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MORPHOLOGIC VARIATION IN KANGAROO RATS (GENUS DIPODOMYS) OF THE HEERMANNI GROUP IN BAJA CALIFORNIA, MEXICO

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

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BY

TROY L. BEST

Norman, Oklahoma

1976

MORPHOLOGIC VARIATION IN KANGAROO RATS (GENUS *DIPODOMYS*) OF THE *HEERMANNI* GROUP IN BAJA CALIFORNIA, MEXICO

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DISSERTATION COMMITTEE

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FOREWORD

This dissertation is presented as three separate papers: 1) Skeletal Variation in Kangaroo Rats (Genus *Dipodomys*) of the *heermanni* Group in Baja California, Mexico; 2) Bacular Variation in Kangaroo Rats (Genus *Dipodomys*) of the *heermanni* Group in Baja California, Mexico; and 3) Relationships Between Ecologic and Morphologic Variation in Kangaroo Rats (Genus *Dipodomys*) of the *heermanni* Group in Baja California, Mexico. They have been prepared in a style appropriate for *The Journal of Mammalogy*, *The American Midland Naturalist*, and *Ecology*, respectively, to which they will be submitted for publication. Appendices have been added to the dissertation to provide supporting data for the benefit of future investigators. The citations of Best (1976*a*) refer to this dissertation.

MORPHOLOGIC VARIATION IN KANGAROO RATS (GENUS *DIPODOMYS*) OF THE *HEERMANNI* GROUP IN BAJA CALIFORNIA, MEXICO

by: Troy L. Best

Major Professor: Gary D. Schnell

Variation in kangaroo rat (*Dipodomys*) skin and skeletal measurements was evaluated using 265 specimens collected from 11 localities in Baja California, Mexico. Cluster analyses readily separated *D. gravipes* from *D. agilis* in areas of sympatry. There was interlocality variation in 41 of the 42 characters analyzed. Males were larger than females in the 14 characters that exhibited sexual dimorphism. Using correlation analyses the 19 least correlated characters were selected from the original 42.

Taxonomic conclusions drawn from these data and from previous studies indicate there are two species of kangaroo rats of the *heermanni* group in Baja California. Suggested changes in taxonomic nomenclature are presented.

Bacular variation was evaluated utilizing 124 specimens. Interlocality variation occurred in the three characters analyzed. OTUs comprised of populations of *D. gravipes* were readily separable from the other taxa. Comparisons of similarity matrices based upon bacular characters with those for various sets of skin and skeletal characters yielded high correlations with the set of post-cranial skeletal characters. Bacular length had a significant linear correlation with body length.

Interlocality variation in temperature, precipitation, vegetation, and burrow systems were analyzed for 11 localities where kangaroo rats (*Dipodomys agilis*) were collected in Baja California. These data were examined to determine their correlations with morphologic variation in the 11 kangaroo rat populations. Principal component I of the *Dipodomys* morphologic data was significantly correlated with latitude and longitude for both sexes---larger specimens were from the southern populations. Component II of burrow variation was correlated with component I for males only. In addition, the female component II was correlated with July mean temperature and January mean precipitation. This second component was significantly correlated with increased hind foot length in the warmer southern localities, and was taken as an indication that Allen's ecogeographic rule was being followed.

The relationships of different groups of morphologic characters and the environmental variables were shown by cluster analyses. Morphologic and environmental data matrices generally clustered separately. Within the morphologic clusters, matrices were generally separated into groups of distance and correlation matrices.

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PAPER I

SKELETAL VARIATION IN KANGAROO RATS (GENUS DIPODOMYS) OF THE HEERMANNI GROUP IN BAJA CALIFORNIA, MEXICO

TROY L. BEST

ABSTRACT.---Variation in kangaroo rat (Dipodomys) skin and skeletal measurements was evaluated using 265 specimens from 11 localities in Baja California, Mexico. Cluster analyses were utilized to verify field identification at the two localities where D. gravipes and D. agilis were sympatric and to examine each of the other nine collecting sites for possible sympatric forms. Sexual dimorphism occurred in two external, three skull, and nine post-cranial measurements. Males were significantly larger than females in all of these characteristics. Significant interOTU variation occurred in 41 of the 42 characters analyzed. Using correlation analyses the 19 least correlated characters were selected from the original 42. D. gravipes was readily separable from the other taxa. The data indicate that there are two species of kangaroo rats of the heermanni group in Baja California. Suggested changes in nomenclature include: D. peninsularis peninsularis to D. agilis peninsularis; D. peninsularis pedionomus to D. agilis pedionomus; D. peninsularis eremoecus to D. agilis eremoecus; D. peninsularis australis to D. agilis australis; D. paralius to D. agilis plectilis; D. antiquarius to D. agilis pedionomus.

INTRODUCTION

Kangaroo rats (genus *Dipodomys*) of the *heermanni* group occupy most of Baja California from the mountains of the north through the desert areas that cover most of the peninsula (Huey, 1951). The widely varying habitats and narrowness of the peninsula, plus the presence of kangaroo rats throughout the region, present a unique opportunity---in terms of North America---for the study of morphologic variation in natural populations.

Kangaroo rats in Baja California have been studied by Villa R. (1941), Alvarez (1960), Huey (e.g., 1925, 1927, 1951, 1962, 1964), Stock (1974), and Best and Schnell (1974). Lidicker (1960) discussed *D. merriami* and *D. insularis*, and Lackey (1967) examined most of the other taxa, though he was primarily interested in *D. stephensi* and *D. cascus* in southern California. I analyzed bacular variation of *D. agilis* and *D. gravipes* (Best, 1976*b*) and relationships between morphologic and ecologic variation of the populations of *D. agilis* discussed herein (Best, 1976*c*).

Univariate and multivariate statistical techniques can be employed to describe relatively complex variation patterns in an objective manner (e.g., Johnston, 1969; Power, 1969*a*; Findley and Traut, 1970; Johnston and Selander, 1971; Niles, 1973; Genoways, 1973; Kennedy, 1976; Best, 1976*b*, 1976*c*). Using these techniques I have identified some patterns of variation in morphologic variables associated with kangaroo rats in Baja California. My purposes were to investigate the: (1) degree of sexual dimorphism; (2) amount and pattern of interlocality variation within each character; (3) phenetic relationships between the populations; and (4) taxonomic relationships of the populations.

MATERIALS AND METHODS

Kangaroo rats were collected at 11 localities in Baja California during June and July, 1972 (Fig. 1). Specimens were divided into 13 Operational Taxonomic Units (OTUs), since at two of the collecting sites, two taxa of kangaroo rats of the *heermanni* group occur sympatrically---*D. gravipes* and *D. agilis* (Fig. 1, OTUs 2,3 and 5,6). Prior to this report the taxonomic designations (Hall and Kelson, 1959, unless otherwise indicated) of the OTUs were as follows: (OTU 1) *D. agilis martirensis*; (2) *D. agilis simulans*; (3) *D. gravipes*; (4) *D. agilis simulans*; (5) *D. agilis plectilis*; (6) *D. gravipes*; (7) *D. peninsularis pedionomus*; (8) *D. paralius*; (9) *D. antiquarius* (Huey, 1962); (10) *D. peninsularis eremoecus*; (11) and (12) *D. peninsularis peninsularis*; and (13) *D. peninsularis australis*. Specimens were taken as near to type localities as possible. For the present analyses I have treated these as populations since their systematics were not fully understood (Lackey, 1967; Stock, 1974; Best, 1976*b*).

The 265 adult specimens of this study were distinguished from immature individuals according to the aging criteria of Best and Schnell (1974). I made the following external measurements, accurate to the nearest millimeter, on freshly collected specimens before they were prepared as standard museum study skins and skeletons: total length, tail length, hind foot length, and ear length from notch; body length was calculated by subtracting tail length from total length. The 37 skeletal measurements (Fig. 2) were taken to the nearest 0.1 mm with the same dial calipers. The specimens have been deposited in the collection of recent mammals at the Stovall Museum of Science and History, University of Oklahoma. Specimen numbers in the text and figures refer to my original field numbers.

Several statistical techniques were used in data analysis. The mean and standard deviation were calculated for each character for each OTU, and are presented in Appendix I of Best (1976*a*). I tested interOTU heterogeneity of each character with a one-way analysis of variance, and used a sums of squares simultaneous test procedure (SS-STP; Gabriel, 1964; Gabriel and Sokal, 1969) to determine the maximally non-significant subsets of OTUs.

For multivariate procedures, the mean measurements for each OTU were used. These characters were standardized (so that each had a mean of 0 and standard deviation of 1 across OTUs) and correlation and distance matrices (Sneath and Sokal, 1973) were calculated. Clusters of OTUs and characters were obtained with the unweighted pair-group method using arithmetic averages (UPGMA). Principal components were calculated from a matrix of correlation among characters, and projections of the OTUs were plotted on the first three components. On the resulting three-dimensional plots I superimposed a shortest minimally connected network computed from the original matrix of distances between OTUs.

To elucidate correlations between characters, dendrograms were constructed from correlation matrices of the 42 standardized characters for all males and for all females. Using these dendrograms I was able to identify groups of characters with intercorrelations of 0.9 or greater. To reduce redundancy in my character set I selected one character from each of these groups on the basis of it being: 1) in the same group for both males and females; and/or 2) the lowest character number of the characters in a particular grouping.

Cluster analyses were performed to verify my visual separation of *D. gravipes* and *D. agilis* at localities 2,3 and 5,6 (Fig. 1). Distance matrices were calculated from the 42 standardized skin and skeletal measurements for each individual from each of the two localities. Clusters of individuals from the original distance matrices were obtained with the UPGMA. Similar examinations of the remaining nine localities were conducted in search of other sympatric forms.

Analyses were performed using the IBM 360 computer at the University of Oklahoma Computation Center. The programs UNIVAR (Power, 1969*b*) and NT-SYS (Rohlf, et al., 1972) provided most of the analytic foundation of this study.

RESULTS

Using individual specimens as OTUs, cluster analyses were performed for each of the 11 localities. Results of two such analyses are shown in Figure 3. Two distinct clusters appear in both dendrograms. The upper cluster in each includes all specimens identified in the field as *D. agilis*; the lower corresponds to specimens of *D. gravipes*. In subsequent analyses these clusters are treated as separate OTUs. Similar analyses for the other nine localities did not reveal a similar degree of heterogeneity, indicating that only one taxon was represented by the specimens collected at each site.

Of the 42 morphological characters, 14 exhibit significant secondary sexual dimorphism in size (Table 2), with males being significantly larger than females. These include two external, three skull, and nine post-cranial measurements. The dimorphism is primarily in lengths of the major structures of the body. Only two widths of structures---characters 17 (skull width) and 41 (width of fused vertebrae)---show sexual dimorphism in size.

Significant interOTU character variation is evident for 41 of the 42 characters in both sexes (Table 3). The only character not showing variation is character 42 (number of fused vertebrae). For a number of characters (e.g., 3, 7, 31, and 34) the extent of interOTU variation was different for males and females as indicated by the *F*-ratios for each sex (Table 3).

The 42 characters showed considerable redundancy in both sexes. Using the criteria outlined above, I selected 16 female and 15 male characters. Only characters 7 (greatest length of skull), 23 (ulna length), 28 (scapula width) and 36 (femur proximal width) for females, and 15 (basioccipital length), 17 (greatest width of skull) and 38 (pelvis depth) for males, were not in common for both sexes. These characters for females were added to the male's selected set of characters and vice versa; thus, a total of 19 characters were chosen for further analyses, and these are shown in Figures 4A and 4B. The major branches place characters 5 (ear length) and 42 (number of fused vertebrae) separate from the other characters for both males and females. Characters 3 (tail length) and 9 (interorbital width) of males, and characters 7 (greatest length of skull) and 21 (alveolar length) of females, branch between characters 5 and 42 and the remainder of the characters. The characters that are relatively highly correlated are: 23 (ulna length), 28 (scapula width) and 30 (scapula depth); 7 (greatest length of skull) and 10 (nasal length); 36 (femur proximal width) and 38 (pelvis depth) for males; and 11 (intermaxillary width) and 15 (basioccipital length); 18 (zygomatic width) and 17 (greatest width of skull); 23 (ulna length), 38 (pelvis depth) and 28 (scapula width); 36 (femur proximal width) and 40 (pelvic foramen width) for females.

The pattern of interOTU character variation is shown in Table 4, where the results of the SS-STP analysis for each of the 19 characters are presented. OTU 6 is the largest in all characters except: 3 (tail length) in males where it is second to OTU 13; 5 (ear length) in both sexes where it has, except for OTU 3, the shortest ears of all the OTUs; 12 (alveolar length) in males with OTU 3 being the only one greater; and 42 (number of fused vertebrae) where it is forth and second largest for males and females, respectively. In addition to OTU 6, OTUs 3, 11, and 13 are frequently among the largest OTUs. OTUs 1, 4, and 8 were generally smaller for most of the 19 characters.

The results of multivariate analyses further describe interOTU variation. Figure 5 shows phenograms for both sexes constructed from correlation and distance matrices of the 19 selected characters. Each of the correlation phenograms (Figs. 5A and 5C) can be divided into two primary clusters. In males the lower cluster contains OTUs 2, 3, and 6 and the remaining OTUs comprise the second cluster. For females OTUs 3 and 6 make up one cluster and the remaining OTUs make up the other group (there were no female specimens for OTUs 2 or 10).

The distance phenograms also show only two major clusters (Figs. 5B and 5D). For both males and females OTUs 3 and 6 comprise one cluster and the other OTUs are in a second cluster. Within the larger cluster in the female phenogram (Fig. 5D), OTUs do not appear to be grouped according to any taxonomic or geographic pattern. The large cluster of male OTUs exhibits subgroupings based upon geographical considerations, i.e., OTUs 1, 2, 4, 5, 7, and 8 represent the northern forms, OTU 10 is the only east coastal form, and OTUs 9, 11, 12, and 13 are the southern OTUs. The most highly correlated OTUs in the distance phenograms are OTUs 1 and 5 for females. All other OTUs in both phenograms (Figs. 5B and 5D) are joined at a phenetic distance of 0.5 or greater.

