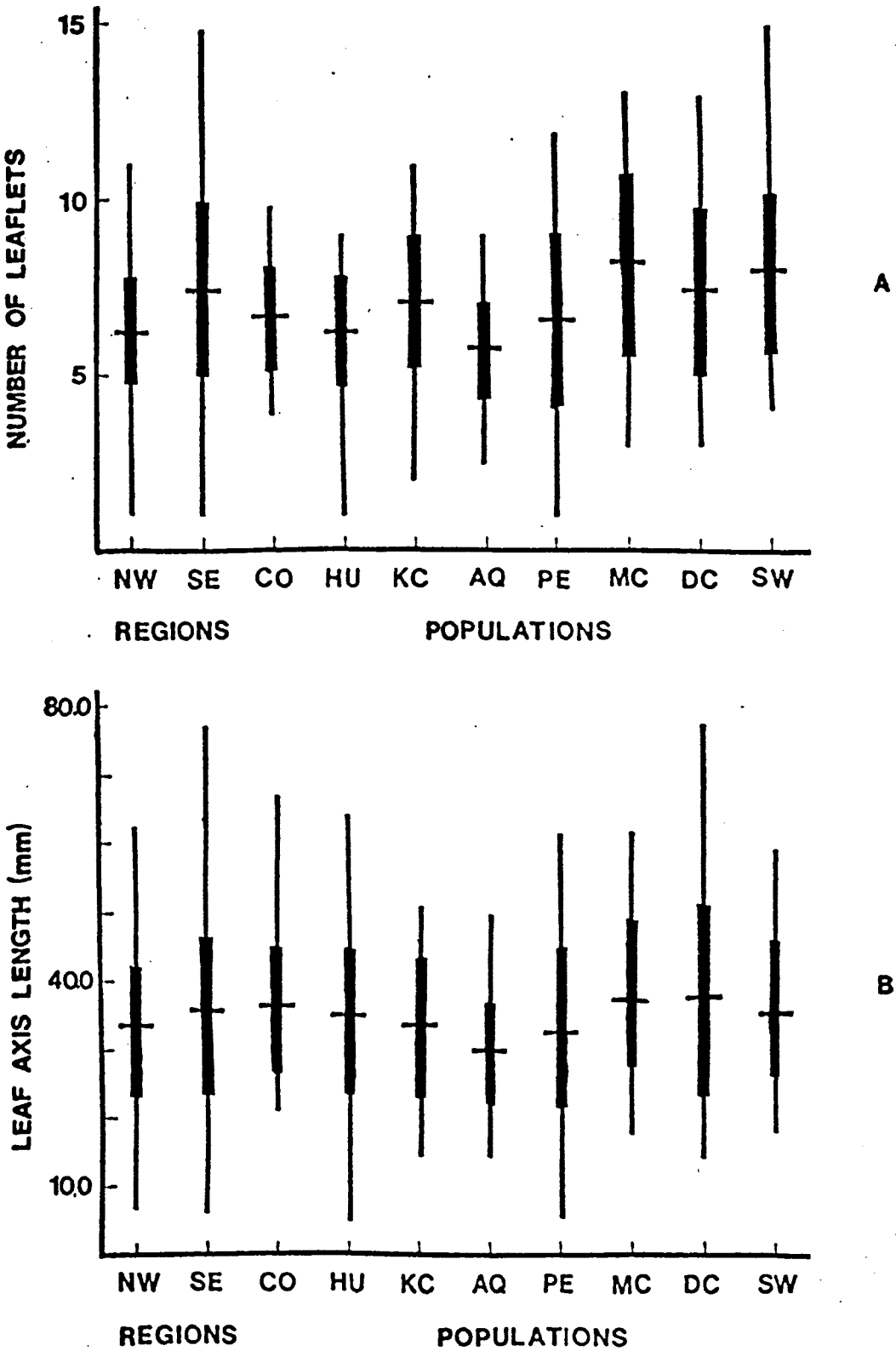


Figure 3. Means, standard deviations, and ranges for variables of shrubby sophoras in Arizona. A. Number of Leaflets. B. Leaf Axis Length.

Figure 4. Means, standard deviations, and ranges for variables of shrubby sophoras in Arizona. A. Stipule Length. B. Median Leaflet Width.

NW, Northwest region; SE, Southeast region; CO, Cottonwood population; HU, Hualapai population; KC, Knight Creek population; AQ, Aquarius population; PE, Pinaleno population; MC, Mattie Canyon population; DC, Dry Canyon population; SW, Swisshelm population.

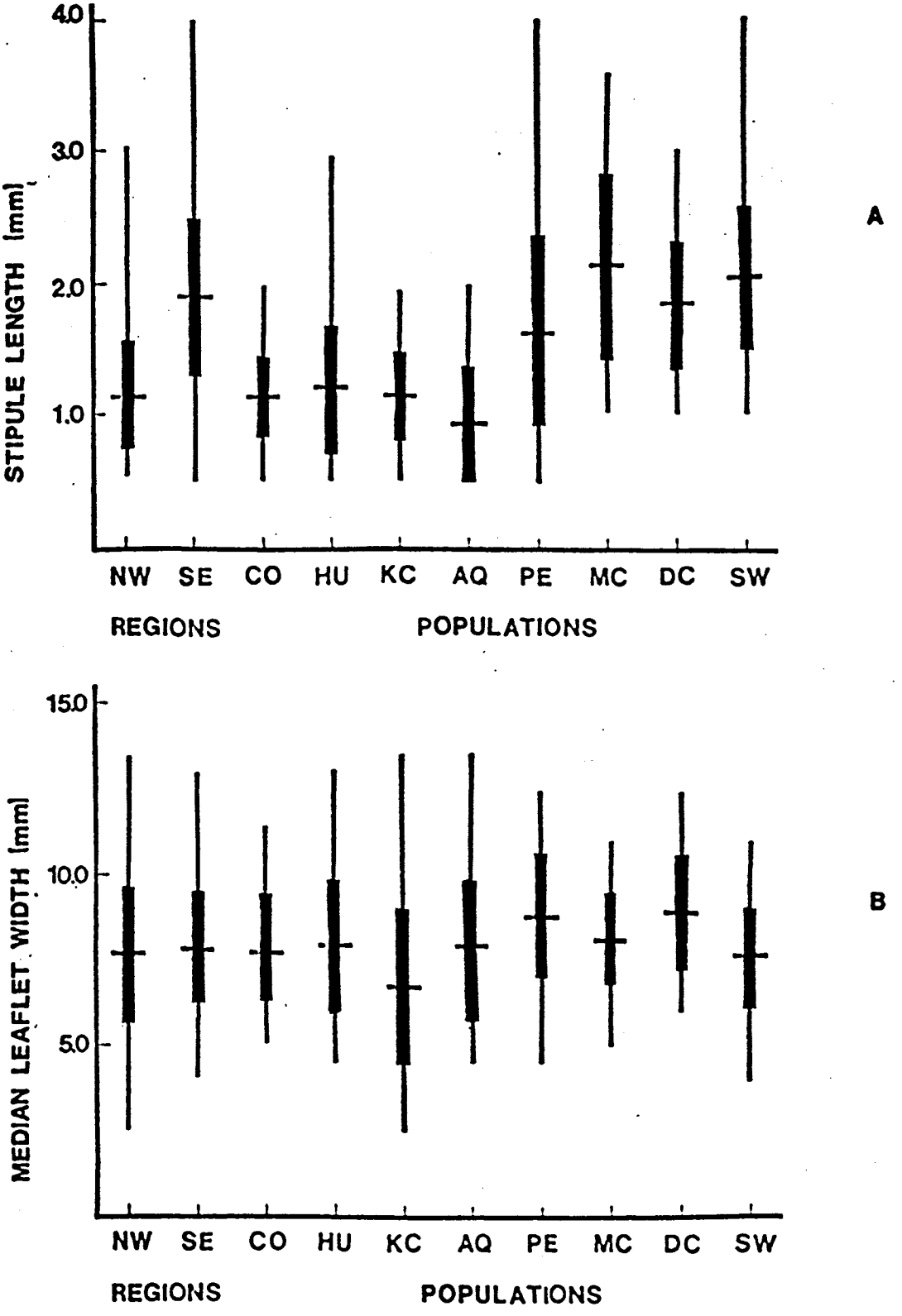


Figure 4. Means, standard deviations, and ranges for variables of shrubby sophoras in Arizona. A. Stipule Length. B. Median Leaflet Width.

Figure 5. Means, standard deviations, and ranges for variables of shrubby sophoras in Arizona. A. Leaflet Length-Width Ratio. B. Flower Length.

NW, Northwest region; SE, Southeast region; CO, Cottonwood population; HU, Hualapai population; KC, Knight Creek population; AQ, Aquarius population; PE, Pinaleno population; MC, Mattie Canyon population; DC, Dry Canyon population; SW, Swisshelm population.

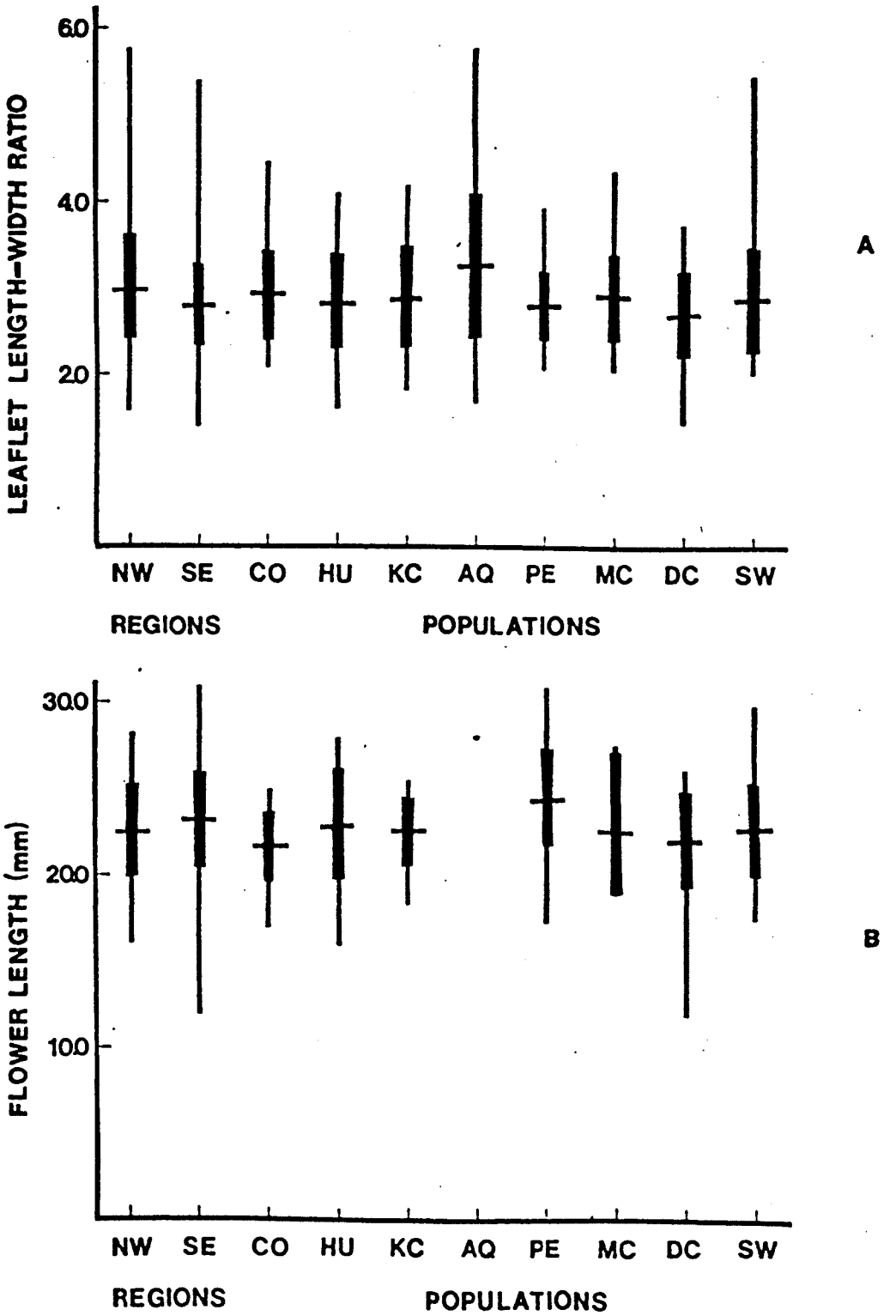


Figure 5. Means, standard deviations, and ranges for variables of shrubby sophoras in Arizona. A. Leaflet Length-Width Ratio. B. Flower Length.

Figure 6. Means, standard deviations, and ranges for variables of shrubby sophoras in Arizona. A. Banner Length. B. Wing Claw Length.

NW, Northwest region; SE, Southeast region; CO, Cottonwood population; HU, Hualapai population; KC, Knight Creek population; AQ, Aquarius population; PE, Pinaleno population; MC, Mattie Canyon population; DC, Dry Canyon population; SW, Swisshelm population.

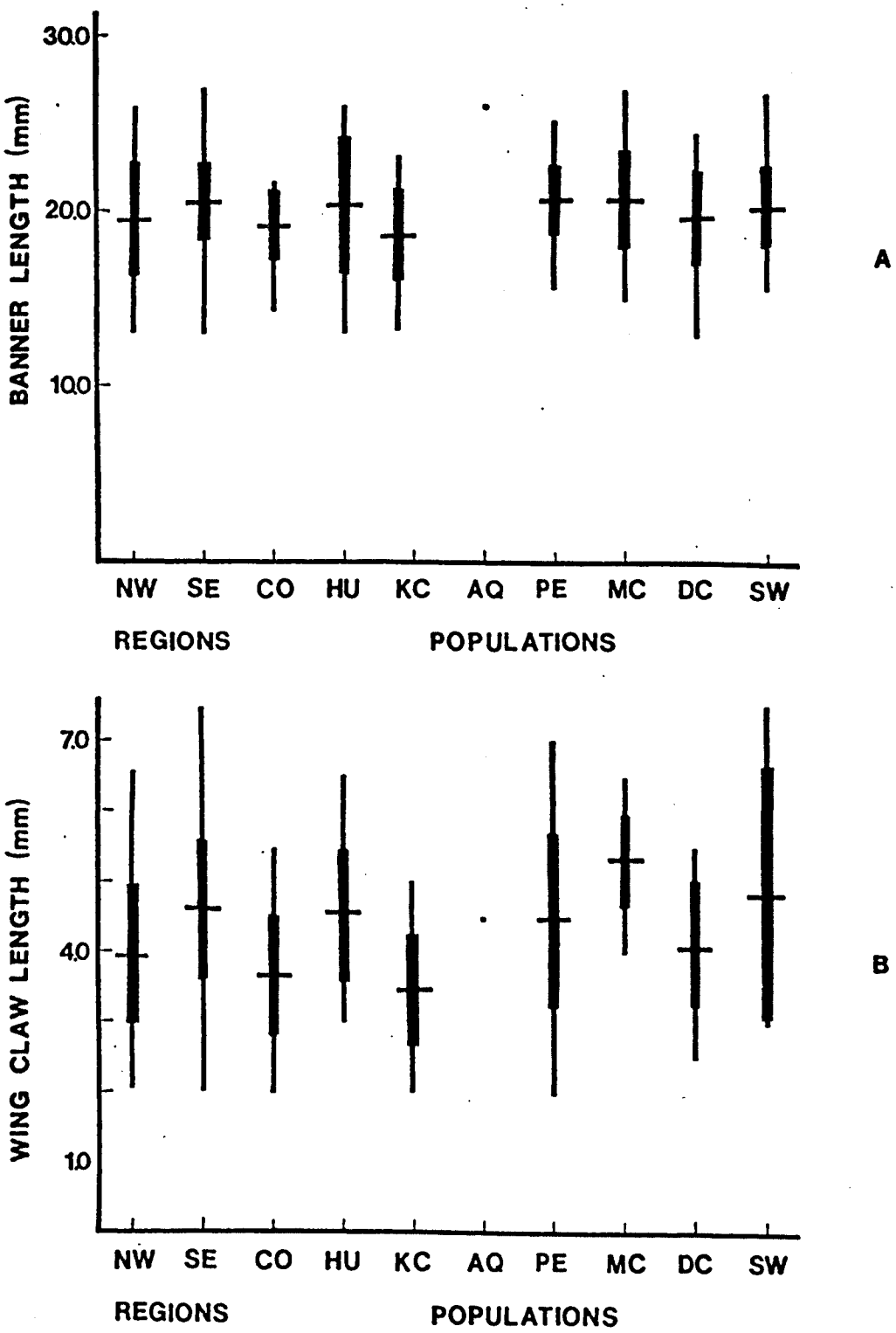


Figure 6. Means, standard deviations, and ranges for variables of shrubby sophoras in Arizona. A. Banner Length. B. Wing Claw Length.

Figure 7. Means, standard deviations, and ranges for variables of shrubby sophoras in Arizona. A. Wing Blade-Claw Ratio. B. Seed Length.

NW, Northwest region; SE, Southeast region; CO, Cottonwood population; HU, Hualapai population; KC, Knight Creek population; AQ, Aquarius population; PE, Pinaleno population; MC, Mattie Canyon population; DC, Dry Canyon population; SW, Swisshelm population.