The loadings of characters on the first three component axes are presented in Table 5 and three-dimensional projections are depicted in Figure 6. The character correlations with principal component I for both males and females are high for all characters except 5 (ear length) and 42 (number of fused vertebrae). Following the reasoning of Johnston and Selander (1971), Niles (1973), and Kennedy (1976) this component may be taken to represent overall size in both sexes, since it accounts for most of the covariation among characters.

On principal component II, character 5 (ear length) has the highest loading for both sexes (Table 5). Other characters have only weak associations with this component.

The third principal component for males has highest loadings for characters 3 (tail length) and 42 (number of fused vertebrae). The females have high negative loadings for character 42 (number of fused vertebrae) and much lower loadings for all other characters. As noted previously, character 42 is the only one examined that did not exhibit interOTU variation.

The three components explain almost 90% of the total character variation for each sex (see bottom of Table 3). Thus distortion of the phenetic distances between OTUs is very small when the character space is reduced to three dimensions.

Principal component I, which accounts for about two-thirds of the phenetic variation, separates populations by size in Figure 6. For males OTUs 3, 6, 11, and 13 are the largest and 1, 8, and 4 are the smallest. The same is true for females, except OTUs 11 and 13 are more closely allied with the smaller OTUs. Except for OTUs 3 and 6, the female OTUs form a chain grading in size from OTU 8, the smallest, to OTU 13, the largest of this group. For both sexes OTU 6 has a much higher loading for component I than any of the other OTUs.

The second principal component separates the shorter-eared OTU 3, which is located toward the back of the models, and places the longer-eared OTUs 9, 10, 11, 12, and 13 near the front. Thus, longer ear lengths are found in the more southern forms, as indicated in Table 4.

Principal component III is represented by the lengths of the vertical lines in the 3-D models (Fig. 6). The two male OTUs (1 and 9) near the base of the diagram have the smallest number of fused vertebrae and also have (except OTU 5) the shortest tail length (see Table 4). These forms are separated from the other OTUs by component III. For females, there is not as distinct a break in terms of this component. However, OTUs 5 and 7, which are placed near the base, are among the shortest tailed forms.

DISCUSSION

Cluster analyses have not previously been utilized to separate individual specimens of Dipodomys from a single locality into their respective species. The techniques used herein for separating D. gravipes from D. agilis might also be useful in separating other sympatric forms. That similar separation did not occur at the other nine localities may be explained in two ways. First, my results may indicate that the only localities with two taxa present were the 8.5 mi. N San Quintin-2 mi. E Colonia Guerrero and the 6 mi. E El Rosario collecting sites (see Table 1). This is the interpretation I favor. Second, if two or more sympatric forms occurred at any of the other nine localities they were not sufficiently distinct for separation based upon the type of cluster analyses used and the characters examined. Only one of these nine localities has been indicated as having sympatric forms, Huey (1951) listed six specimens of D. peninsularis pedionomus from San Borjas Mission, but later does not include these specimens in those listed for D. antiquarius (Huey, 1962, 1964). He described D. antiquarius (Huey, 1962) as being known only from eight specimens collected at San Juan Mine, Sierra San Borja, alt. 4,000 ft., 28°41'N, 113°37'W. These localities are within 2 km of each other. I attempted to collect specimens along the slopes at the San Juan Mine but failed. Along the canyon floor at the base of San Juan Mine (a few hundred meters away) I was successful in obtaining 13 adult specimens (see Table 1). As mentioned previously the cluster analysis for these specimens did not reveal any distinctive groupings. This could have been because my sample included only one of the species present. However, the sample was taken from the only suitable habitat in the area, i.e., it was not rocky and shallow soiled, and there were several *Dipodomys* burrows observed in the area.

Sexual dimorphism has been described previously in *D. ordii* (Desha, 1967; Schmidly, 1971; Kennedy, 1976; Schmidly and Hendricks, 1976), and in *D. merriami* (Lidicker, 1960). Sexual dimorphism in the Baja California populations I examined is particularly noteworthy because of the degree and numbers of characters involved as compared to *D. ordii* and *D. merriami*. Kennedy (1976) found significant sexual dimorphism in 11 of 16 skull characters in *D. ordii*, and Lidicker (1960) noted at least some sexual dimorphism in 11 of 13 characters in *D. merriami*. Only three of the skull characteristics I studied show significant sexual dimorphism (see Table 2)---greatest length of skull, basioccipital length, and greatest width of skull. None of these appear to be releated to food habit separation of the sexes as has been suggested in birds (Selander, 1960). Size in post-cranial skeletal elements---except for clavicle, scapula and pelvic lengths---is strongly dimorphic.

InterOTU character variation is shown in all except character 42, number of fused vertebrae in the pelvic girdle (see Table 3). It is not suprising that a character of this type (the only non-metric one taken) does not vary significantly among OTUs or between the sexes (see Table 2). The support given by the fusion of these vertebrae in the pelvic girdle probably is closely associated with the saltatorial mode of locomotion of kangaroo rats.

Phenograms resulting from cluster analyses of correlation and distance matrices for both sexes (Fig. 5) indicate that there are two primary clusters of OTUs. Except for the male correlation phenograms where OTU 2 joins them, OTUs 3 and 6 consistantly group away from the remaining OTUs (Fig. 5A). A portion of Huey's (1925) original description characterizes D. gravipes (OTUs 3 and 6) as, "A large-sized, heavy-bodied, small-eared animal, with thick tail of medium length, belonging to the heermanni group. Tip of tail dark and five toes on hind foot, which is extremely large-boned." This characterization is adequate to separate specimens of D. gravipes from the remaining OTUs.

Further subdivisions of the non-D. gravipes cluster in each of the female phenograms (Figs. 5C and 5D) and the male correlation phenogram (Fig. 5A) does not seem warrented, particularly on taxonomic or geographic bases. The male distance phenogram can be divided into three subclusters at a phenetic distance of about 1.05. The upper subcluster represents the northern forms (OTUs 1, 2, 4, 5, 7, and 8), the center single-member subcluster (OTU 10) the east coastal form, and in the lower subcluster (OTUs 9, 11, 12, and 13) are the remaining southern forms. Correlations between environmental variables and morphologic variation of the non-D. gravipes OTUs are presented elsewhere (Best, 1976c).

Two obvious taxonomic conclusions can be drawn from the data presented previously and herein. First, D. gravipes is separable from D. agilis on the basis of karyotypes (Stock, 1974), bacular measurements (Best and Schnell, 1974; Best, 1976b), and the set of morphologic characters analyzed herein. Second, D. agilis, D. peninsularis, D. paralius, and D. antiquarius are not distinct on the basis of these analyses. These findings support a contention that there are only two species of kangaroo rats of the heermanni group in Baja California, Mexico---D. gravipes and D. agilis.

Huey (1951) separated D. peninsularis from D. agilis on the basis of the former's "...extremely inflated bullae, brightly colored and heavily boned tail and average dorsal color tones..." Stock (1974) in his "own examination of many specimens of this series" of Baja California populations believed that they all may be subspecies of *D. agilis* (including *D. paralius* and *D. antiquarius*). Stock (1974) based his conclusions primarily upon Lackey's (1967) cranial measurements and his own findings of identical karyotypes for *D. peninsularis pedionomus* and *D. agilis plectilis*. The evidence presented by Lackey (1967) and Stock (1974) as well as bacular (Best and Schnell, 1974; Best, 1976*b*) analyses seems to greatly outweigh Huey's (1951) justification for separating *D. peninsularis* from *D. agilis*. Therefore, I propose the following changes in the taxonomic designations of the "*D. peninsularis*" OTUs studied herein (subspecies designations are based solely upon range maps in Hall and Kelson, 1959): *D. peninsularis peninsularis* (Merriam, 1907) to *D. agilis peninsularis* (Merriam, 1907); *D. peninsularis pedionomus* Huey, 1951 to *D. agilis pedionomus* Huey, 1951; *D. peninsularis eremoecus* Huey, 1951 to *D. agilis eremoecus* Huey, 1951; *D. peninsularis australis* Huey, 1951 to *D. agilis australis* Huey, 1951.

Huey (1951) described *D. paralius* on the basis of 28 specimens from three localities near Santa Catarina. He characterized the species as follows: "...similar in color to *Dipodomys peninsularis pedionomus*, but it is smaller and has smaller ears. Cranially, it is widely divergent, with smaller, proportionally flatter, more inflated bullae and with slightly more angular and more widely spreading maxillary arches. This latter character is prominent and places this species very near to the broad-faced group of kangaroo rats. Compared with *Dipodomys agilis plectilis*, *D. paralius* is lighter in dorsal coloration and smaller in size, and further differs in the cranial characters mentioned above. The general outline of the skull is more nearly that of an equilateral triangle than that of an acute triangle, such as characterizes *D. a. simulans*, *D. a. plectilis* and other members of the *agilis* group. However, *paralius* is nearer to the *D. a. simulans-plectilis* chain than it is to the *D. peninsularis* group and it is best left under the *agilis* series." Stock (1974) did not examine this species karyotypically, but could not distinguish between specimens of *D. paralius* and *D. agilis* by visual inspection (nor can I). My analyses group *D. paralius* (OTU 8) consistantly with the OTUs representing *D. agilis*, and particularly close to OTUs 4 (*D. agilis simulans*) and 5 (*D. agilis plectilis*). Bacular measurements (Best, 1976*b*) also indicate a close phenetic affinity with nearby populations. I suggest that *D. paralius* Huey, 1951 be included as a population of *D. agilis plectilis* Huey, 1951.

Based upon eight specimens *D. antiquarius* was described as "very closely related" to *D. stephensi* (Huey, 1962). Lackey (1967) examined specimens of *D. antiquarius* and postulated that the species is more reasonably placed in the narrow-faced group than the broad-faced group. He considered *D. antiquarius* closer to *D. peninsularis* than *D. stephensi* and pointed out that his samples of *D. antiquarius* and four subspecies of *D. peninsularis* showed no important differences in the 10 characters he studied (see Table 3 of Lackey, 1967). He also noted that *D. antiquarius* differed more from *D. agilis* in inflation of auditory bullae than from *D. peninsularis*. Stock (1974) theorized that *D. antiquarius* was a subspecies of *D. agilis*. I have examined the 22 specimens of *D. antiquarius* and am not able to distinguish them from *D. agilis pedionomus* or *D. a. peninsularis* from nearby localities. In addition, none of the analyses presented herein significantly differentiates *D. antiquarius* (OTU 9) from the other non-*D. gravipes* OTUs. I suggest that *D. antiquarius* is a population of *D. agilis pedionomus*, following Huey's (1951) listing of six specimens from San Borjas Mission.

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FIGURES

FIG. 1.---Map showing the 11 localities where specimens were taken for this study. Note that specimens from two of the locations were divided into two OTUs each. The numeral identification corresponds to the OTU numbers listed in Table 1. With the exceptions of OTUs 12 and 13, which are in the Territorio de Baja California del Sur, all localities were in the state of Baja California.

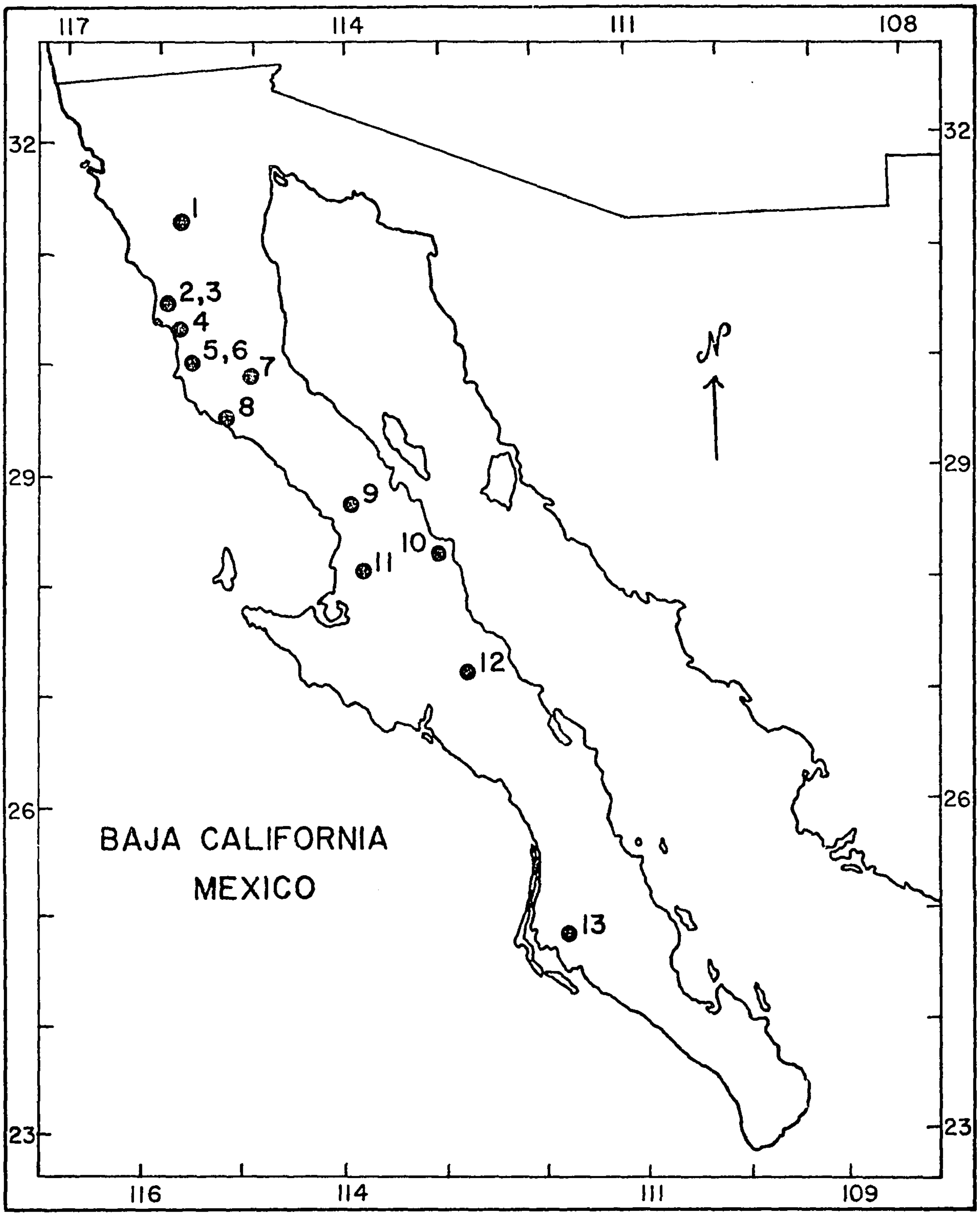

117
114
111
108
32
29
26
23
116
114
111
109
1
2,3
4
5,6
7
8
9
10
11
12
13
N
BAJA CALIFORNIA
MEXICO

FIG. 2.---Skeletal elements of Dipodomys gravipes (TLB 6072♀) illustrating the 37 skeletal measurements taken. A, skull, dorsal view; B, skull, ventral view; C, skull, lateral view; D, mandible, lateral view; E, radius, lateral view; F, ulna, lateral view; G, humerus, anterior view; H, clavicle, anterior view; I, scapula, dorsal and lateral views; J, tibia, posterior view; K, femur, posterior view; L, pelvic, lateral view; M, pelvic girdle, dorsal view. Numbers correspond to the characters listed in Table 2.

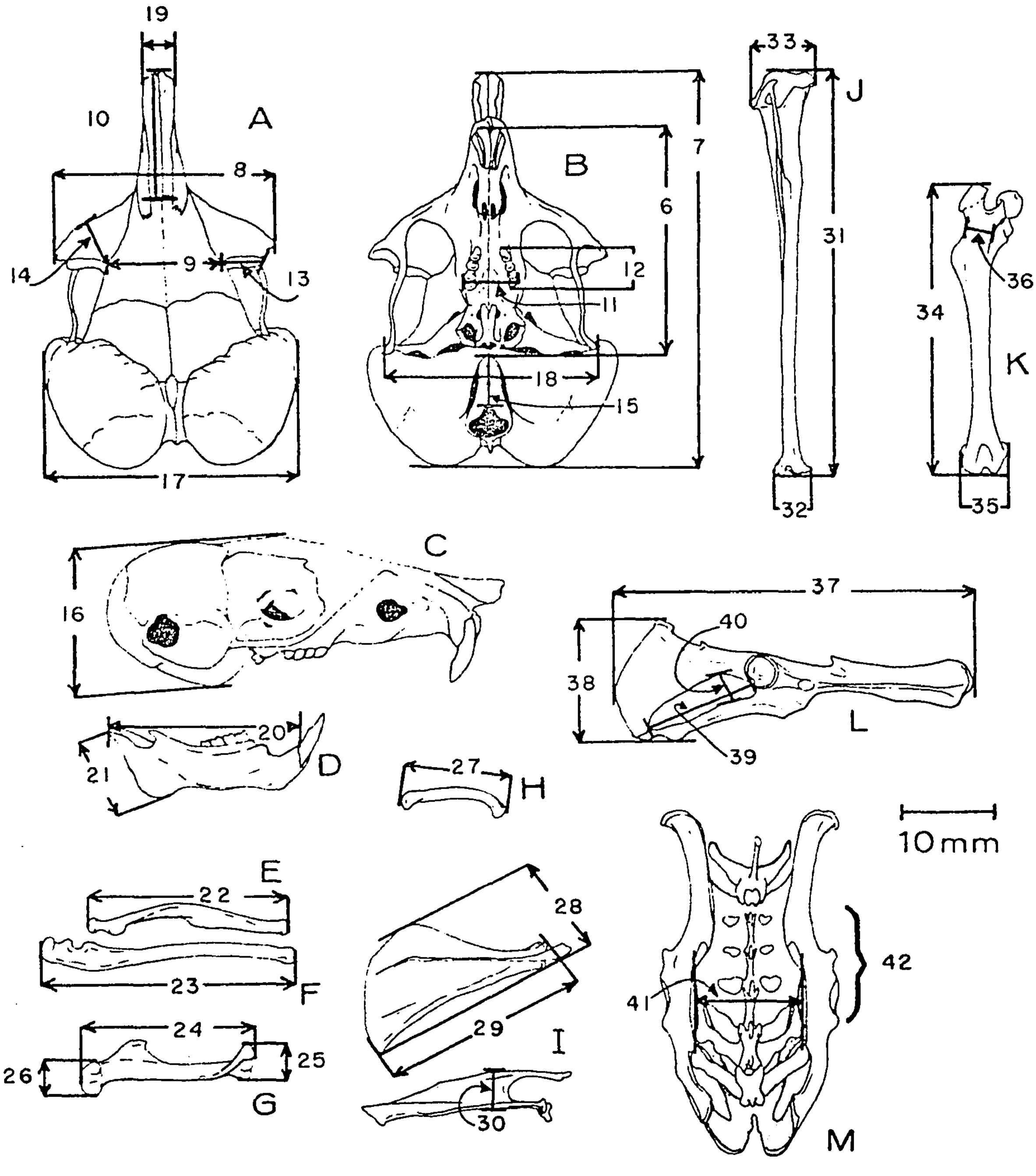

19
10
A
8
14
9
13
17
B
7
6
12
11
18
15
33
J
31
32
34
36
K
35
C
16
37
40
38
L
39
20
21
D
27
H
10mm
E
22
23
F
24
26
25
G
28
29
I
30
41
42
M

FIG. 3.---Dendrograms constructed from distance matrices calculated from 42 skin and skeletal characters of Baja California kangaroo rats (Dipodomys). A. 17 specimens from 2 mi. E Colonia Guerrero (1 specimen) and 8.5 mi. N San Quintin (16). B. 41 specimens from 6 mi. E El Rosario. Specimen numbers in the figures refer to my original field numbers. The cophenetic correlation coefficients (r) are given.

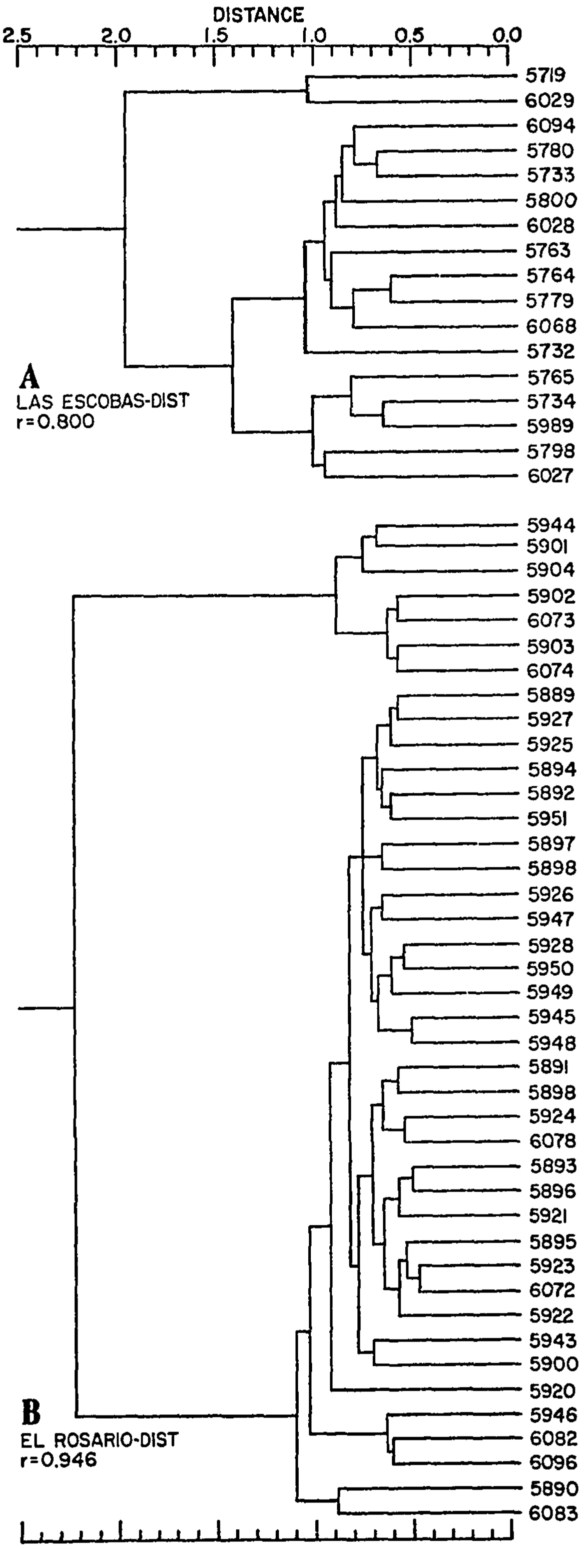

DISTANCE
2.5
2.0
1.5
1.0
0.5
0.0
5719
6029
6094
5780
5733
5800
6028
5763
5764
5779
6068
5732
5765
5734
5989
5798
6027
A
LAS ESCOBAS-DIST
r=0.800
5944
5901
5904
5902
6073
5903
6074
5889
5927
5925
5894
5892
5951
5897
5898
5926
5947
5928
5950
5949
5945
5948
5891
5898
5924
6078
5893
5896
5921
5895
5923
6072
5922
5943
5900
5920
5946
6082
6096
5890
6083
B
EL ROSARIO-DIST
r=0.946

FIG. 4.---Phenograms constructed from the matrices of correlation of the 19 selected male (A) and female (B) skin and skeletal characters measured for Baja California Dipodomys. The high cophenetic correlation coefficients (r) indicate very little distortion in the dendrograms. Identification numbers refer to the list of characters presented in Table 2.

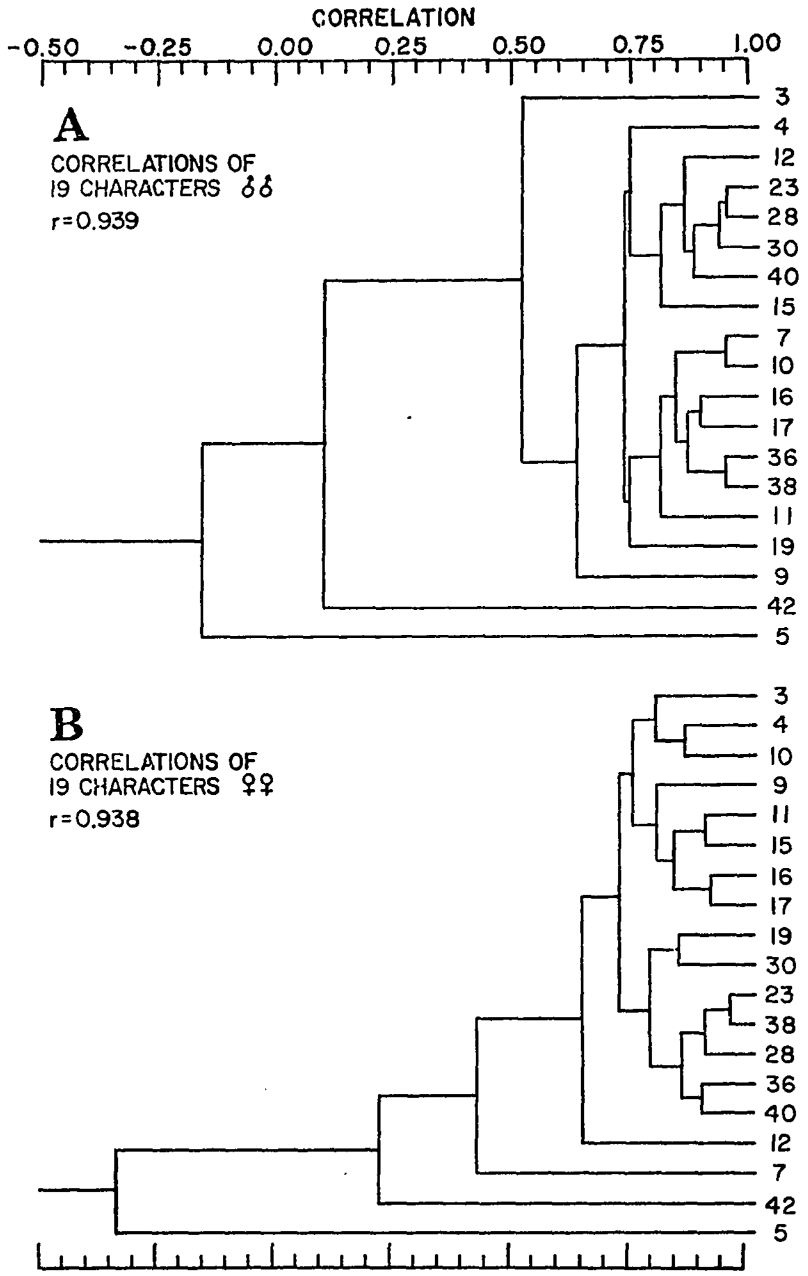

CORRELATION
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
A
CORRELATIONS OF
19 CHARACTERS ♂♂
r=0.939
3
4
12
23
28
30
40
15
7
10
16
17
36
38
11
19
9
42
5
B
CORRELATIONS OF
19 CHARACTERS ♀♀
r=0.938
3
4
10
9
11
15
16
17
19
30
23
38
28
36
40
12
7
42
5

FIG. 5.---Phenograms constructed from correlation and distance matrices for male (A and C, respectively) and female (B and D, respectively) kangaroo rats from Baja California. Clusters were obtained using the UPGMA. Accuracy of the diagrams in depicting interpopulation relationships increases from left to right. Numeral identifications are the same as listed in Table 1.