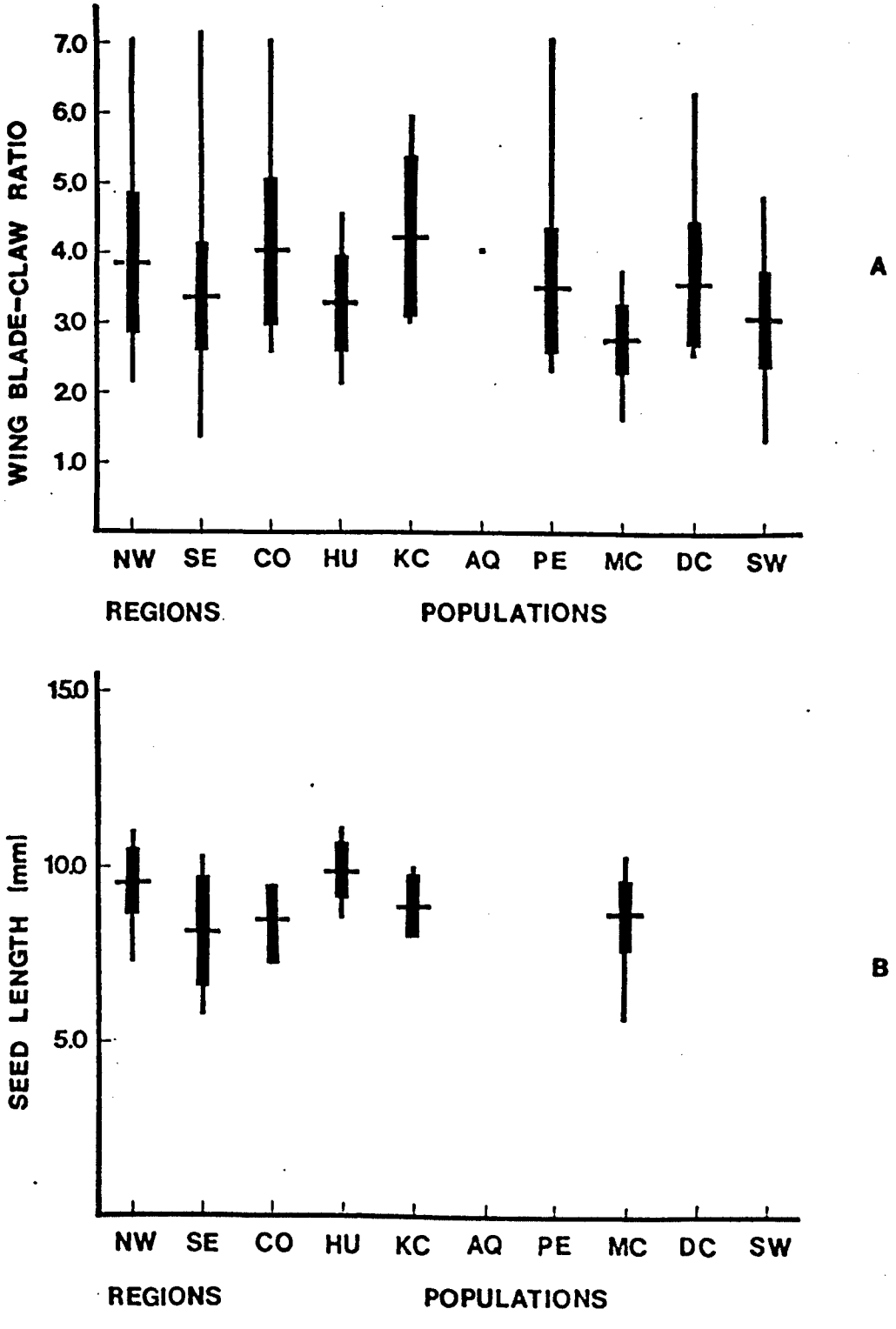


Figure 7. Means, standard deviations, and ranges for variables of shrubby sophoras in Arizona. A. Wing Blade-Claw Ratio. B. Seed Length.

## DISCUSSION

Examination of most variables revealed great similarities between regions and between populations. None of the regions has variables with means separated by minimum or maximum values.

Characters listed in Table 1 are discussed below:

1. Flower length: The result of the Student's T Test is not significant. The ANOVA test has a significant result; however, the greatest differences between the means occurs in the populations of the northwest region. Means of the populations are not separated by minimum or maximum values.
2. Banner shape: The maximum width of the banner is primarily at or below the middle of the petal for all of the populations.
3. Banner length: Variances of the regions for this variable lack homoscedasticity. The ANOVA test has a significant result with the greatest differences between the means occurring in the populations of the northwest region. The means for the populations are not separated by minimum or maximum values.
4. Banner length-width ratio: With the exception of the Aquarius population (no sample) all the populations

have average ratios large enough to qualify as S. arizonica.

5. Keel blade-claw relationships: The use of keel blade-claw relationships to distinguish taxa was examined by three variables: keel blade length, keel claw length, and keel blade-claw ratio. The variable keel blade length has insignificant results for both the Student's T and the ANOVA tests. The means for the populations are not separated by minimum or maximum values. Variances for both keel claw length and keel blade-claw ratio lack homoscedasticity at the regional and population level of organization. Kearney and Peebles (1939) observed (Table 1) that keel claws were larger in S. formosa than in S. arizonica. Except for Mattie Canyon all the populations have average keel claws less than one half the length of the blades. The average keel blade-claw ratio for Mattie Canyon is 2.0 while the other populations have averages of 2.3 or larger.
6. Vexillar teeth length: The Student's T test is not significant. Variances for the populations lack homoscedasticity.
7. Seed length: Only the Hualapai and Mattie Canyon populations have adequate sample sizes to warrant inferential statistical tests. For this reason only the Student's T test for the regions was performed.

The result is significant with 1 mm separating the average lengths.

8. Seed width: The result of the Student's T test is not significant.

9. Median leaflet width: Variances of the regions were very close to being significantly different. The Student's T test has a significant result. Variances of the populations lack homoscedasticity.

Several variables with significant results from the Chi Square, Student's T, or ANOVA tests were not listed in Table 1. The result is significant with the Chi Square test for the variable number of leaflets. The population means are not separated by minimum or maximum values. Stipule length has significant results in both the Student's T and ANOVA tests. The population means are separated by minimum and maximum values with southeastern populations having longer means than the northwestern populations. Leaf axis length has a significant result with the Student's T test and a lack of homoscedasticity for the populations. Terminal leaflet length-width ratio has a significant result with the Student's T test but not the ANOVA. The population means are not separated by minimum or maximum values. Wing claw length and wing blade-claw ratio both have significant Student's T and ANOVA tests with population means separated by minimum and maximum values. The significance of the Student's T test for wing blade-claw ratio is marginal due to nearly significant differences between variances.

The results of the Pearson's Coefficient of Correlation tests (Table 2) provide only partial support to Yakovlev's hypothesis that the characters used by Kearney and Peebles (Table 1) to distinguish S. arizonica and S. formosa are attributable to differences in flower size. As would be expected, linear variables are positively correlated with the variable flower length. The banner length has a larger slope than the banner width resulting in a positive correlation between flower length and banner length-width ratio. The result is that smaller flowers do tend to have smaller banner length-width ratios because of relatively wider petals. Keel blade lengths, however, have slightly smaller slopes than the respective claws with the result that larger flowers tend to have smaller keel blade-claw ratios.

Figure 8, a polygonal graph, represents the means (mode for number of leaflets) and ranges of those variables which had significant results with the Chi Square or Student's T test. Apparently none of the variables have differences which would characterize regions. None of the variables (Figures 4, 5, 6, 7) which had significant results with the ANOVA tests characterizes any population or group of populations. Yakovlev (1968) retains Calia arizonica ssp. formosa (Kearn. & Peeb.) Yakovl. on the basis of the degree of pubescence on the leaflets. Specimens cited by Yakovlev and numerous other plants examined show no consistent differences between populations or regions for this variable. Although regions and populations do exhibit morphological differences, the results support the recognition of only one taxonomic species of a fruticose Sophora in Arizona, S. arizonica. This supports Rudd (1972).

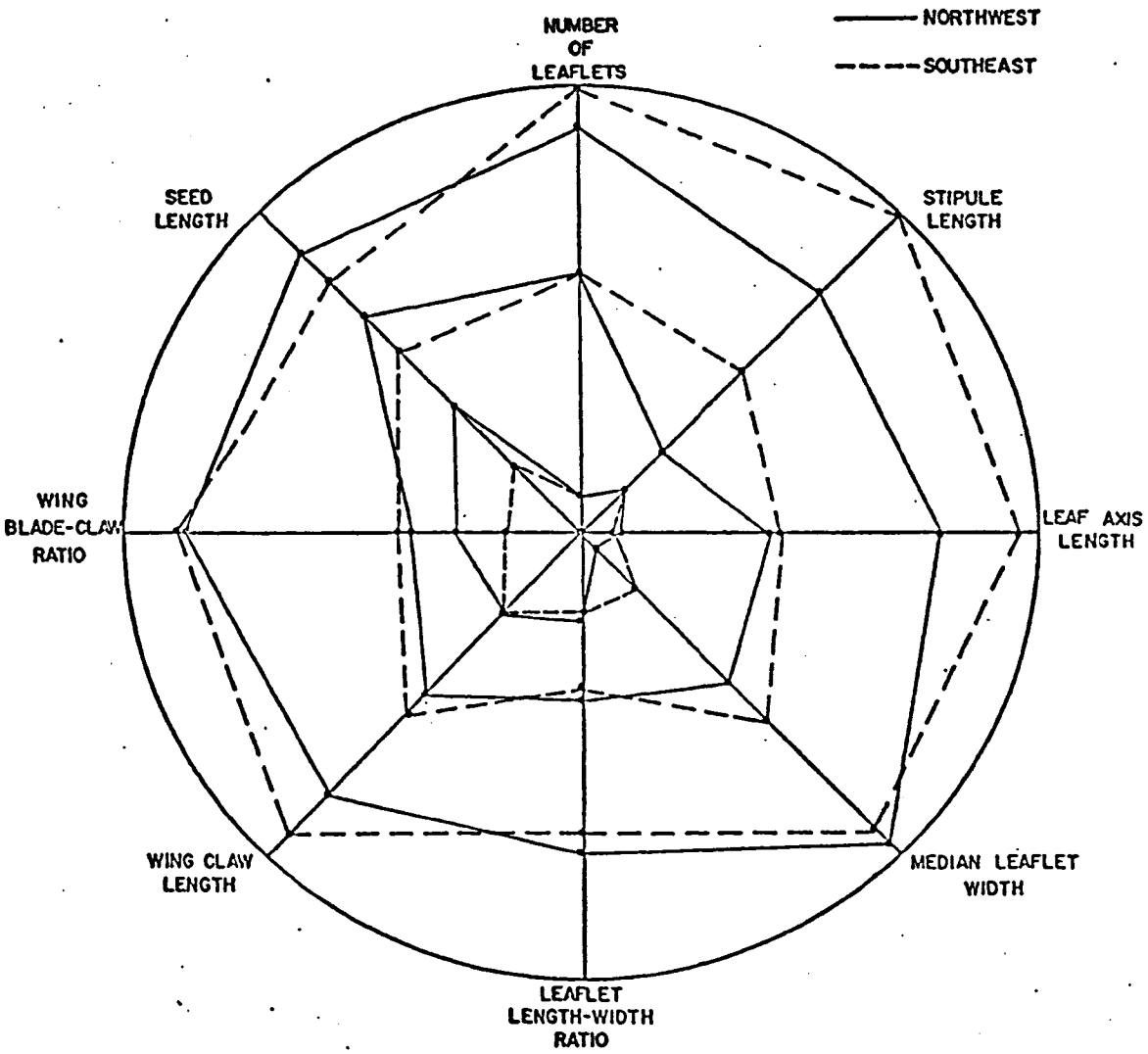


Figure 8. A polygonal graph representing means (mode for number of leaflets) and ranges of eight variables of S. arizonica Wats. for the Northwest and Southeast regions.