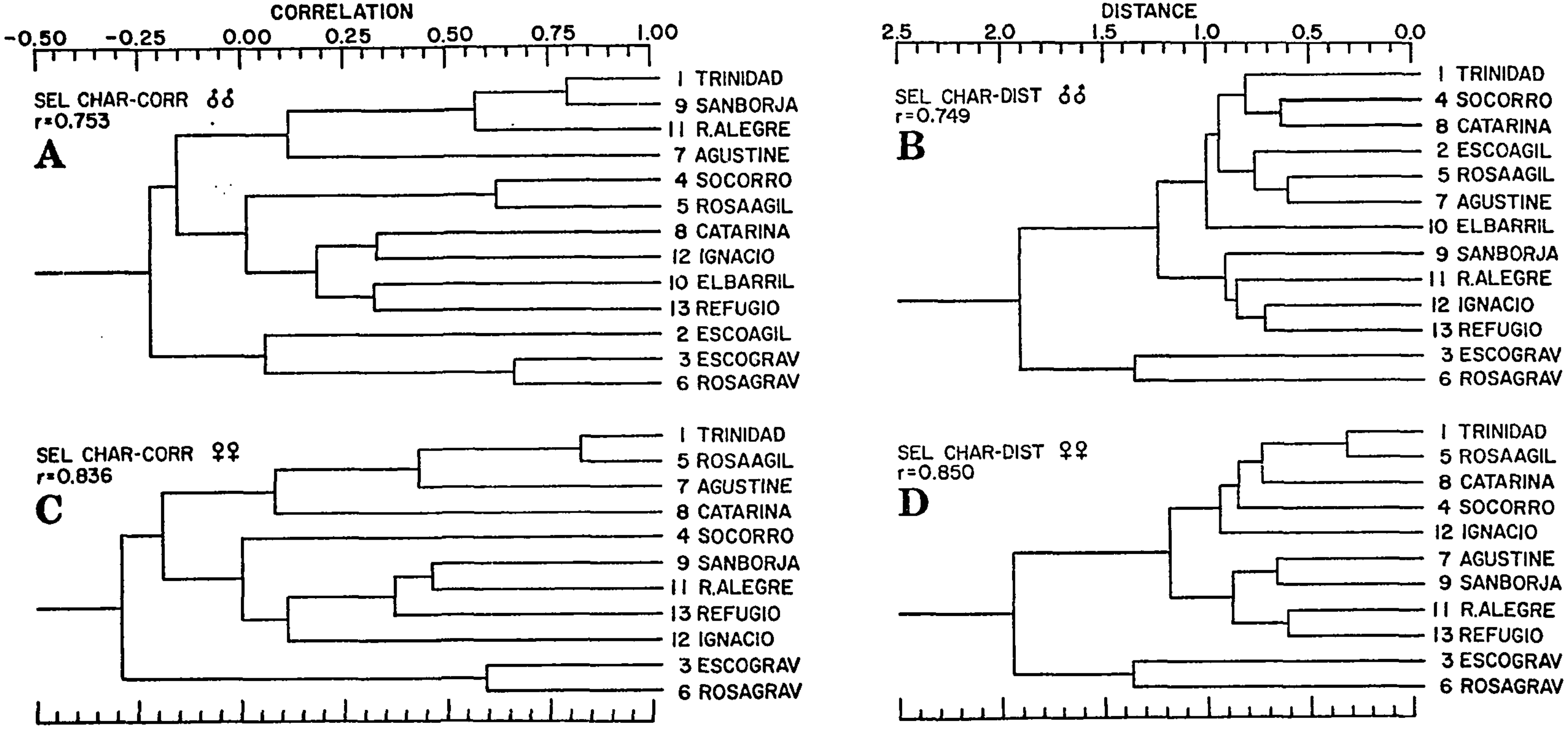
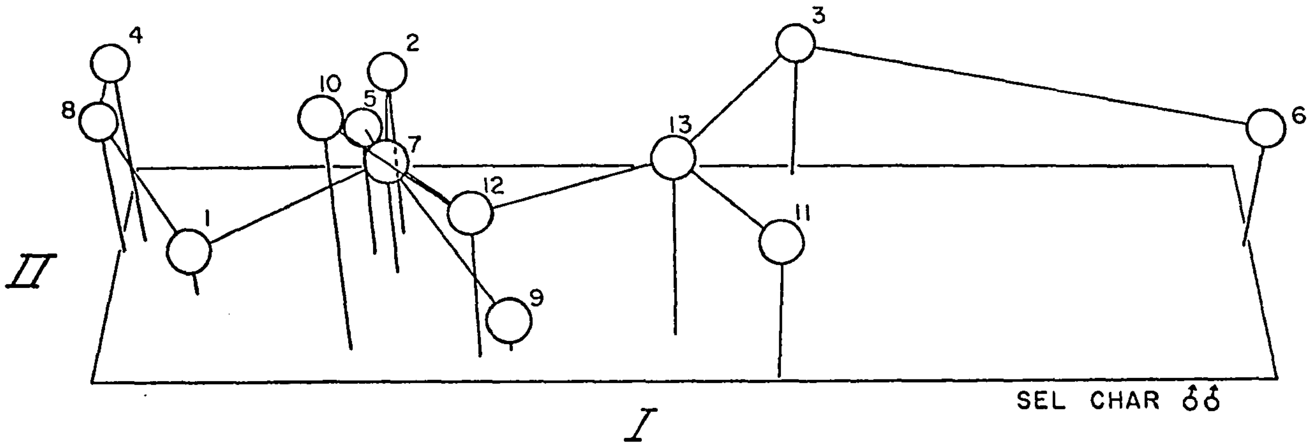
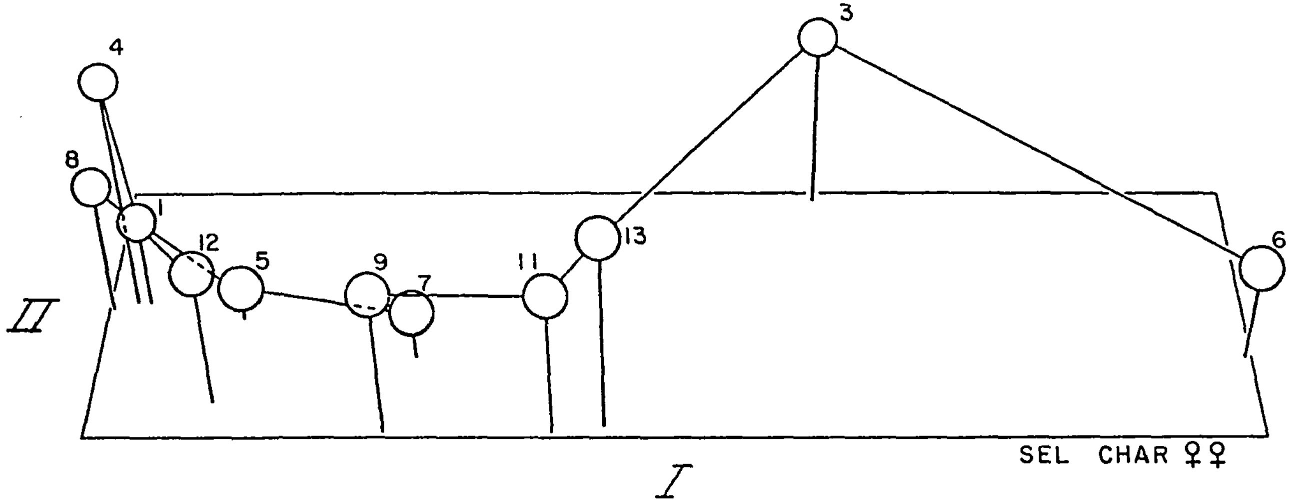

CORRELATION
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
SEL CHAR-CORR ♂♂
r=0.753
A
1 TRINIDAD
9 SANBORJA
11 R.ALEGRE
7 AGUSTINE
4 SOCORRO
5 ROSAAGIL
8 CATARINA
12 IGNACIO
10 ELBARRIL
13 REFUGIO
2 ESCOAGIL
3 ESCOGRAV
6 ROSAGRAV
DISTANCE
2.5
2.0
1.5
1.0
0.5
0.0
SEL CHAR-DIST ♂♂
r=0.749
B
1 TRINIDAD
4 SOCORRO
8 CATARINA
2 ESCOAGIL
5 ROSAAGIL
7 AGUSTINE
10 ELBARRIL
9 SANBORJA
11 R.ALEGRE
12 IGNACIO
13 REFUGIO
3 ESCOGRAV
6 ROSAGRAV
SEL CHAR-CORR ♀♀
r=0.836
C
1 TRINIDAD
5 ROSAAGIL
7 AGUSTINE
8 CATARINA
4 SOCORRO
9 SANBORJA
11 R.ALEGRE
13 REFUGIO
12 IGNACIO
3 ESCOGRAV
6 ROSAGRAV
SEL CHAR-DIST ♀♀
r=0.850
D
1 TRINIDAD
5 ROSAAGIL
8 CATARINA
4 SOCORRO
12 IGNACIO
7 AGUSTINE
9 SANBORJA
11 R.ALEGRE
13 REFUGIO
3 ESCOGRAV
6 ROSAGRAV

FIG. 6.---Three-dimensional projection of OTUs onto the first three principal component axes of variation in the matrix of correlations of 19 skin and skeletal characters of male (A) and female (B) *Dipodomys* from Baja California. The shortest simply-connected network, derived from the matrix of distance coefficients for the same characters, is superimposed on the principal component space to indicate where possible distortion may be present. The numbers correspond to the OTUs listed in Table 1.

A


4
8
10
5
2
7
1
12
9
13
3
11
6
II
I
SEL CHAR ♂♂

B


4
8
1
12
5
9
7
11
13
3
6
II
I
SEL CHAR ♀♀

TABLES

TABLE 1.—*Skeletal samples of kangaroo rats from Baja California used in this study.*

OTU No.	Code Name	Collecting Localities	Number of Specimens	
			Male	Female
1	TRINIDAD	Valle de Trinidad	9	13
		4 mi. S Valle de Trinidad	10	15
		W end Valle de Trinidad	1	---
2	ESCOAGIL	2 mi. E Colonia Guerrero	1	---
		8.5 mi. N San Quintin	1	---
3	ESCOGRAV	8.5 mi. N San Quintin	8	7
4	SOCORRO	12 mi. N El Rosario	2	2
5	ROSAAGIL	6 mi. E El Rosario	3	4
6	ROSAGRAV	6 mi. E El Rosario	17	17
7	AGUSTINE	San Agustine	19	13
8	CATARINA	Santa Catarina Landing	7	3
9	SANBORJA	Mission de San Borjas	8	5
10	ELBARRIL	7 mi. W San Francisquito Bay	2	---
11	R.ALEGRE	2.5 mi. W Mesquital	18	17
12	IGNACIO	10 mi. E San Ignacio	11	9
13	REFUGIO	4.5 mi. N El Refugio	24	19
		Total	141	124

TABLE 2. Secondary sexual dimorphism in size in 42 skin and skeletal characters of Baja California kangaroo rats (*Dipodomys*).

Character	Char. No.	Character-state Means[3]		Analysis of Variance[1]	
		♂♂ (G=13,N=141)	♀♀ (G=11,N=124)	D.F.	F-ratio[2]
Skin					
Total length	1	294.13	288.84	1,209	6.532*
Body length	2	120.13	124.99	1,263	0.514
Tail length	3	173.40	171.18	1,209	2.343
Hind Foot length	4	43.38	42.41	1,263	8.406**
Ear length	5	17.30	17.08	1,263	1.145
Skull and Mandible					
Basal length	6	22.03	21.89	1,254	2.274
Greatest length	7	39.95	39.34	1,231	5.817*
Maxillary Arch Spread	8	21.67	21.51	1,252	0.902
Interorbital width	9	10.62	10.62	1,257	0.017
Nasal length	10	14.26	14.14	1,257	2.274
Intermaxillary width	11	7.60	7.59	1,259	0.089
Alveolar length	12	5.06	5.05	1,260	0.112
Lacrimal length	13	3.84	3.83	1,263	0.011
Maxillary Arch Spread	14	5.20	5.24	1,263	0.303
Basioccipital length	15	5.67	5.56	1,243	6.025*
Greatest depth	16	13.47	13.41	1,241	1.233
Greatest width	17	25.31	25.06	1,243	4.236*
Zygomatic width	18	19.44	19.29	1,256	1.279
Nasal width	19	3.72	3.66	1,258	3.799
Mandible length	20	16.58	16.49	1,263	0.684
Mandible depth	21	7.50	7.41	1,263	1.581
Post-cranial Skeleton					
Radius length	22	18.21	17.86	1,262	8.531**
Ulna length	23	22.03	21.63	1,263	7.172**
Humerus length	24	14.66	14.40	1,262	5.790*
Humerus distal width	25	4.53	4.48	1,262	1.533
Humerus proximal width	26	3.74	3.72	1,262	0.483
Clavicle length	27	9.12	8.95	1,262	3.665
Scapula width	28	8.22	8.07	1,220	2.764
Scapula length	29	16.90	16.71	1,232	1.414
Scapula depth	30	2.73	2.74	1,253	0.090
Tibia length	31	38.97	38.09	1,257	7.816**
Tibia distal width	32	4.26	4.19	1,262	3.173
Tibia proximal width	33	5.37	5.32	1,263	0.776
Femur length	34	28.83	28.33	1,262	3.992*
Femur distal width	35	5.08	4.99	1,263	3.190

Table 2 Continued

Femur proximal width	36	3.17	3.12	1,261	1.636
Pelvis length	37	31.97	31.38	1,263	3.335
Pelvis depth	38	11.86	10.93	1,263	48.106**
Pelvic Foramen length	39	9.61	9.85	1,263	4.958*
Pelvic Foramen width	40	3.82	3.66	1,263	7.702**
Width Fused Vertebrae	41	9.76	9.45	1,257	6.845**
Number Fused Vertebrae	42	4.84	4.77	1,260	1.628

[1] Single-classification analysis of variance, sexes compared pairwise for each character.