## TAXONOMY OF SOPHORA ARIZONICA WITH NOTES ON ITS RANGE AND DISTRIBUTION

Sophora arizonica Wats. Proc. Am. Acad. 11:135, 1876. Type: USA. Arizona: White Cliff Creek and Cactus Pass, 29 January 1854, J. M. Bigelow s.n. (LECTOTYPE: GH! ft.; ISOTYPE: NY!; DS! (photograph of LECTOTYPE).

The synonmy listed here is as cited in Rudd (1972).

Sophora formosa Kearn. & Peeb., Journ. Wash. Acad. Sci. 29:482, 1939.

Calia arizonica (Wats.) Yakovl., Proc. Leningr. Chem.-Pharm. Inst. 21:45, 1967.

Calia formosa (Kearn. & Peeb.) Yakovl., Proc. Leningr. Chem.-Pharm. Inst. 21:45, 1967.

Calia arizonica (Wats.) Yakovl. ssp. formosa (Kearn. & Peeb.) Yakovl., Proc. Leningr. Chem.-Pharm. Inst. 26:109, 1968.

The following description includes data from the descriptive statistics for all the specimens used in the present study. Ranges are given as the mean $\pm$ two standard deviations.

S. arizonica is a small to medium size evergreen shrub that occasionally approaches arborescence. The young branches are tomentose and older branches have rough bark. Alternate pubescent leaves, 32.0-82.0 mm long, are evenly or oddly pinnately compound with 3-12 leaflets in an opposite to alternate arrangement. Stipules are up to 4.0 mm long. The lanceolate to suboblanceolate leaflets have a short petiolule

and are up to 43.0 mm long. The trichomes are densest on the abaxial surface of the leaflets. Prominent venation consists of the midnerve only; the margins are entire.

The inflorescence is a terminal raceme up to 45.0 mm long. Pedicels, bracteoles, and calyces are densely pubescent. The papilionaceous flowers, 17.5-29.0 mm long, vary in color from almost white to purple. Each pedicel is subtended by a subulate to oblanceolate bract which is highly variable in length. On the pedicel are a pair of bracteoles, 0.5-2.5 mm long, that subtend the flower. The length of the symsepalous, zygomorphic calyx varies from 9.5-16.0 mm. The five calyx teeth vary in the degree of fusion with the two vexillar teeth larger than the abaxial teeth. The banner petal, 17.5-25.5 mm long, is ovate to obovate. Wing and keel petals are 15.5-23.5 and 12.5-23.5 mm long respectively, with keel blades being loosely adnate along the base. There are 10 glabrous filaments which are free with dorsifixed anthers. Mature fruits are torulose legumes which are lightly flattened and moderately to strongly constricted between the seeds with lengths up to 125.0 mm, but often less. The number of seeds per pod varies greatly with about 10 being the maximum. Seeds are reddish brown, 7.0-11.0 mm long, 3.5-6.0 mm thick, 5.0-7.5 mm wide, and subreniform with a subapical hilum.

In the localities where it is found, S. arizonica is usually the dominant or codominant species. In most cases populations are restricted to relatively small areas. The Hualapai population is an exception. The eight populations used in the present study are discussed below.

1. Cottonwood: Secs. 19, 20, T21N, R11W. This may be the same area as Bigelow's type collection, "White Cliff Creek and Cactus Pass." "Cactus Pass" was the name given to a deep pass through the Cottonwood Mountains by Wheeler in 1885, according to Barnes (1935). The construction of Interstate Highway 40 through this area has inflicted damage on the southern edge of the population. Flowers and fruits were recorded in April and May. The elevation is 4,600 feet and the substrate is basalt (Wilson and Moore, 1959a).
2. Hualapai: Secs. 9, 11, 12, 16, 17, T20N, R14W; Sec. 13, T20N, R15W; Sec. 18, T20N, R13W. This population is found on the eastern slopes of the Hualapai Mountains, primarily on the Miller Ranch and further south along the abandoned section of Highway 93. Shrubs were found growing in washes, but they are primarily on hills with slopes ranging from 3-16°. Records date flowering from early March to mid-July with fruits in mid-April. The elevation is 3,800-5,000 feet with granite as the substrate (Wilson and Moore, 1959a).
3. Knight Creek: Sec. 9, T18N, R13W. This population is located about 19 miles north of the town of Wikieup on Highway 93. Flowers were recorded from early March with both flowers and fruits being present in late April. The elevation is 3,000 feet and the substrate is composed of sand, gravel, and conglomerate bordering on granite gneiss (Wilson and Moore, 1959a).

4. Aquarius: T19S, R19E. The location of this population is on the western foothills of the Aquarius Mountains. Flowers were recorded from early March to mid-April. The elevation for the population is 4,100-4,200 feet and the substrate is granite (Wilson and Moore, 1959a).
5. Pinaleno: This population is represented by specimens from three locations which are all found on the northern foothills of the Pinaleno Mountains. The locations are discussed below:
   a. Frye Mesa: Sec. 6, T8S, R25E and Sec. 31, T7S, R25E. This location is on the slopes of Frye Mesa which is the type locality of S. formosa Kearn. & Peeb. Records date flowers from March through April with fruits found present in March. The elevation ranges from 3,800-4,400 feet and the substrate is silt, sand, and gravel bordering on granite gneiss (Wilson and Moore, 1958).
   b. Ash Creek: Secs. 26, 35, T7S, R24E. The Ash Creek location was discovered by Steve Bingham. The plants are found on side canyons west of Ash Creek where the shrubs are most common on the northern slopes. There were no previous herbarium records found of this group. Flowers were observed in early April. The elevation is about 3,700 feet and the substrate is similar to Frye Mesa (Wilson and Moore, 1958).

c. Bear Springs: This location is on very steep slopes directly north of U. S. F. S. 28b (Mesa Road) 12.3 miles southwest of Pima. Flowering has been observed in early April. The elevation ranges from 3,350-3,600 feet and the substrate is silt, sand, and gravel (Wilson and Moore, 1958).

6. Mattie Canyon: Secs. 5, 8, T18S, R18E. The location of this population is on the west side of the Whetstone Mountains on the Cienega Ranch. I have not been able to find any herbarium records of this location. Power line construction by both Tucson Gas and Electric and Arizona Electric Power have inflicted damage on the denser eastern section of the population. Flowers were observed in early March with fruits being present in late August. Elevation for the population ranges from 4,500-4,700 feet and the substrate is limestone (Wilson, Moore, and O'Haire, 1960).

7. Dry Canyon: NW¼ Sec. 23 (and a location about 0.7 mile to the west), T19S, R19E. A report by Judith Wilder provided directions for the location of the Dry Canyon population. No previous herbarium records are known to me. Individuals are on the north facing slopes of two separate hills. Flowers have been observed from early March to mid-April. Fruits were recorded present in mid-April. The elevation ranges from 4,900-5,000 feet and the substrate is limestone (Wilson and Moore, 1959b).

8. Swisshelm: Secs. 23, 25, 26, NW¼ 35, T19S, R27E. This population is located on a ranch owned by Charles Whitehead. Flowers have been observed in mid-April. The elevation ranges from 4,625-5,225 feet and the substrate is limestone (Wilson and Moore, 1959b).

The following specimens were acquired from various herbaria.

Specimens Examined: UNITED STATES. Arizona: Mohave Co.: 20 miles south of Kingman along Highway 93, Barr 66-10 (ARIZ); 15 miles southwest of Yucca, Benson 101017 (ARIZ); Highway 93, 15.7 miles east of Kingman, Bohrer 1065 (ARIZ); 1 mile north of Kingman, Blakley 1785 (ASU); hills near Stevens Ranch near Kingman, 30 March 1927, Braen s.n. (DS); sandy road vicinity of Kingman, 15 April 1928, Braen s.n. (DS); sandy road near Kingman, 12 September 1927, Braen s.n. (A, DS); Wickiup Trail, 15 April 1952, Cook s.n. (ASU); gravelly knolls along McGerry's Wash 22 miles west of Kingman, Cronquist 10563 (DS); 20 miles north of Wikieup, Crooks & Darrow 3602 (ARIZ, NY); 23 miles east of Kingman, Darrow & Gould 3718 (ARIZ); on road to Aquarius Mountains from Kingman, Eastwood 18352 (CAS, ARIZ); Hualapai Mountains 25 miles east-southeast of Kingman, Glowenke 10939 (GH); 15 miles east of Yucca, Goodding 242 (ARIZ); 10 miles northeast of Wickiup in Aquarius Mountains, Green 1 (ASU); near Kingman, Harrison et al. 7623 (ARIZ); just south of Wickiup on Highway 93, Higgins 6520 (NY); east side of Hualapai Mountains along secondary road southwest of Highway 93, Phillips & Mason 1759 (CAS, DS); rocky slopes south side Hualapai Mountains, Mason 2870 (ARIZ, ASU, CAS, NY, UC); not far from Kingman on road to Big Sandy River, McKelvey 1512

(A); Big Sandy River 60 miles from Kingman, McKelvey 1513B (A, US); near Kingman, McKelvey 2240 (UC); near Kingman, 13 March 1930, McKelvey s.n. (CAS, GH); Hualapai Creek, April, 1896, Orcutt (UC); near Prescott, Palmer 65 (UC); Cottonwood Creek 75 miles west of Prescott, Palmer 65 (GH -- with Lectotype, NY, US); south of Kingman Round Valley, 17 March 1957, Passey s.n. (ASC); east of Hualapai Mountains, Peebles & Kearney 11268 (ARIZ, GH, NY); 18 miles north of Wickieup on Highway 93, Phillips & Phillips 74-171 (ARIZ); 20 miles southeast of Kingman Jct. of Route 93 and Route 66, Pinkava 2095A (ASU); US 93 0.9 mile south of Hackberry turnoff, Pinkava et al. 11287 (ASU); Hualapai Mountains, Shreve 7845 (ARIZ, DS); 8 miles east of Kingman on Highway 93, Spring 1952, Tompkins s.n. (CAS); Hualapai Mountains east of Kingman, 2 June 1938, without collector (ARIZ). Pima Co.: Santa Rita Mountains, Summer 1880, Lemmon s.n. (GH -- with Lectotype). Cochise Co.: Sec. 24, T19S, R27E, Whitehead Ranch, Swisshelm Mountains, August, 1971, Sommerville (ARIZ). Graham Co.: southwest of Safford, Goodding 206-60 (ARIZ); escarpment of Frye Mesa, Pinaleno Mountains, Kearney & Peebles 14233 (A, ARIZ, CAS, GH, NY, UC, US); above Bear Springs Flat, Kessler 397 (ARIZ); slopes above Bear Springs, Kessler 784 (ARIZ); 15 miles southwest of Safford, gully banks below front of Frye Mesa, Maguire 10993 (ARIZ, GH, NY, UC, US); 5.3 miles south of Thatcher, northern slopes Frye Mesa, 9 March 1970, Weber s.n. (ASU, ASC); Safford, without collector 784 (ARIZ).

The following specimens are those from which data were taken. Each field number represents one single plant except for mass

collections, McManus & McLaughlin 467 & 493, in which each twig represents an individual.

Specimens Examined: UNITED STATES. Arizona: Mohave Co.: Cottonwood Mountains, Secs. 19, 20, T21N, R11W, McManus et al. 403-408, 410-420; McLaughlin & McManus 493; Hualapai Mountains, McLaughlin et al. 275, 276, 279-297; Sec. 12, T20N, R14W, McManus et al. 334-348; Sec. 16, T20N, R14W, McManus et al. 350, 351; Sec. 9, T20N, R14W, McManus et al. 352; Sec. 17, T20N, R14W, McManus et al. 358, 359, 363-367; Sec. 12, T20N, R14W, McManus et al. 370, 371; Sec. 9, T20N, R14W, McManus et al. 374-377; Sec. 16, T20N, R14W, McManus et al. 378, 379, 381, 382; Sec. 13, T20N, R15W, McManus et al. 386-388; Sec. 12, T20N, R14W, McManus et al. 391; Sec. 18, T20N, R13W, McLaughlin & McManus 476-487; McManus & McLaughlin 593-595; about 20 miles north of Wikieup, Sec. 9, T18N, R13W, 7 November 1974, Busman s.n.; McManus et al. 392; McManus & McLaughlin 584-592; McLaughlin & McManus 469-475, 522; Aquarius Mountains, Secs. 26, 27, T18N, R12W, McManus & McLaughlin 572-580; Sec. 27, T18N, T12W, McManus et al. 394-396; Sec. 26, T18N, R12W, McManus et al. 398, 399; Secs. 26, 27, T18N, R12W, McLaughlin & McManus 467. Graham Co.: north facing slopes above Bear Springs, 12.3 miles southwest of Pima on U. S. F. S. 28b (Mesa Road), McManus et al. 528-536; McLaughlin 615-617; Ash Creek, Secs. 26, 35, T7S, R24E, McManus et al. 538-553; McLaughlin et al. 620-629; northwestern slopes of Frye Mesa, Sec. 31, T7S, R22E and Sec. 6, T8S, R25E, McManus et al. 524-526; McLaughlin & McManus 554-566; McManus & McLaughlin 633-639. Pima Co.: Mattie Canyon, Sec. 8, T18S, R18E, McManus & McLaughlin 186-188; 192; Sec. 5,

T18S, R18E, McLaughlin & McManus 245-259; Sec. 8, T18S, R18E, McLaughlin & McManus 260; Sec. 5, T18S, R18E, McManus & McLaughlin 399-412; Sec. 8, T18S, R18E, McManus & McLaughlin 413-416; McLaughlin & McManus 457, 458. Cochise Co.: Dry Canyon, Sec. 23 (and north of Sec. 27), T19S, R19E, McManus et al. 294, 295, 298-305; McLaughlin et al. 205-216; Swisshelm Mountains, Sec. 23, T19S, R27E, McLaughlin & McManus 316, 317; Secs. 23, 26, T19S, R27E, McLaughlin & McManus 451; McManus & McLaughlin 453-456, 650-656, 660-670; McLaughlin & McManus 573-582, 586-588; NW¼ Sec. 25, T19S, R27E, McManus & McLaughlin 674-683; McLaughlin & McManus 592-599, 606, 607.

# APPENDIX A

## SELECTED DESCRIPTIVE AND INFERENTIAL STATISTICS OF CONTINUOUS AND DISCONTINUOUS VARIABLES

Variable: Number of Leaflets

| Population | Sample Size | Mode | Range | Standard Deviation | Standard Error | Inferential Statistics |
|---|---|---|---|---|---|---|
| All | 337 | 7 | 1-15 | 2.194 | 0.120 | |
| Northwest | 163 | 7 | 1-11 | 1.661 | 0.130 | Chi Square[a] |
| Southeast | 174 | 7 | 1-15 | 2.477 | 0.188 | 64.550 |
| Cottonwood | 40 | 7 | 4-10 | 1.548 | 0.245 | |
| Hualapai | 60 | 7 | 1-9 | 1.664 | 0.215 | |
| Knight Creek | 20 | 7 | 3-11 | 1.997 | 0.447 | |
| Aquarius | 43 | 5 | 3-9 | 1.419 | 0.216 | Analysis of Variance |
| Pinaleno | 54 | 7 | 1-12 | 2.486 | 0.338 | N.A. |
| Mattie | 35 | 9 | 3-13 | 2.636 | 0.445 | |
| Dry | 30 | 9 | 3-13 | 2.374 | 0.443 | |
| Swisshelm | 55 | 7 | 4-15 | 2.227 | 0.300 | |

[a] L.S. $\alpha < .05$
N.A. Not Applicable

Variable: Leaf Length

| Population | Sample Size | Mean | Range | Standard Deviation | Standard Error | Inferential Statistics |
|---|---|---|---|---|---|---|
| All | 337 | 57.0 | 21.0-96.5 | 12.496 | 0.681 | |
| Northwest | 164 | 56.0 | 30.0-96.5 | 12.871 | 1.005 | Student's T Test[c] |
| Southeast | 173 | 58.0 | 21.0-86.0 | 12.074 | 0.918 | |
| Cottonwood | 40 | 58.0 | 41.0-89.0 | 11.678 | 1.847 | |
| Hualapai | 60 | 57.0 | 30.0-96.5 | 14.559 | 1.880 | |
| Knight Creek | 20[a] | 51.5 | 34.0-75.0 | 13.691 | 3.061[b] | |
| Aquarius | 44 | 54.5 | 36.0-84.5 | 10.663 | 1.608 | Analysis of Variance |
| Pinaleno | 53 | 55.5 | 31.5-83.5 | 12.314 | 1.691 | 1.702 |
| Mattie | 35 | 62.0 | 24.0-81.0 | 12.297 | 2.079 | |
| Dry | 29 | 60.0 | 40.5-86.0 | 11.390 | 2.115 | |
| Swisshelm | 56 | 57.0 | 21.0-83.5 | 11.560 | 1.545 | |

[a] Inadequate sample size

[b] Calculated manually

[c] Variances unequal

Variable: Stipule Length

| Population | Sample Size | Mean | Range | Standard Deviation | Standard Error | Inferential Statistics |
|---|---|---|---|---|---|---|
| All | 317 | 1.5 | 0.5-4.0 | 0.662 | 0.037 | |
| Northwest | 152 | 1.0 | 0.5-3.0 | 0.432 | 0.035 | Student's T Test |
| Southeast | 165 | 2.0 | 0.5-4.0 | 0.624 | 0.049 | -12.61[b] |
| Cottonwood | 32[a] | 1.0 | 0.5-2.0 | 0.311 | 0.055 | |
| Hualapai | 61 | 1.0 | 0.5-3.0 | 0.479 | 0.061 | |
| Knight Creek | 18[a] | 2.0 | 0.5-2.0 | 0.335 | 0.079 | |
| Aquarius | 41[a] | 1.0 | 0.5-2.0 | 0.436 | 0.068 | Analysis of Variance |
| Pinaleno | 51[a] | 1.5 | 0.5-4.0 | 0.692 | 0.097 | 17.971[b] |
| Mattie | 31[a] | 2.0 | 1.0-3.5 | 0.593 | 0.107 | |
| Dry | 30 | 2.0 | 1.0-3.0 | 0.497 | 0.091 | |
| Swisshelm | 53 | 2.0 | 1.0-4.0 | 0.562 | 0.077 | |

[a] Inadequate sample size

[b] $LS \ll .05$

Variable: Leaf Axis Length

| Population | Sample Size | Mean | Range | Standard Deviation | Standard Error | Inferential Statistics |
|---|---|---|---|---|---|---|
| All | 341 | 34.5 | 6.0-77.0 | 10.717 | 0.580 | |
| Northwest | 165 | 33.5 | 7.0-63.5 | 9.850 | 0.767 | Student's T Test |
| Southeast | 176 | 35.5 | 6.0-77.0 | 11.402 | 0.859 | -1.85[b] |
| Cottonwood | 40 | 36.0 | 21.0-57.0 | 9.118 | 1.442 | |
| Hualapai | 61 | 34.5 | 7.0-63.5 | 10.745 | 1.376 | |
| Knight Creek | 20[a] | 33.5 | 14.5-50.5 | 9.992 | 2.234 | |
| Aquarius | 44 | 30.0 | 14.5-49.0 | 7.975 | 1.202 | Analysis of Variance[c] |
| Pinaleno | 56 | 32.0 | 6.0-62.0 | 11.265 | 1.505 | |
| Mattie | 35 | 38.5 | 17.5-61.0 | 11.018 | 1.862 | |
| Dry | 29[a] | 37.5 | 14.5-77.0 | 13.791 | 2.561 | |
| Swisshelm | 56 | 35.5 | 18.0-59.0 | 9.776 | 1.305 | |