[2] Minimally significant sexual dimorphism assumed where $P \leq 0.05$ (one asterisk); two asterisks indicates $P \leq 0.01$.

[3] Dimensions in mm; *G* = number of localities; *N* = number of specimens.

TABLE 3. *InterOTU variation in 42 skin and skeletal characters in Baja California kangaroo rats* (Dipodomys).[1]

Character	No.	Sex	Degrees of Freedom	*F*-ratio[2]
Skin				
Total length	1	♂♂	10,108	13.061
		♀♀	9, 80	12.817
Body length	2	♂♂	12,128	14.286
		♀♀	10,113	12.810
Tail length	3	♂♂	10,108	4.983
		♀♀	9, 80	7.163
Hind Foot length	4	♂♂	12,128	12.342
		♀♀	10,113	8.299
Ear length	5	♂♂	12,128	10.920
		♀♀	10,113	7.479
Skull and Mandible				
Basal length	6	♂♂	12,124	17.782
		♀♀	10,108	15.676
Greatest length	7	♂♂	12,112	21.243
		♀♀	10, 97	4.096
Maxillary Arch Spread	8	♂♂	12,124	29.035
		♀♀	10,106	22.052
Interorbital width	9	♂♂	12,127	4.156
		♀♀	10,108	3.240
Nasal length	10	♂♂	12,127	9.163
		♀♀	10,108	5.476
Intermaxillary width	11	♂♂	12,127	19.107
		♀♀	10,110	12.800
Alveolar length	12	♂♂	12,128	8.927
		♀♀	10,100	6.184
Lacrimal length	13	♂♂	12,128	20.645
		♀♀	10,113	21.626
Maxillary Arch Spread	14	♂♂	12,128	40.235
		♀♀	10,113	38.958
Basioccipital length	15	♂♂	12,116	19.481
		♀♀	10,105	15.283
Greatest depth	16	♂♂	12,112	12.705
		♀♀	10,107	16.368
Greatest width	17	♂♂	12,115	15.605
		♀♀	10,106	12.339
Zygomatic width	18	♂♂	12,124	24.123
		♀♀	10,110	28.707
Nasal width	19	♂♂	12,127	9.307
		♀♀	10,109	9.637
Mandible length	20	♂♂	12,128	41.126
		♀♀	10,113	42.184
Mandible depth	21	♂♂	12,128	32.712
		♀♀	10,113	23.888
Post-cranial Skeleton				
Radius length	22	♂♂	12,127	27.225
		♀♀	10,113	31.774
Ulna length	23	♂♂	12,128	27.796
		♀♀	10,113	30.886
Humerus length	24	♂♂	12,128	37.973
		♀♀	10,112	43.641

Table 3 Continued

Humerus distal width	25	♂♂	12,128	47.204
		♀♀	10,112	53.187
Humerus proximal width	26	♂♂	12,128	29.925
		♀♀	10,112	31.213
Clavicle length	27	♂♂	12,127	23.533
		♀♀	10,113	28.770
Scapula width	28	♂♂	11,102	15.759
		♀♀	10, 97	12.451
Scapula length	29	♂♂	11,107	19.463
		♀♀	10,103	22.173
Scapula depth	30	♂♂	11,122	13.505
		♀♀	10,109	13.283
Tibia length	31	♂♂	12,125	46.435
		♀♀	10,110	61.515
Tibia distal width	32	♂♂	12,128	29.134
		♀♀	10,112	23.759
Tibia proximal width	33	♂♂	12,128	23.491
		♀♀	10,113	30.627
Femur length	34	♂♂	12,128	44.682
		♀♀	10,112	21.019
Femur distal width	35	♂♂	12,128	39.921
		♀♀	10,113	53.052
Femur proximal width	36	♂♂	12,127	7.836
		♀♀	10,112	10.113
Pelvis length	37	♂♂	12,128	31.560
		♀♀	10,113	35.887
Pelvis depth	38	♂♂	12,128	32.874
		♀♀	10,113	27.420
Pelvic Foramen length	39	♂♂	12,128	32.434
		♀♀	10,113	36.990
Pelvic Foramen width	40	♂♂	12,128	18.724
		♀♀	10,113	23.499
Width Fused Vertebrae	41	♂♂	10,123	39.768
		♀♀	10,112	34.714
Number Fused Vertebrae	42	♂♂	11,125	1.590
		♀♀	10,113	1.034

[1] Single-classification analysis of variance.

[2] Significant interpopulation heterogeneity is indicated by an *F*-ratio exceeding 2.040.

TABLE 4. Variation in means of 19 skin and skeletal characters in Baja California kangaroo rats. Statistically homogeneous subsets derived from SS-STP analysis are shown by lines below the OTU numbers and ranked means.

Character	No.	Sex	Results of SS-STP Analysis												
Tail length	3	♂♂	13	6	10	12	11	3	7	8	9	1	5		
			181.14	179.94	179.50	176.00	174.00	173.71	168.23	167.00	167.00	164.94	162.67		
			—	—	—	—	—	—	—						
				—	—	—	—	—	—	—					
					—	—	—	—	—	—	—	—	—		
		♀♀	6	13	9	3	11	12	7	5	1	8			
			180.42	179.86	173.80	172.40	170.11	167.50	167.08	165.50	165.10	159.50			
			—	—	—	—	—								
				—	—	—	—	—							
					—	—	—	—	—	—	—	—			
Hind Foot length	4	♂♂	6	3	12	13	11	9	5	7	1	8	4	2	10
			45.47	44.50	44.36	44.17	43.17	43.13	43.00	42.63	41.90	41.71	41.50	41.50	41.00
			—	—	—	—									
				—	—	—	—	—	—						
						—	—	—	—	—					
							—	—	—	—	—	—	—	—	
								—	—	—	—	—	—	—	—
		♀♀	6	3	12	13	7	9	11	4	8	5	1		
			44.65	43.57	43.44	43.26	42.62	42.40	42.18	42.00	41.67	41.50	41.50		
			—	—	—	—									
				—	—	—	—	—	—	—	—	—	—		
Ear length	5	♂♂	11	12	10	13	9	7	1	4	5	8	2	6	3
			18.83	18.36	18.00	17.88	17.50	17.05	17.05	17.00	17.00	16.86	16.50	15.82	15.50
			—	—	—	—	—								
				—	—	—	—	—	—	—	—				
					—	—	—	—	—	—	—	—	—		
								—	—	—	—	—	—	—	
										—	—	—	—	—	—
		♀♀	11	9	12	13	7	5	4	8	1	6	3		
			18.47	18.20	17.67	17.63	17.31	17.25	17.00	17.00	16.96	16.12	15.43		
			—	—	—	—	—	—	—	—					
				—	—	—	—	—	—	—	—				
							—	—	—	—	—	—			
								—	—	—	—	—	—		
Greatest length skull	7	♂♂	6	11	13	12	9	3	5	7	2	10	1	8	4
			42.51	40.85	40.16	39.97	39.89	39.53	39.47	39.39	39.25	38.80	38.80	38.40	38.00
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		♀♀	6	11	13	9	7	5	12	8	1	4	3		
			41.75	40.06	40.02	39.52	39.27	39.22	39.10	38.40	38.05	37.80	36.63		
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Interorbital width	9	♂♂	6	11	2	12	3	9	10	7	13	1	8	5	4
			11.01	10.92	10.90	10.76	10.67	10.65	10.55	10.53	10.47	10.43	10.24	10.20	10.15
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		♀♀	6	11	7	9	3	5	13	1	12	4	8		
			11.10	10.79	10.73	10.68	10.67	10.60	10.47	10.39	10.33	10.30	10.30		
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Nasal length	10	♂♂	6	12	9	11	13	3	7	2	5	8	1	10	4
			15.19	14.44	14.41	14.41	14.37	14.06	14.05	13.90	13.87	13.80	13.70	13.55	13.50
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		♀♀	6	9	13	12	3	7	11	1	5	4	8		
			14.85	14.22	14.21	14.17	14.10	14.08	14.08	13.82	13.80	13.65	13.60		
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Intermaxillary width	11	♂♂	6	11	3	10	9	13	12	7	1	2	5	8	4
			8.00	7.88	7.85	7.65	7.65	7.61	7.48	7.46	7.37	7.35	7.23	7.23	7.10
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		♀♀	6	3	11	7	9	13	5	12	8	1	4		
			8.02	7.82	7.65	7.62	7.62	7.58	7.45	7.44	7.40	7.36	7.20		
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Table 4 Continued

Alveolar length	12	♂♂	3 5.41	6 5.41	7 5.15	11 5.11	13 5.10	2 5.05	5 4.90	4 4.90	12 4.87	10 4.85	9 4.81	1 4.80	8 4.77
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		♀♀	6 5.35	7 5.29	3 5.28	13 5.02	5 5.00	11 4.98	9 4.96	1 4.93	8 4.87	4 4.85	12 4.64		
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Basioccipital length	15	♂♂	6 6.35	3 5.91	2 5.80	11 5.73	13 5.64	9 5.56	8 5.53	7 5.50	1 5.48	12 5.47	5 5.47	10 5.30	4 5.10
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		♀♀	6 6.20	3 5.84	13 5.64	9 5.56	8 5.53	11 5.48	7 5.46	5 5.45	1 5.32	12 5.26	4 5.25		
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Greatest depth skull	16	♂♂	6 14.02	13 13.73	11 13.72	9 13.56	12 13.39	5 13.37	2 13.35	3 13.32	10 13.30	7 13.29	1 13.15	4 13.05	8 12.86
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		♀♀	6 13.96	13 13.64	11 13.58	7 13.47	3 13.44	8 13.17	12 13.16	5 13.12	9 13.12	1 13.08	4 12.75		
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Greatest width skull	17	♂♂	6 26.66	11 26.09	10 25.80	13 25.77	9 25.63	12 25.22	3 25.09	5 24.80	7 24.77	1 24.51	2 24.45	8 23.86	4 23.80
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		♀♀	6 26.13	13 25.55	11 25.44	3 25.13	9 25.10	7 24.86	12 24.60	5 24.52	1 24.33	8 24.27	4 23.90		
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Nasal width	19	♂♂	6 3.99	11 3.93	9 3.91	3 3.79	5 3.70	13 3.66	7 3.65	4 3.60	12 3.60	1 3.60	10 3.50	2 3.45	8 3.37
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		♀♀	6 3.93	11 3.78	3 3.73	13 3.67	4 3.65	5 3.62	7 3.59	1 3.58	9 3.57	12 3.36	8 3.33		
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Ulna length	23	♂♂	6 24.36	3 23.34	11 22.25	13 22.07	9 21.87	5 21.57	4 21.45	7 21.45	12 21.37	2 21.35	8 21.01	1 20.95	10 20.65
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		♀♀	6 23.72	3 23.33	13 21.62	11 21.61	4 21.40	5 21.35	8 21.20	9 21.10	7 21.07	1 20.76	12 20.51		
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Scapula width	28	♂♂	6 9.35	3 8.92	11 8.64	13 8.43	4 8.00	7 7.91	5 7.90	9 7.86	12 7.84	2 7.80	1 7.59	8 7.57	
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		♀♀	6 8.88	3 8.73	11 8.28	13 8.26	4 8.00	8 7.80	9 7.75	1 7.71	7 7.67	5 7.50	12 7.31		
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Table 4 Continued

Scapula depth	30	♂♂	6 3.13	3 3.01	11 2.78	13 2.76	5 2.73	9 2.69	2 2.65	12 2.65	4 2.60	7 2.60	1 2.54	8 2.41	
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		♀♀	6 3.10	3 3.00	13 2.77	11 2.76	4 2.70	5 2.65	12 2.64	9 2.62	7 2.60	1 2.57	8 2.35		
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Femur proximal width	36	♂♂	6 3.47	11 3.35	3 3.29	13 3.25	5 3.13	10 3.10	9 3.07	7 3.06	2 3.05	12 3.03	4 2.95	8 2.93	1 2.92
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		♀♀	6 3.36	3 3.27	13 3.21	11 3.19	9 3.12	7 3.08	4 3.05	12 3.03	8 3.00	5 2.95	1 2.94		
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Pelvis depth	38	♂♂	6 13.85	11 12.56	13 12.25	3 12.16	5 11.63	12 11.56	9 11.56	10 11.55	2 11.20	7 11.14	8 10.67	1 10.60	4 10.25
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		♀♀	6 12.58	3 12.03	11 11.22	13 11.05	7 10.49	5 10.42	9 10.38	12 10.34	8 10.33	4 10.30	1 10.07		
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Pelvic Foramen width	40	♂♂	6 4.54	3 4.37	2 3.95	11 3.83	13 3.82	12 3.75	10 3.70	9 3.70	5 3.63	7 3.62	8 3.44	1 3.42	4 3.40
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		♀♀	6 4.37	3 4.21	13 3.73	11 3.72	12 3.70	9 3.50	7 3.42	8 3.40	1 3.29	4 3.25	5 3.12		
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Number Fused Vertebrae	42	♂♂	2 5.00	4 5.00	5 5.00	6 4.94	13 4.92	12 4.91	11 4.89	3 4.88	8 4.86	7 4.83	9 4.63	1 4.58	
			—	—	—	—	—	—	—	—	—	—	—	—	
		♀♀	5 5.00	6 4.94	1 4.86	3 4.86	7 4.85	12 4.78	8 4.67	11 4.65	9 4.60	13 4.58	4 4.50		
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TABLE 5. Character loadings[1] of the first three principal components of interOTU phenetic variation among 19 selected characters.