[a] Inadequate sample size

[b] LS $\alpha < .05$

[c] Variances unequal

Variable: Maximum Leaflet Length

| Population | Sample Size | Mean | Range | Standard Deviation | Standard Error | Inferential Statistics |
|---|---|---|---|---|---|---|
| All | 342 | 23.0 | 6.0-43.0 | 5.444 | 0.294 | |
| Northwest | 165 | 23.0 | 6.0-43.0 | 6.271 | 0.988 | Student's T Test[b] |
| Southeast | 177 | 24.0 | 11.0-37.5 | 4.556 | 0.342 | |
| Cottonwood | 40 | 22.5 | 13.5-35.0 | 4.615 | 0.730 | |
| Hualapai | 61 | 22.5 | 10.0-43.0 | 6.834 | 0.875 | |
| Knight Creek | 20[a] | 19.5 | 6.0-29.0 | 5.951 | 1.331 | |
| Aquarius | 44 | 25.0 | 12.5-40.0 | 6.283 | 1.947 | Analysis of Variance[b] |
| Pinaleno | 56 | 24.0 | 12.0-37.5 | 5.403 | 0.722 | |
| Mattie | 35 | 23.5 | 16.5-34.5 | 4.448 | 0.752 | |
| Dry | 30 | 23.5 | 17.0-31.0 | 3.716 | 0.678 | |
| Swisshelm | 56 | 21.5 | 11.0-27.5 | 3.829 | 0.512 | |

[a] Inadequate sample size

[b] Variances unequal

Variable: Median Leaflet Width

| Population | Sample Size | Mean | Range | Standard Deviation | Standard Error | Inferential Statistics |
|---|---|---|---|---|---|---|
| All | 330 | 8.0 | 2.5-13.5 | 1.841 | 0.101 | |
| Northwest | 156 | 7.5 | 2.5-13.5 | 1.982 | 0.159 | Student's T Test |
| Southeast | 174 | 8.5 | 4.0-13.0 | 1.659 | 0.126 | -3.04[b] |
| Cottonwood | 37 | 7.5 | 4.5-11.5 | 1.627 | 0.267 | |
| Hualapai | 59 | 8.0 | 4.5-13.0 | 1.927 | 0.251 | |
| Knight Creek | 19[a] | 6.5 | 2.5-13.5 | 2.244 | 0.515 | |
| Aquarius | 41 | 8.0 | 4.5-13.5 | 2.138 | 0.334 | Analysis of Variance[c] |
| Pinaleno | 54 | 8.5 | 4.5-12.5 | 1.849 | 0.252 | |
| Mattie | 35 | 8.0 | 5.0-11.0 | 1.339 | 0.226 | |
| Dry | 30 | 9.0 | 6.0-13.0 | 1.618 | 0.295 | |
| Swisshelm | 55 | 7.5 | 4.0-11.0 | 1.471 | 0.198 | |

[a] Inadequate sample size

[b] $LS \ll .05$

[c] Variances unequal

Variable: Leaflet Apex Angle

| Population | Sample Size | Mean | Range | Standard Deviation | Standard Error | Inferential Statistics |
|---|---|---|---|---|---|---|
| All | 296 | 57.5 | 24.0-92.0 | 9.397 | 0.545 | |
| Northwest | 141 | 57.0 | 33.0-92.0 | 9.164 | 0.769 | Student's T Test |
| Southeast | 155 | 58.0 | 24.0-82.0 | 9.591 | 0.770 | -1.24 |
| Cottonwood | 37 | 59.0 | 44.0-76.5 | 8.011 | 1.317 | |
| Hualapai | 49 | 58.5 | 43.0-92.0 | 9.822 | 1.403 | |
| Knight Creek | 16 | 54.5 | 44.5-62.0 | 5.755 | 1.439 | |
| Aquarius | 39 | 53.5 | 33.0-76.5 | 9.465 | 1.497 | Analysis of Variance[a] |
| Pinaleno | 45 | 61.0 | 43.0-77.5 | 8.692 | 1.296 | |
| Mattie | 32 | 53.0 | 35.0-75.0 | 9.452 | 1.671 | |
| Dry | 28 | 60.0 | 42.5-78.0 | 8.843 | 1.671 | |
| Swisshelm | 50 | 58.0 | 24.0-82.0 | 9.665 | 1.367 | |

[a]Variances unequal

Variable: Leaflet Base Angle

| Population | Sample Size | Mean | Range | Standard Deviation | Standard Error | Inferential Statistics |
|---|---|---|---|---|---|---|
| All | 306 | 62.5 | 30.0-87.0 | 8.497 | 0.485 | |
| Northwest | 144 | 62.0 | 33.0-86.0 | 8.813 | 0.732 | Student's T Test |
| Southeast | 162 | 63.0 | 30.0-87.0 | 8.200 | 0.644 | -1.06 |
| Cottonwood | 36 | 63.5 | 46.0-84.0 | 8.083 | 1.347 | |
| Hualapai | 51 | 62.5 | 45.0-86.0 | 8.774 | 1.229 | |
| Knight Creek | 16 | 62.0 | 45.0-80.0 | 8.316 | 2.079 | |
| Aquarius | 41 | 60.0 | 33.0-78.5 | 9.564 | 1.476 | Analysis of Variance |
| Pinaleno | 51 | 64.5 | 51.5-82.5 | 7.636 | 1.069 | 1.270 |
| Mattie | 31 | 61.0 | 47.0-87.0 | 7.566 | 1.359 | |
| Dry | 29 | 63.0 | 49.5-78.0 | 7.461 | 1.386 | |
| Swisshelm | 51 | 62.5 | 30.0-85.5 | 9.348 | 1.309 | |

Variable: Raceme Length

| Population | Sample Size | Mean | Range | Standard Deviation | Standard Error | Inferential Statistics |
|---|---|---|---|---|---|---|
| All | 206 | 10.5 | 1.0-45.0 | 5.348 | 0.373 | |
| Northwest | 49[a] | 11.0 | 4.0-23.0 | 4.535 | 0.648 | Student's T Test |
| Southeast | 157[a] | 10.0 | 1.0-45.0 | 5.571 | 0.445 | |
| Cottonwood | 17[a] | 13.0 | 6.0-23.0 | 5.041 | 1.223 | |
| Hualapai | 7[a] | 10.5 | 5.0-14.0 | 3.302 | 1.248 | |
| Knight Creek | 20[a] | 9.5 | 4.0-20.0 | 4.402 | 0.984 | |
| Aquarius | 5[a] | 12.5 | 10.0-18.0 | 3.286 | 1.470 | Analysis of Variance |
| Pinaleno | 57[a] | 11.5 | 2.0-45.0 | 7.558 | 1.001 | |
| Mattie | 31[a] | 9.0 | 1.0-14.0 | 2.614 | 0.469 | |
| Dry | 29[a] | 11.5 | 6.0-23.0 | 4.702 | 0.873 | |
| Swisshelm | 40[a] | 8.0 | 3.0-18.0 | 3.242 | 0.513 | |

[a] Inadequate sample size

Variable: Flower Length

| Population | Sample Size | Mean | Range | Standard Deviation | Standard Error | Inferential Statistics |
|---|---|---|---|---|---|---|
| All | 196 | 23.0 | 12.0-31.0 | 2.822 | 0.202 | |
| Northwest | 52 | 22.5 | 16.0-28.0 | 2.625 | 0.364 | Student's T Test |
| Southeast | 144 | 23.0 | 12.0-31.0 | 2.879 | 0.240 | -1.45 |
| Cottonwood | 16 | 21.5 | 17.0-25.0 | 2.159 | 0.540 | |
| Hualapai | 18 | 23.0 | 16.0-28.0 | 3.100 | 0.735 | |
| Knight Creek | 17 | 22.5 | 18.5-25.5 | 2.116 | 0.513 | |
| Aquarius | 1[a] | 28.0 | | | | Analysis of Variance |
| Pinaleno | 56 | 24.5 | 17.5-31.0 | 2.885 | 0.386 | 3.248[b] |
| Mattie | 17 | 22.5 | 19.0-27.5 | 2.353 | 0.571 | |
| Dry | 29 | 22.0 | 12.0-26.0 | 2.819 | 0.523 | |
| Swisshelm | 42 | 23.0 | 17.5-28.0 | 2.687 | 0.415 | |

[a] Inadequate sample size

[b] $LS \propto < .05$

Variable: Calyx Length

| Population | Sample Size | Mean | Range | Standard Deviation | Standard Error | Inferential Statistics |
|---|---|---|---|---|---|---|
| All | 207 | 11.5 | 7.5-19.0 | 2.092 | 0.145 | |
| Northwest | 59 | 12.0 | 7.5-19.0 | 2.127 | 0.277 | Student's T Test |
| Southeast | 148 | 11.5 | 7.5-18.5 | 2.071 | 0.170 | 1.41 |
| Cottonwood | 16 | 12.0 | 9.5-17.0 | 1.720 | 0.430 | |
| Hualapai | 24 | 12.0 | 7.5-17.0 | 2.276 | 0.465 | |
| Knight Creek | 18 | 12.5 | 9.5-19.0 | 2.353 | 0.555 | |
| Aquarius | 1[a] | 13.0 | | | | Analysis of Variance |
| Pinaleno | 58 | 12.0 | 7.5-17.0 | 2.207 | 0.290 | 2.008 |
| Mattie | 14 | 12.5 | 10.0-14.0 | 1.284 | 0.343 | |
| Dry | 29 | 11.5 | 9.0-17.0 | 1.678 | 0.312 | |
| Swisshelm | 47 | 11.0 | 7.5-18.5 | 2.059 | 0.300 | |

[a]Inadequate sample size

Variable: Vexillar Teeth Length

| Population | Sample Size | Mean | Range | Standard Deviation | Standard Error | Inferential Statistics |
|---|---|---|---|---|---|---|
| All | 195 | 2.0 | 0.5-4.0 | 0.583 | 0.042 | |
| Northwest | 60 | 2.5 | 1.0-4.0 | 0.531 | 0.069 | Student's T Test |
| Southeast | 135 | 2.0 | 0.5-4.0 | 0.601 | 0.052 | 1.63 |
| Cottonwood | 16[a] | 2.5 | 1.5-3.0 | 0.408 | 0.102 | |
| Hualapai | 25 | 2.5 | 1.0-4.0 | 0.624 | 0.125 | |
| Knight Creek | 18 | 2.0 | 1.5-3.0 | 0.439 | 0.103 | |
| Aquarius | 1[a] | 3.0 | | | | Analysis of Variance[b] |
| Pinaleno | 58 | 2.0 | 0.5-3.0 | 0.614 | 0.081 | |
| Mattie | 18 | 2.5 | 2.0-3.0 | 0.338 | 0.080 | |
| Dry | 29 | 2.5 | 1.5-4.0 | 0.631 | 0.117 | |
| Swisshelm | 30 | 2.0 | 1.0-3.0 | 0.524 | 0.096 | |

[a]Inadequate sample size

[b]Variances unequal

Variable: Calyx Mid-tooth Length

| Population | Sample Size | Mean | Range | Standard Deviation | Standard Error | Inferential Statistics |
|---|---|---|---|---|---|---|
| All | 211 | 1.5 | 0.5-4.0 | 0.507 | 0.035 | |
| Northwest | 58[a] | 1.5 | 1.0-4.0 | 0.596 | 0.078 | Student's T Test |
| Southeast | 153 | 1.5 | 0.5-3.0 | 0.470 | 0.038 | |
| Cottonwood | 16[a] | 1.5 | 1.0-2.5 | 0.464 | 0.116 | |
| Hualapai | 23[a] | 2.0 | 1.0-4.0 | 0.693 | 0.145 | |
| Knight Creek | 18[a] | 1.0 | 1.0-2.0 | 0.304 | 0.072 | |
| Aquarius | 1[a] | 2.5 | | | | Analysis of Variance |
| Pinaleno | 58 | 1.5 | 0.5-2.5 | 0.463 | 0.061 | |
| Mattie | 18[a] | 1.75 | 1.0-2.5 | 0.462 | 0.109 | |
| Dry | 29[a] | 1.5 | 1.0-3.0 | 0.431 | 0.080 | |
| Swisshelm | 48 | 1.5 | 1.0-2.5 | 0.429 | 0.062 | |

[a]Inadequate sample size

Variable: Banner Length

| Population | Sample Size | Mean | Range | Standard Deviation | Standard Error | Inferential Statistics |
|---|---|---|---|---|---|---|
| All | 199 | 20.0 | 13.0-27.0 | 2.518 | 0.186 | |
| Northwest | 49 | 19.5 | 13.0-26.0 | 3.097 | 0.5 | Student's T Test[b] |
| Southeast | 150 | 20.5 | 13.0-27.0 | 2.430 | 0.198 | |
| Cottonwood | 12 | 19.0 | 14.5-21.5 | 2.071 | 0.598 | |
| Hualapai | 19 | 20.5 | 13.0-26.0 | 3.763 | 0.863 | |
| Knight Creek | 17 | 19.0 | 13.0-22.5 | 2.391 | 0.580 | |
| Aquarius | 1[a] | 26.0 | | | | Analysis of Variance |
| Pinaleno | 58 | 20.5 | 15.5-25.5 | 2.071 | 0.272 | 2.441[c] |
| Mattie | 15 | 20.5 | 15.0-27.0 | 2.846 | 0.735 | |
| Dry | 29 | 19.5 | 13.0-24.5 | 2.624 | 0.487 | |
| Swisshelm | 48 | 20.0 | 15.5-26.5 | 2.553 | 0.368 | |

[a] Inadequate sample size

[b] Variances unequal

[c] LS $\alpha < .05$

Variable: Banner Width

| Population | Sample Size | Mean | Range | Standard Deviation | Standard Error | Inferential Statistics |
|---|---|---|---|---|---|---|
| All | 192 | 11.5 | 6.5-16.0 | 1.697 | 0.122 | |
| Northwest | 41 | 11.0 | 6.5-15.0 | 1.908 | 0.298 | Student's T Test[b] |
| Southeast | 151 | 12.0 | 8.0-16.0 | 1.613 | 0.131 | |
| Cottonwood | 7[a] | 11.0 | 7.5-15.0 | 2.231 | 0.843 | |
| Hualapai | 17 | 12.0 | 6.5-14.0 | 1.961 | 0.476 | |
| Knight Creek | 17[a] | 10.5 | 7.0-13.5 | 1.616 | 0.392 | |
| Aquarius | | | | | | Analysis of Variance[b] |
| Pinaleno | 58 | 11.0 | 9.0-14.0 | 1.175 | 0.154 | |
| Mattie | 16 | 12.0 | 9.0-15.0 | 1.672 | 0.418 | |
| Dry | 29 | 12.0 | 8.0-15.5 | 1.672 | 0.311 | |
| Swisshelm | 48 | 12.5 | 9.0-16.0 | 1.619 | 0.234 | |

[a]Inadequate sample size

[b]Variances unequal

Variable: Keel Blade Length

| Population | Sample Size | Mean | Range | Standard Deviation | Standard Error | Inferential Statistics |
|---|---|---|---|---|---|---|
| All | 209 | 12.5 | 7.5-17.0 | 1.608 | 0.111 | |
| Northwest | 58 | 12.5 | 7.5-16.0 | 1.659 | 0.218 | Student's T Test |
| Southeast | 151 | 13.0 | 9.0-17.0 | 1.580 | 0.129 | -1.53 |
| Cottonwood | 17 | 12.5 | 8.5-13.5 | 1.296 | 0.314 | |
| Hualapai | 23[a] | 12.5 | 7.5-15.5 | 1.983 | 0.413 | |
| Knight Creek | 17 | 12.0 | 10.0-14.5 | 1.346 | 0.326 | |
| Aquarius | 1[a] | 16.0 | | | | Analysis of Variance |
| Pinaleno | 58 | 13.0 | 10.0-17.0 | 1.571 | 0.206 | 1.252 |
| Mattie | 17 | 12.0 | 11.0-15.5 | 1.106 | 0.268 | |
| Dry | 29 | 12.5 | 10.0-16.0 | 1.479 | 0.275 | |
| Swisshelm | 47 | 13.0 | 9.0-16.5 | 1.771 | 0.258 | |

[a]Inadequate sample size

Variable: Wing Blade Length

| Population | Sample Size | Mean | Range | Standard Deviation | Standard Error | Inferential Statistics |
|---|---|---|---|---|---|---|
| All | 201 | 15.0 | 7.0-28.5 | 2.215 | 0.156 | |
| Northwest | 50 | 14.5 | 11.0-18.5 | 1.716 | 0.243 | Student's T Test |
| Southeast | 151 | 15.0 | 7.0-28.5 | 2.354 | 0.192 | -1.13 |
| Cottonwood | 13 | 14.5 | 12.0-16.0 | 1.225 | 0.340 | |
| Hualapai | 19 | 14.5 | 11.0-18.0 | 2.167 | 0.497 | |
| Knight Creek | 17 | 14.0 | 11.5-16.5 | 1.146 | 0.278 | |
| Aquarius | 1[a] | 18.5 | | | | Analysis of Variance[b] |
| Pinaleno | 58 | 15.5 | 10.5-28.5 | 2.719 | 0.357 | |
| Mattie | 16 | 14.5 | 10.5-18.5 | 1.893 | 0.473 | |
| Dry | 29 | 14.5 | 11.5-19.0 | 1.701 | 0.316 | |
| Swisshelm | 48 | 14.5 | 7.0-19.5 | 2.312 | 0.334 | |

[a]Inadequate sample size

[b]Variances unequal

Variable: Keel Claw Length

| Population | Sample Size | Mean | Range | Standard Deviation | Standard Error | Inferential Statistics |
|---|---|---|---|---|---|---|
| All | 207 | 5.5 | 3.0-9.0 | 1.051 | 0.073 | |
| Northwest | 57 | 4.5 | 3.0-6.0 | 0.750 | 0.099 | Student's T Test[b] |
| Southeast | 150 | 5.5 | 3.5-9.0 | 0.960 | 0.078 | |
| Cottonwood | 17[a] | 4.5 | 3.0-5.5 | 0.667 | 0.162 | |
| Hualapai | 21 | 5.0 | 3.5-6.0 | 0.736 | 0.157 | |
| Knight Creek | 17 | 4.0 | 3.0-5.0 | 0.496 | 0.120 | |
| Aquarius | 1[a] | 6.0 | | | | Analysis of Variance[b] |
| Pinaleno | 58 | 5.5 | 3.5-8.0 | 0.821 | 0.108 | |
| Mattie | 16 | 6.5 | 4.0-9.0 | 1.181 | 0.295 | |
| Dry | 29 | 5.0 | 3.5-6.5 | 0.833 | 0.155 | |
| Swisshelm | 47 | 5.5 | 3.5-7.5 | 0.976 | 0.142 | |

[a] Inadequate sample size

[b] Variances unequal

Variable: Wing Claw Length

| Population | Sample Size | Mean | Range | Standard Deviation | Standard Error | Inferential Statistics |
|---|---|---|---|---|---|---|
| All | 201 | 4.5 | 2.0-7.5 | 1.006 | 0.071 | |
| Northwest | 51 | 4.0 | 2.0-6.5 | 1.961 | 0.135 | Student's T Test |
| Southeast | 150 | 4.5 | 2.0-7.5 | 0.967 | 0.079 | -4.23[b] |
| Cottonwood | 14[a] | 3.5 | 2.0-5.5 | 0.871 | 0.233 | |
| Hualapai | 19 | 4.5 | 3.0-6.5 | 0.870 | 0.200 | |
| Knight Creek | 17[a] | 3.5 | 2.0-5.0 | 0.800 | 0.194 | |
| Aquarius | 1[a] | 4.5 | | | | Analysis of Variance |
| Pinaleno | 58 | 4.5 | 2.0-7.0 | 0.856 | 0.112 | 3.390[b] |
| Mattie | 15 | 5.0 | 4.0-6.5 | 0.753 | 0.194 | |
| Dry | 29[a] | 4.0 | 2.5-5.5 | 0.816 | 0.152 | |
| Swisshelm | 48 | 5.0 | 3.0-7.5 | 1.082 | 0.156 | |