Char. No.[2]	Sex	Principal Components I	II	III
3	♂♂	.629	-.294	.604
	♀♀	.827	-.354	.311
4	♂♂	.837	.033	-.176
	♀♀	.833	-.062	.158
5	♂♂	-.212	-.923	.158
	♀♀	-.426	-.852	.003
7	♂♂	.931	-.203	-.132
	♀♀	.496	-.728	-.291
9	♂♂	.743	-.207	-.035
	♀♀	.847	-.152	-.366
10	♂♂	.869	-.196	-.238
	♀♀	.870	-.348	-.097
11	♂♂	.894	-.207	-.026
	♀♀	.948	-.045	-.178
12	♂♂	.823	.426	.123
	♀♀	.768	.287	-.300
15	♂♂	.861	.267	-.168
	♀♀	.925	.130	-.073
16	♂♂	.890	-.325	-.033
	♀♀	.876	-.240	-.176
17	♂♂	.844	-.472	.058
	♀♀	.910	-.376	-.041
19	♂♂	.791	-.140	-.380
	♀♀	.802	.029	.034
23	♂♂	.915	.330	-.114
	♀♀	.891	.390	.099
28	♂♂	.941	.166	.199
	♀♀	.858	.250	.328
30	♂♂	.932	.253	.007
	♀♀	.892	.157	.161
36	♂♂	.951	-.010	.142
	♀♀	.940	-.060	.288
38	♂♂	.970	-.114	.076
	♀♀	.962	.177	.078
40	♂♂	.908	.303	.097
	♀♀	.900	.087	.191
42	♂♂	.134	.205	.887
	♀♀	.300	.373	-.826
Total[3]	♂♂	68.1	10.8	8.2
	♀♀	67.9	11.8	7.6

[1] Correlations of locality mean values (*n* ♂♂ =13; *n* ♀♀ =11) of individual characters with the component axes.

[2] Character numbers correspond to the list of characters in Table 2.

[3] Percent of total phenetic variance explained.

PAPER II

Bacular Variation in Kangaroo Rats (Genus *Dipodomys*) of the *heermanni* Group in Baja California, Mexico

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ABSTRACT: Variation in kangaroo rat (*Dipodomys*) bacula was evaluated using 124 specimens collected from 11 localities in Baja California, Mexico. There was significant interlocality variation in the three characters analyzed. OTUs comprised of populations of *D. gravipes* were readily separable from the other taxa. Comparisons of similarity matrices based upon bacular characters with those of various sets of skin and skeletal characters yielded high correlations with post-cranial skeletal characters. Bacular length had a significant linear correlation with body length.

INTRODUCTION

Kangaroo rats (genus *Dipodomys*) of the *heermanni* group occur throughout much of the peninsula of Baja California, Mexico (Huey, 1951; Hall and Kelson, 1959; Lackey, 1967; Best, 1976*c*). They occupy various habitats including the chaparral and cactus covered slopes of the north and central regions, and the barren deserts to the south (Huey, 1951). Studies of the bacula of these and other forms of *Dipodomys* have recently been summarized by Best and Schnell (1974), who studied 20 of the 23 species, including *Dipodomys agilis*, *D. peninsularis*, and *D. gravipes* from Baja California. The present study includes the latter three species as well as *D. antiquarius* and *D. paralius* (=*D. agilis pedionomus* and *D. agilis plectilis*, respectively, see Best, 1976*b*). Of the Baja California species only bacula of *D. insularis* remain to be examined.

Best and Schnell (1974) pointed out the possible effects of geographic variation upon interspecific bacular comparisons. Such variation in bacula has not been considered in detail, but their subjective analysis of limited data indicated that since differences between species are considerably greater than within, the similarity values they found between species probably would not be changed by more detailed sampling. In the present study I have analyzed bacular measurements for a group of closely related taxa, the *heermanni* group of kangaroo rats in Baja California, Mexico, to determine the: (1) degree of interlocality variation in bacular measurements; (2) patterns of variation in bacula; (3) phenetic affinities of populations in Baja California based upon bacular measurements; and (4) relationships between variation observed in skin and skeletal measurements, and bacular measurements.

MATERIALS AND METHODS

During the summer of 1972, bacula were collected from kangaroo rats as they were prepared into museum study specimens. Bacula were allowed to dry in small vials and upon returning to the laboratory were prepared and stored in glycerin following Lidicker's (1960) method. Bacular length, height, and width were measured as described by Best and Schnell (1974). Each specimen was aged according to their four cranial criteria, and only data from fully adult males are presented.

The 124 specimens were collected from 11 localities in Baja California (Fig. 1, Table 1). At two of these collecting sites, two taxa of kangaroo rats of the *heermanni* group occur sympatrically---*D. gravipes* and *D. agilis* (Fig. 1 and Table 1, Nos. 2,3 and 5,6). I divided these samples into two Operational Taxonomic Units (OTUs), for a total of 13 OTUs. Current taxonomic designations (Best, 1976*b*) are as follows: (OTU 1) *D. agilis martirensis*; (2) *D. agilis simulans*; (3) *D. gravipes*; (4) *D. agilis simulans*; (5) *D. agilis plectilis*; (6) *D. gravipes*; (7) *D. agilis pedionomus*; (8) *D. agilis plectilis*; (9) *D. agilis pedionomus*; (10) *D. agilis eremoecus*; (11) and (12) *D. agilis peninsularis*; and (13) *D. agilis australis*. Best (1976*b*) found that only *D. gravipes* was readily separable from the other taxa using skin and skeletal characters. The other previously recognized species---*agilis*, *antiquarius*, *paralius*, and *peninsularis*---were not distinguishable on morphologic grounds (Best, 1976*b*).

Mean and standard deviation were calculated for each character from each OTU (Table 1). I tested interlocality heterogeneity of each character with a one-way analysis of variance, and used a sums of squares simultaneous test procedure (SS-STP; Gabriel and Sokal, 1969) to determine the maximally non-significant subsets. Correlation and distance matrices (Sneath and Sokal, 1973) were computed from the standardized locality means for each OTU. Clusters of OTUs were obtained with the unweighted pair-group method using arithmetic averages (UPGMA). Further explanation of these techniques (Sneath and Sokal, 1973), plus the rationale for the use of only three characters in bacular studies are given elsewhere (Best and Schnell, 1974).

For comparisons of bacular measurements with other morphologic data sets I also computed correlations and distances from the standardized OTU means for each morphologic data set. These included the following sets: 21 skin, skull, and mandibular characters (SKIN+SKULL/CORR and DIST); 21 post-cranial skeletal characters (P-CRAN SKEL/CORR and DIST); 42 skin and skeletal characters (42 CHAR/CORR and DIST); and the 19 "selected" characters from Best, 1976_b_ (SEL CHAR/CORR and DIST). Descriptions of each character (Best, 1976_b_), as well as sample size, mean and standard deviation for each OTU (Appendix I, Best, 1976_a_) are presented elsewhere. Analyses were performed on the IBM 360 computer at the University of Oklahoma Computation Center using UNIVAR (Power, 1969) and NT-SYS (Rohlf, et al., 1972).

RESULTS AND DISCUSSION

There is significant interpopulation heterogeneity in all three of the bacular characters (Length, _F_=86.0, d.f.=12,110; Width, _F_=3.9, d.f.=21,111; Height, F=6.9, d.f.=12,111). Bacular length varys more than either bacular width or height as shown by the _F_-ratios. Most of this length variation results from the difference between _D. gravipes_ and the remaining taxa (Table 1). Table 2 shows the pattern of variation in means of the three bacular measurements. OTUs 3 and 6 (both _D. gravipes_) are significantly different from the remaining OTUs in bacular length, but not in width or height. Bacular height and width measurements for _D. gravipes_ are well within the range of means observed for the remaining OTUs. OTU 1 is of medium length but largest in both width and height of bacula; also OTU 9 is one of the largest in all measurements.

Distinct patterns of variation were not evident from the SS-STP analyses (Table 2). The only non-overlapping homogeneous subset was for bacular length---_D. gravipes_ was significantly different from the other OTUs. Bacular length could thus serve in distinguishing _D. gravipes_ from the other taxa. Notably absent in the SS-STP analyses of bacular measurements was north to south or east to west clinal variation.

The correlation phenogram (Fig. 2A) contains an upper cluster, a middle cluster made up of the two D. gravipes OTUs, and a lower cluster. The distance phenogram (Fig. 2B) can be considered as two clusters. The lower cluster contains OTUs 3 and 6 (both D. gravipes) and the upper cluster includes the remaining OTUs. In the latter, OTUs 1 and 9 are distinct from the remaining members. Both are among the largest in bacular width and height as indicated by the SS-STP analysis.

In the three-dimensional plot of bacular measurements (Fig. 3) a close correspondence to the two primary clusters and sub-clusters in the distance phenogram (Fig. 2B) is apparent. It is clear that the phenetic separation of D. gravipes (OTUs 3 and 6) from the other OTUs is primarily based on bacular length, and that there is overlap in bacular height and width between all the OTUs.

Results from comparisons of bacular and other morphologic features are presented in Table 3. A perfect correlation between a distance and a correlation matrix would equal -1.0; between two distance or two correlation matrices, 1.0. The bacular correlation matrix (BAC/CORR) is not highly correlated with any of the other matrices based on morphologic characters. In contrast, the distance matrix (BAC/DIST) has higher loadings for all matrix comparisons, particularly the distance matrices. Highest values are shown for P-CRAN SKEL/DIST (0.699) and 42 CHAR/DIST (0.536). The correlation between BAC/CORR and BAC/DIST is -0.418. I expected bacula to vary in a way similar to other morphologic characters, but comparisons of bacular and morphologic matrices did not produce large correlation coefficients (Table 3). The skin-skeletal data matrices had very low correlations with the bacular correlation matrix (BAC/CORR), but their correlations were much higher when compared to the bacular distance matrix (BAC/DIST). The matrices with skin and skull measurements (SKIN+SKULL/CORR and DIST) were the least correlated with BAC/DIST. These characters are very similar to those used in many mammalian morphologic studies. The distance matrix for post-cranial skeletal characters (P-CRAN SKEL/DIST) was most highly correlated with BAC/DIST.

The correlation coefficient of 0.801 ($P \leq 0.01$) between mean bacular length and mean length of body for each of the 13 OTUs indicates a very close relationship between body size and bacular size. Within the 11 *D. agilis* OTUs the correlation coefficient I calculated was also significant ($r=0.699$, $P \leq 0.05$). This is contrary to Best and Schnell's (1974) conclusion when they compared phenograms with and without body size considered. A linear correlation performed on their data (bacular length vs. body length) was not significant ($r=0.340$, $P>0.05$), supporting their conclusions. However, the correlation value is significant ($r=0.599$, $P \leq 0.05$) if *D. deserti* and *D. nitratoides* are removed from their data set. It appears that generally in *Dipodomys* there is a significant relationship between bacular and body size. Certainly this is true in the Baja California forms studied here.

My data show significant variation in bacula of kangaroo rats of the *heermanni* group in Baja California. In addition, *D. gravipes* is well separated from the other taxa---primarily on the basis of bacular length. Further studies are needed to determine what type of variation is present in other species of *Dipodomys*.

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Oklahoma, assisted in the preparation of Figure 3. Steven Erkenbeck assisted in the field work. I am grateful to Bernardo Villa R., Director General de la Fauna Silvestre, Mexico, D. F., for providing the necessary permits to collect specimens in Mexico. I especially thank Gary D. Schnell, Cluff E. Hopla, Anthony A. Echelle, and James R. Estes for their many suggestions, encouragement, and patience, during my tenure at the University of Oklahoma, and Harold A. Smith for his valuable assistance in the field work and preparation of specimens.

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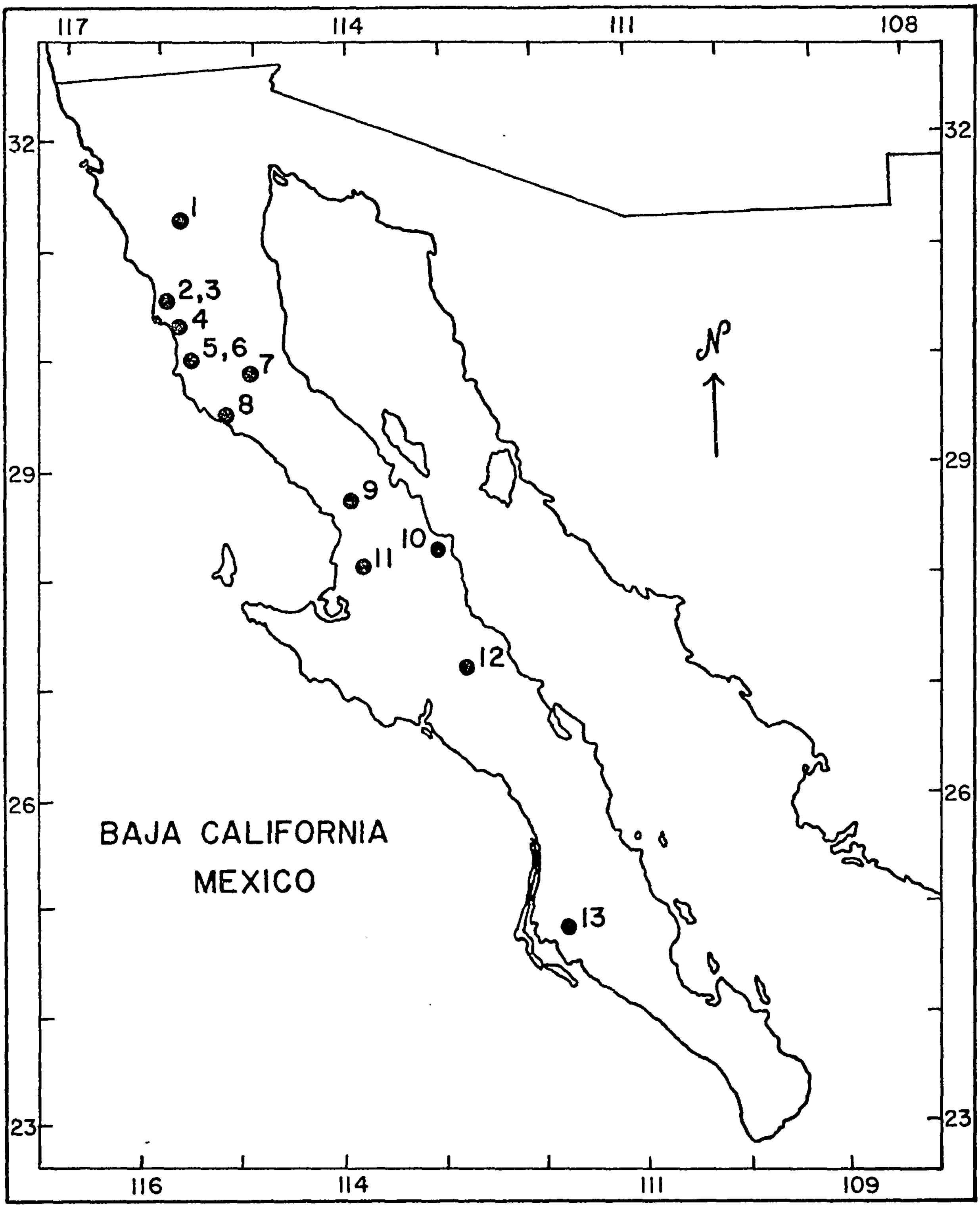
FIGURES

Fig. 1.---Map of the 11 localities (represented by dots) in Baja California, Mexico, where kangaroo rats (Dipodomys) used in this study were collected. For two of the localities specimens were divided into two OTUs (i.e., 2 and 3; 5 and 6). Numbers correspond to the OTU numbers and precise locations listed in Table 1. Except for 12 and 13, which are in the Territorio de Baja California del Sur, all localities are in the state of Baja California


117
114
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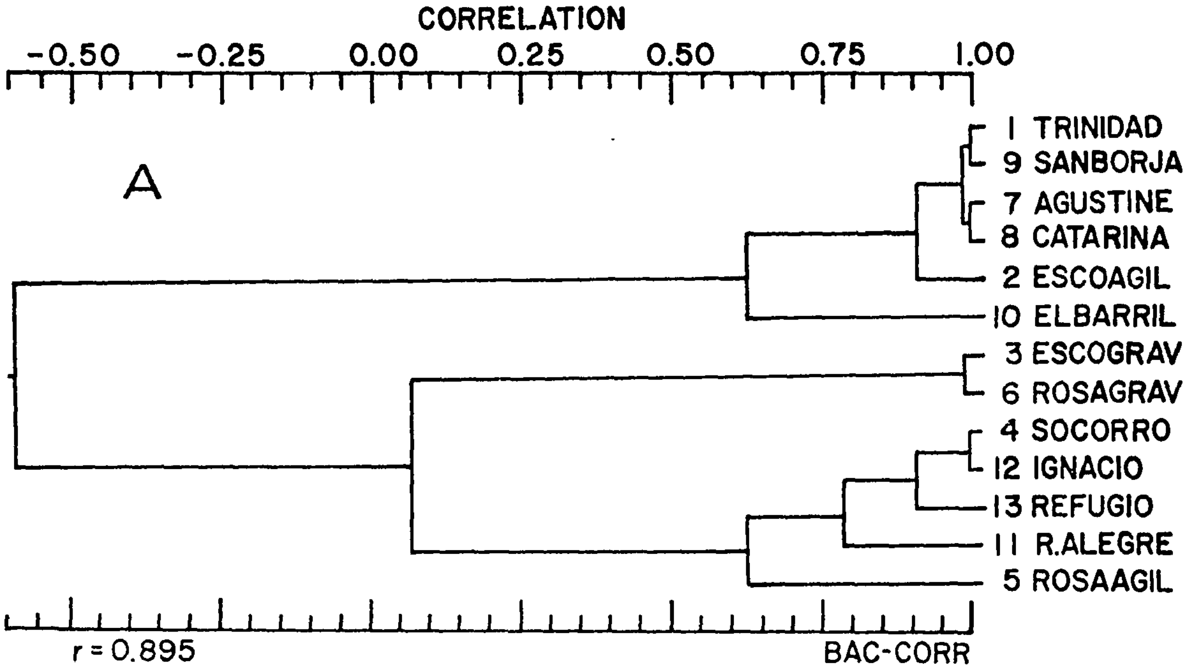
N
BAJA CALIFORNIA
MEXICO

Fig. 2.---Correlation (A) and distance (B) phenograms indicating similarities between the 13 OTUs of kangaroo rats (_Dipodomys_) from Baja California. Similarities were calculated on the basis of the three mean bacular measurements for each OTU. The unweighted pair-group method using arithmetic averages (UPGMA) was used in clustering. The cophenetic correlation coefficients (_r_) for A and B indicate that the phenograms give an accurate representation of their similarity matrices


CORRELATION
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
A
1 TRINIDAD
9 SANBORJA
7 AGUSTINE
8 CATARINA
2 ESCOAGIL
10 ELBARRIL
3 ESCOGRAV
6 ROSAGRAV
4 SOCORRO
12 IGNACIO
13 REFUGIO
11 R.ALEGRE
5 ROSAAGIL
r = 0.895
BAC-CORR

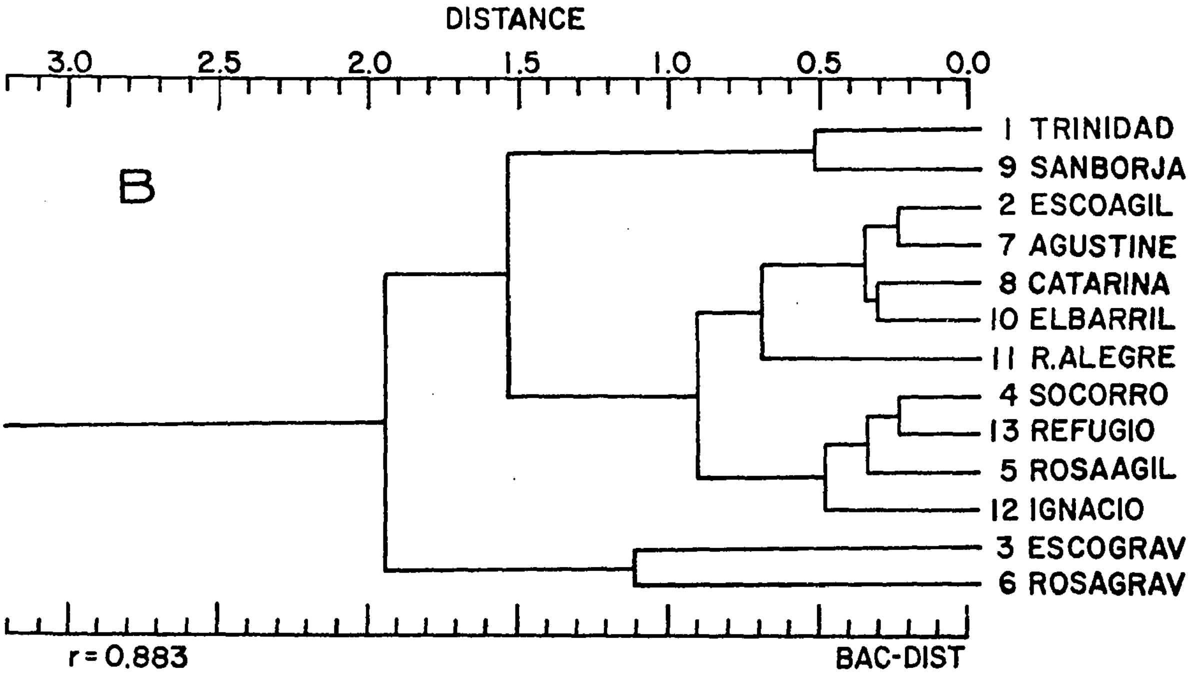
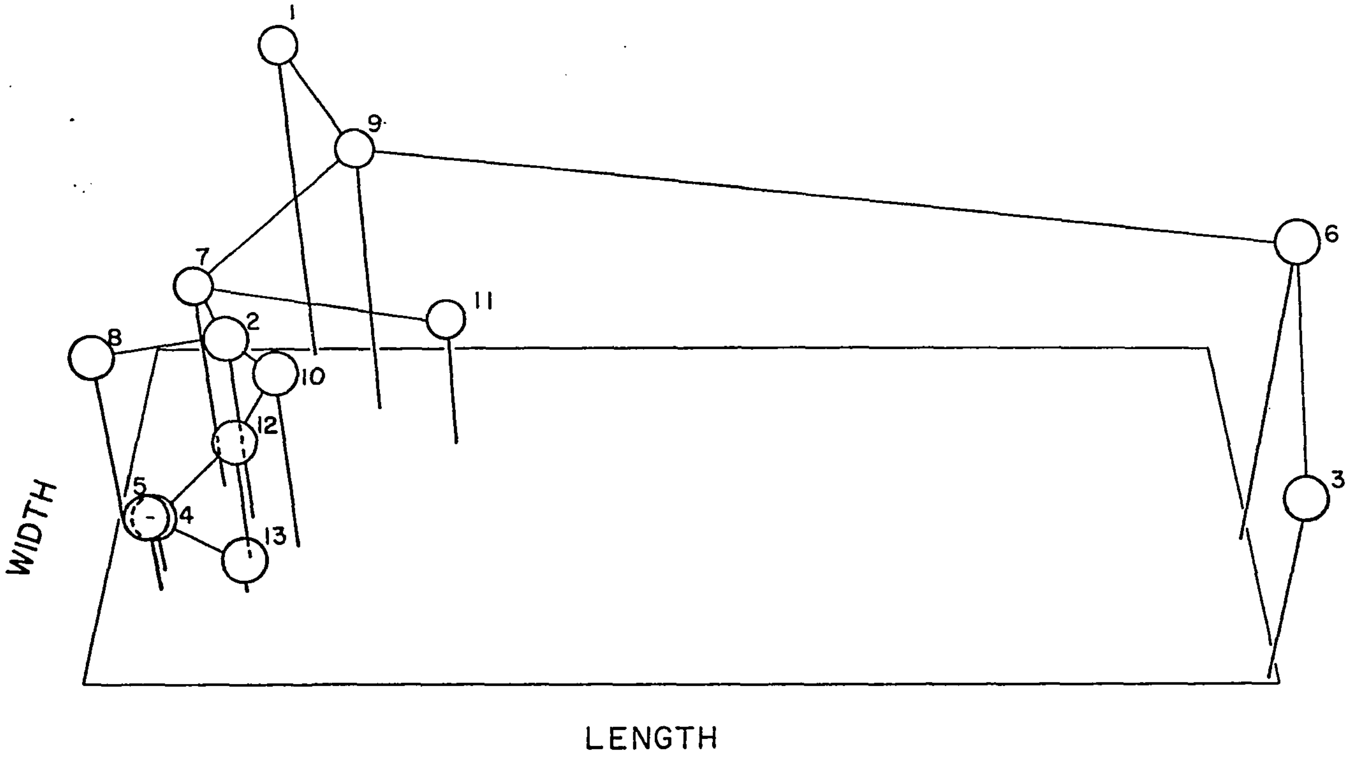

DISTANCE
3.0
2.5
2.0
1.5
1.0
0.5
0.0
B
1 TRINIDAD
9 SANBORJA
2 ESCOAGIL
7 AGUSTINE
8 CATARINA
10 ELBARRIL
11 R.ALEGRE
4 SOCORRO
13 REFUGIO
5 ROSAAGIL
12 IGNACIO
3 ESCOGRAV
6 ROSAGRAV
r = 0.883
BAC-DIST

Fig. 3.---Three-dimensional plot of average bacular measurements for each of the 13 OTUs of kangaroo rats (Dipodomys) from Baja California. The vertical axis represents height of bacular base


1
9
6
7
11
2
8
10
12
3
5
4
13
WIDTH
LENGTH

TABLES

TABLE 1.---OTU numbers, code names, collecting localities, and bacular measurements (mm) of kangaroo rats (*Dipodomys*) from Baja California