[a] Inadequate sample size

[b] LS $\alpha < .05$

Variable: Bracteole Length

| Population | Sample Size | Mean | Range | Standard Deviation | Standard Error | Inferential Statistics |
|---|---|---|---|---|---|---|
| All | 208 | 1.5 | 0.5-3.5 | 0.591 | 0.041 | |
| Northwest | 55[a] | 1.0 | 0.5-3.0 | 0.456 | 0.062 | Student's T Test |
| Southeast | 153 | 1.5 | 0.5-3.5 | 0.609 | 0.049 | |
| Cottonwood | 13[a] | 1.0 | 0.5-1.5 | 0.289 | 0.080 | |
| Hualapai | 23[a] | 1.5 | 1.0-3.0 | 0.543 | 0.113 | |
| Knight Creek | 18[a] | 1.0 | 0.5-1.5 | 0.354 | 0.083 | |
| Aquarius | 1[a] | 1.0 | | | | Analysis of Variance |
| Pinaleno | 58[a] | 1.5 | 0.5-3.0 | 0.654 | 0.086 | |
| Mattie | 19 | 2.0 | 1.0-3.0 | 0.417 | 0.096 | |
| Dry | 28[a] | 1.5 | 0.5-2.0 | 0.424 | 0.080 | |
| Swisshelm | 48 | 1.6 | 0.5-3.5 | 0.615 | 0.089 | |

[a]Inadequate sample size

Variable: Seed Length

| Population | Sample Size | Mean | Range | Standard Deviation | Standard Error | Inferential Statistics |
|---|---|---|---|---|---|---|
| All | 45 | 9.0 | 5.5-11.0 | 1.105 | 0.165 | |
| Northwest | 22 | 9.5 | 7.0-11.0 | 0.960 | 0.205 | Student's T Test |
| Southeast | 23 | 8.5 | 5.5-10.5 | 1.089 | 0.227 | 2.79[b] |
| Cottonwood | 3[a] | 8.5 | 7.0-9.5 | 1.179 | 0.681 | |
| Hualapai | 15 | 10.0 | 8.5-11.0 | 0.721 | 0.186 | |
| Knight Creek | 4[a] | 9.0 | 8.0-10.0 | 0.929 | 0.465 | |
| Aquarius | | | | | | Analysis of Variance |
| Pinaleno | | | | | | |
| Mattie | 23 | 8.5 | 5.5-10.5 | 1.089 | 0.227 | |
| Dry | | | | | | |
| Swisshelm | | | | | | |

[a] Inadequate sample size

[b] LS $\alpha < .05$

Variable: Seed Depth

| Population | Sample Size | Mean | Range | Standard Deviation | Standard Error | Inferential Statistics |
|---|---|---|---|---|---|---|
| All | 45 | 5.0 | 3.5-6.0 | 0.671 | 0.100 | |
| Northwest | 22 | 5.0 | 3.5-6.0 | 0.784 | 0.167 | Student's T Test[b] |
| Southeast | 23 | 4.5 | 4.0-6.0 | 0.508 | 0.106 | |
| Cottonwood | 3[a] | 4.0 | 3.5-4.5 | 0.400 | 0.231 | |
| Hualapai | 15 | 5.5 | 4.5-6.0 | 0.561 | 0.145 | |
| Knight Creek | 4[a] | 4.5 | 3.5-5.0 | 0.714 | 0.357 | |
| Aquarius | | | | | | Analysis of Variance |
| Pinaleno | | | | | | |
| Mattie | 23 | 4.5 | 4.0-6.0 | 0.508 | 0.106 | |
| Dry | | | | | | |
| Swisshelm | | | | | | |

[a] Inadequate sample size

[b] Variances unequal

Variable: Seed Width

| Population | Sample Size | Mean | Range | Standard Deviation | Standard Error | Inferential Statistics |
|---|---|---|---|---|---|---|
| All | 45 | 6.5 | 5.0-8.5 | 0.656 | 0.098 | |
| Northwest | 22 | 6.5 | 5.0-8.5 | 0.670 | 0.143 | Student's T Test |
| Southeast | 23 | 6.5 | 5.5-8.0 | 0.633 | 0.132 | 1.29 |
| Cottonwood | 3[a] | 6.0 | 5.0-6.5 | 0.700 | 0.404 | |
| Hualapai | 15 | 7.0 | 5.5-8.5 | 0.656 | 0.169 | |
| Knight Creek | 40 | 6.0 | 6.0-6.5 | 0.189 | 0.095 | |
| Aquarius | | | | | | Analysis of Variance |
| Pinaleno | | | | | | |
| Mattie | 23 | 6.5 | 5.5-8.0 | 0.633 | 0.132 | |
| Dry | | | | | | |
| Swisshelm | | | | | | |

[a]Inadequate sample size

Variable: Maximum Fruit Width

| Population | Sample Size | Mean | Range | Standard Deviation | Standard Error | Inferential Statistics |
|---|---|---|---|---|---|---|
| All | 44 | 11.0 | 7.0-15.0 | 1.496 | 0.226 | |
| Northwest | 23 | 11.0 | 7.0-14.0 | 1.630 | 0.340 | Student's T Test |
| Southeast | 21 | 11.0 | 9.0-15.0 | 1.361 | 0.297 | 0.55 |
| Cottonwood | 2[a] | 11.0 | 10.0-11.5 | 1.061 | 0.750 | |
| Hualapai | 17 | 11.5 | 7.0-14.0 | 1.809 | 0.439 | |
| Knight Creek | 4[a] | 10.0 | 10.0-11.0 | 0.500 | 0.250 | |
| Aquarius | | | | | | Analysis of Variance |
| Pinaleno | | | | | | |
| Mattie | 21 | 11.0 | 9.0-15.0 | 1.361 | 0.297 | |
| Dry | | | | | | |
| Swisshelm | | | | | | |

[a]Inadequate sample size

Variable: Minimum Fruit Width

| Population | Sample Size | Mean | Range | Standard Deviation | Standard Error | Inferential Statistics |
|---|---|---|---|---|---|---|
| All | 38 | 5.5 | 2.5-15.0 | 2.596 | 0.421 | |
| Northwest | 18[a] | 4.5 | 2.5-8.0 | 1.622 | 0.382 | Student's T Test |
| Southeast | 20[a] | 6.0 | 3.0-15.0 | 3.054 | 0.683 | |
| Cottonwood | 2[a] | 6.5 | 5.0-8.0 | 2.121 | 1.500 | |
| Hualapai | 12[a] | 4.5 | 2.5-7.0 | 1.459 | 0.421 | |
| Knight Creek | 4[a] | 3.5 | 2.5-5.0 | 1.109 | 0.554 | |
| Aquarius | | | | | | Analysis of Variance |
| Pinaleno | | | | | | |
| Mattie | 20[a] | 6.0 | 3.0-15.0 | 3.054 | 0.683 | |
| Dry | | | | | | |
| Swisshelm | | | | | | |

[a]Inadequate sample size

## LITERATURE CITED


Barnes, W. C. 1935. Arizona place names. Univ. of Arizona, Tucson. 503 p.

Benson, L., and R. A. Darrow. 1954. The trees and shrubs of the southwestern deserts. Univ. of Arizona Press, Tucson. 437 p.

Holmgren, P. K., and W. Keuken. 1974. Index herbariorum. Part I. The herbaria of the world. Oosthoek, Scheltema & Holkema, Utrecht. 397 p.

Izaddoost, M. 1973. Biochemical systematics of the genus Sophora. North Texas Univ. Ph. D. Dissertation. Denton, Texas. 96 p.

Kearney, T. H., and R. H. Peebles. 1939. Arizona Plants: new species, varieties, and combinations. J. Wash. Acad. 29:474-492.

_____. 1964. Arizona flora. Univ. of California Press, Berkeley. 1085 p.

Nie, N. H., D. H. Bent, and C. H. Hull. 1970. Statistical package for the social sciences. McGraw Hill, Inc. 643 p.

Rudd, V. E. 1972. Leguminoseae, Faboideae, Sophoreae. North Amer. Flora. Ser. II, 7:1-53.

Schefler, W. C. 1969. Statistics for the biological sciences. Addison-Wesley Publishing Co., Menlo Park. 231 p.

Sokal, R. R., and F. J. Rohlf. 1969. Biometry. W. H. Freeman and Co., San Francisco. 757 p.

Vogelback Computing Center. 1974. SPSS 6000 update manual version 5.8. Northwestern Univ., Evanston. (54 unnumbered p.)

Watson, S. S. 1876. Botanical Contributions 3. Descriptions of new species of plants, chiefly Californian with revisions of certain genera. Proc. Amer. Acad. III:121-148.

Wilson, E. D., and R. T. Moore. 1958. Geologic map of Graham and Greenlee counties, Arizona. Arizona Bureau of Mines, Univ. of Arizona, Tucson.

Wilson, E. D., and R. T. Moore. 1959a. Geologic map of Mohave county, Arizona. Arizona Bureau of Mines, Univ. of Arizona, Tucson.

_____. 1959b. Geologic map of Cochise county, Arizona. Arizona Bureau of Mines, Univ. of Arizona, Tucson.

_____, _____, and R. T. O'Haire. 1960. Geologic map of Pima and Santa Cruz counties, Arizona. Arizona Bureau of Mines, Univ. of Arizona, Tucson.

Yakovlev, G. P. 1967. Observations on the classification and geography of genus Sophora L. and related genera. (in Russian). Proc. Leningr. Chem.-Pharm. Inst. 21:42-62.

_____. 1968. The genus Calia Teran & Berl. (Sophoreae) in America. (in Russian). Proc. Leningr. Chem.-Pharm. Inst. 26:104-112.