OTU No.	Code Name	Collecting Localities	LENGTH mean (n; st. dev.)	WIDTH mean (n; st. dev.)	HEIGHT mean (n; st. dev.)
1	TRINIDAD	Valle de Trinidad (n=3) 4 mi. S Valle de Trinidad (6) W end Valle de Trinidad (1)	9.40 (10; .502)	2.07 (10; .285)	2.16 (10; .239)
2	ESCOAGIL	2 mi. E Colonia Guerrero (1) 8.5 mi. N San Quintin (1)	9.27 (2; .559)	1.72 (2; .141)	1.94 (2; .127)
3	ESCOGRAV	8.5 mi. N San Quintin	12.74 (4; .647)	1.42 (4; .202)	1.94 (4; .225)
4	SOCORRO	12 mi. N El Rosario	8.98 (2; .044)	1.62 (2; .113)	1.67 (2; .120)
5	ROSAAGIL	6 mi. E El Rosario	9.00 (4; .208)	1.57 (4; .262)	1.73 (4; .275)
6	ROSAGRAV	6 mi. E El Rosario	12.76 (17; .267)	1.68 (17; .229)	2.14 (17; .182)
7	AGUSTINE	San Agustine	9.14 (17; .424)	1.78 (17; .214)	1.96 (17; .236)
8	CATARINA	Santa Catarina Landing	8.80 (7; .493)	1.71 (7; .306)	1.89 (7; .223)
9	SANBORJA	Mission de San Borjas	9.67 (8; .431)	1.94 (8; .227)	2.07 (8; .107)
10	ELBARRIL	7 mi. W San Francisquito Bay	9.44 (2; .219)	1.67 (2; .016)	1.89 (2; .304)
11	R.ALEGRE	2.5 mi. W Mesquital	9.97 (18; .461)	1.86 (18; .285)	1.82 (18; .226)
12	IGNACIO	10 mi. E San Ignacio	9.29 (10; .402)	1.65 (10; .190)	1.79 (10; .226)
13	REFUGIO	4.5 mi. N El Refugio	9.29 (22; .558)	1.58 (23; .283)	1.63 (23; .244)

TABLE 2.---Variation in means of three bacular measurements in Baja California kangaroo rats (*Dipodomys*). Statistically homogeneous subsets derived from SS-STP analysis are shown by lines below the OTU numbers and ranked means

Character	Results of SS-STP Analysis												
Length	6	3	11	9	10	1	13	12	2	7	5	4	8
	12.76	12.74	9.97	9.67	9.43	9.40	9.29	9.29	9.27	9.14	9.00	8.98	8.80
	—	—											
			—	—	—	—	—	—	—				
				—	—	—	—	—	—	—	—	—	—
Width	1	9	11	7	2	8	6	10	12	4	13	5	3
	2.07	1.94	1.86	1.78	1.72	1.71	1.68	1.67	1.65	1.62	1.58	1.57	1.42
	—	—	—	—	—	—	—	—	—	—			
		—	—	—	—	—	—	—	—	—	—	—	
			—	—	—	—	—	—	—	—	—	—	—
Height	1	6	9	7	3	2	8	10	11	12	5	4	13
	2.16	2.14	2.07	1.96	1.94	1.94	1.89	1.89	1.82	1.79	1.73	1.67	1.63
	—	—	—	—	—	—	—	—	—				
		—	—	—	—	—	—	—	—	—			
			—	—	—	—	—	—	—	—	—	—	
				—	—	—	—	—	—	—	—	—	—

TABLE 3.---Correlation coefficients resulting from comparisons of correlation and distance matrices calculated from standardized character means of bacular and various skin and skeletal character sets[a]

Matrix Name	BAC/CORR	BAC/DIST
SKIN+SKULL/CORR	.202	-.236
SKIN+SKULL/DIST	-.220	.402
P-CRAN SKEL/CORR	-.112	-.303
P-CRAN SKEL/DIST	-.324	.609
42 CHAR/CORR	.170	-.398
42 CHAR/DIST	-.291	.536
SEL CHAR/CORR	.158	-.395
SEL CHAR/DIST	-.271	.482

[a] The matrix names and the characters considered in each are referred to in the text

PAPER III

RELATIONSHIPS BETWEEN ECOLOGIC AND MORPHOLOGIC VARIATION IN KANGAROO RATS (GENUS DIPODOMYS) OF THE HEERMANNI GROUP IN BAJA CALIFORNIA, MEXICO

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Abstract. Interlocality variation in temperature, precipitation, vegetation, and burrow systems were analyzed for 11 localities where kangaroo rats (*Dipodomys agilis*) were collected in Baja California, Mexico. These data were examined to determine their correlations with morphologic variation in the 11 kangaroo rat populations. Principal component I of the *Dipodomys* morphologic data was significantly correlated with latitude and longitude for both sexes---larger specimens were from the southern populations. Component II of burrow variation was correlated with component I for males only. In addition, the female component II was correlated with July mean temperature and January mean precipitation. This second component was significantly correlated with increased hind foot length in the warmer southern localities, and was taken as an indication that Allen's ecogeographic rule was being followed. The relationships of different groups of morphologic characters and the environmental variables were shown by cluster analyses. Morphologic

and environmental data matrices generally clustered separately. Within the morphologic clusters, matrices were generally separated into groups of distance and correlation matrices.

INTRODUCTION

Previously I examined external and skeletal (Best 1976*b*), and bacular (Best 1976*c*) variation in populations of kangaroo rats (genus *Dipodomys*) of the *heermanni* group in Baja California, Mexico. My purpose in the present paper is to examine intraspecific variation and its relationships to environmental parameters for one species of the group, *Dipodomys agilis* Gambel, 1848.

In a recent review of geographic variation analysis Gould and Johnston (1972) emphasized the importance of examining environmental correlates of geographic variation in populations. With this in mind I have: 1) examined interlocality variation in temperature, precipitation, vegetation, burrow systems, and kangaroo rat morphology; 2) determined the correlation of environmental variables with the morphologic variation; and 3) demonstrated the possible effect of using different sets of morphologic characters upon the covariation observed.

MATERIALS AND METHODS

Population numbers, code names, and collecting localities where samples of kangaroo rats from Baja California were collected for use in this study are presented in Table 1. The 216 *D. agilis* were collected at 11 localities during June and July, 1972. Sample sizes and descriptions of morphologic characters are given by Best (1976*b*). At each locality I attempted to sample all habitats occupied by kangaroo rats. Specimens were collected with Sherman live traps and Victor rat traps during three to four days at each site. At each locality live traps were set in two grids with trap stations 12.2 m apart in 5 rows and 5 columns. Two traps were placed at each trap station. Kill traps were set in 4 or 5 linear transects of 50 traps each (one trap per station) with the traps about 5 m apart.

Burrow data are treated as an "environmental variable," while realizing that they may simply reflect the morphology of the organism that constructed the burrow system. To collect data on burrows, additional traps were placed directly outside burrow entrances that were not in the grids or along the transects. I assumed that the animal caught in the trap was the one that lived in the burrow. Burrow data were not obtained for locality 2, but at each of the other sites 3 to 11 burrows (mean=7.3) were excavated, measured, and mapped (see Appendix V of Best 1976_a_ for means, standard deviations, and sample sizes for each site). The 17 burrow characteristics studied are listed in Table 5.

For each locality altitude, latitude, longitude, temperature, and precipitation were taken from the nearest weather station (Table 1) as determined from the maps in Hastings and Humphrey's (1969) report on the climate of Baja California (see Appendices II and III of Best 1976_a_ for temperature and precipitation means used in this study). For both temperature and precipitation I used 12 monthly and four seasonal means (Table 3). With one exception, collecting localities were within 20 km of a weather station. For Santa Catarina Landing, which is located on the west coast, the nearest weather station, and the one used, is approximately 35 km away at an elevation of 450 m.

At each collecting site I used a line-intercepts method to characterize the vegetation. A string 61 m (200 ft.) long was placed above each of the five rows and columns of each of the two trapping grids. Vegetation, rocks, and debris encountered directly below the line were recorded as well as the distance between these intercepts (=bare areas). The characters derived from these data are given in Table 4 (see Appendix IV of Best 1976a for mean values for each locality). At two localities where *D. gravipes* and *D. agilis* occurred sympatrically (8.5 mi. N San Quintin; 6 mi. E El Rosario) one grid was placed into the habitat occupied by each of the species. Thus only 610 m of transect data are provided for the *D. agilis* populations from each of these localities.

Correlation and distance matrices (Sneath and Sokal 1973) were calculated from the standardized locality means of the morphologic, temperature, precipitation, vegetation, and burrow data for each site and also for each character. Clusters of localities and characters from these original matrices of distance and correlation were obtained with the unweighted pair-group method using arithmetic averages (UPGMA). Principal components were calculated from a matrix of correlation among characters and locality means. The projections of the localities were plotted on the first three principal components. On these three-dimensional plots I have superimposed a shortest minimally connected network computed for the original matrix of distances.

Morphologic data for females are represented by fewer populations than for males---no female data were obtained for populations 2 and 8. The discussion of analyses of environmental character correlations, phenograms, and three-dimensional models utilize matrices and phenograms with all 11 localities represented; comparisons involving female matrices were based on 9.

To demonstrate the effect of using different groups of morphologic characters I derived character sets based on the 42 skin and skeletal characters studied previously (Best 1976b). The character numbers and mean values used in these analyses were taken from Best (Appendix I, 1976a). A list and a description of the characters are also presented in Best, 1976b. The matrices compared are as follows (unless otherwise indicated, matrix code name and the characters included in each are enclosed in parentheses):

skin correlation (SKIN-CORR, characters 1 through 5); skin distance (SKIN-DIST, 1-5); skull correlation (SKULL-CORR, 6-21); skull distance (SKULL-DIST, 6-21); skin and skull correlation (SKIN+SKULL-CORR, 1-21); skin and skull distance (SKIN+SKULL-DIST, 1-21); 42 skin and skeletal characters correlation (ALL CHAR-CORR, 1-42); 42 skin and skeletal characters distance (ALL CHAR-DIST, 1-42); 19 selected characters correlation (SEL CHAR-CORR, Table 2); 19 selected characters distance (SEL CHAR-DIST, Table 2). For males bacular correlation (BAC-CORR) and distance (BAC-DIST) matrices constructed using the *D. agilis* populations listed in Best (1976*c*) were also included. Standardized data matrices were used for intermatrix comparisons.

Analyses were performed using the IBM 370 computer at the University of Oklahoma Computation Center. Bivariate correlations were determined with a program (BIVAR) written by Power (1967), and multivariate analyses were conducted using the NT-SYS series of programs (Rohlf et al. 1972).

RESULTS AND DISCUSSION

Character Correlations

The relationships among male and female morphologic characters are depicted in Figs. 1A and 1B, respectively. In both phenograms character 42 (number of fused vertebrae) is relatively uncorrelated with the other characters. The characters that are the most highly correlated are: 11 (intermaxillary width) and 17 (greatest width of skull); 7 (greatest length of skull) and 10 (nasal length); 16 (greatest depth of skull) and 30 (scapula depth); 28 (scapula width) and 36 (proximal width of femur) for males; and 7 (greatest length of skull), 17 (greatest width of skull), and 11 (intermaxillary width) for females.

Characters used in the temperature analysis formed three very distinct clusters. Within each group the characters were correlated 0.95 or greater. The November through March and the Winter means composed the first cluster; April, May, October, Fall, and Spring means made up the second; and June through September, plus the Summer mean comprised the third cluster. December through March were the coolest months at each locality, with the January mean temperature consistently the lowest. Temperature means for July, August, and September were the highest at all localities.

Precipitation characters formed two distinct clusters diverging at the 0.03 correlation level. The November through June, Spring, and Winter means were well separated from the July through October, Summer, and Fall means. These groupings represent distinct Winter-Spring and Summer-Fall clusters. Within each cluster the characters were not as highly correlated as the temperature characters.

Hastings and Turner (1965) have studied the seasonal precipitation regimes in Baja California. They noted that like the west coast of the United States, the Pacific side of Baja California receives its maximum precipitation in winter. The November through June cluster closely corresponds to the wettest months of the year among northern and Pacific coastal localities, i.e., localities 1 through 7, and 9. These months are generally drier for localities 8, 10, and 11, which are east coastal and/or southern localities. Conversely, the July through October cluster closely corresponds to the dry months for the northern and western localities (1-7, 9) and generally represents the wettest months for the eastern and/or southern areas (8, 10, 11).

The characters used in the vegetative analyses (listed in Table 4) were generally not highly correlated (Fig. 2). Two distinct clusters occur in the phenogram, with considerable variation in character correlations within each cluster. Each character appears to contribute considerable independent information based upon the low correlations observed between characters.

Among burrow characters only characters 6 (number of nests) and 7 (average depth of nests) are highly correlated (Fig. 3). Generally, the burrow characteristics seem to vary independently.

Interlocality Variation

Fig. 4 shows phenograms for male and female morphologic variation constructed from correlation and distance matrices. Populations shown in the male (Fig. 4A) and female (Fig. 4C) correlation phenograms are relatively uncorrelated, and do not reflect geographic groupings of the populations. In the male distance phenogram (Fig. 4B) populations 9 and 11 cluster away from the others, and for females (Fig. 4D) 5, 7, 9, and 11 are separate from the other populations.

The temperature correlation phenogram (Fig. 5A) shows two very distinct clusters. The two clusters represent a separation of the northern inland and Gulf of California side of the peninsula (localities 1, 5, 6, 8) from the southern and Pacific side of the peninsula. Temperature data for locality 6 were taken about 35 km inland from the actual collecting site, accounting for its inclusion in the Gulf of California-northern inland cluster. The distance phenogram (Fig. 5B) shows localities 8, 10, and 11 clustered together and well separated from the other localities. These are in the southern half of the peninsula and have the warmest mean annual temperatures.

Two major clusters comprise the precipitation correlation phenogram (Fig. 5C). Excepting locality 5, localities in the upper cluster are the northern localities. The two major clusters in the distance phenogram (Fig. 5D) reflect the difference in mean annual precipitation of the localities. The cluster containing localities 1 and 9 represents the two sites with the greatest mean annual precipitation. Because of its extreme aridity, locality 8 is quite divergent from the others in the lower cluster.

Localities in the vegetation correlation phenogram (Fig. 5E) are grouped into two primary clusters. The corresponding distance phenogram (Fig. 5F) has locality 1 branching distant from the others. Correspondingly, locality 1 was the only locality with large expanses of grass. Examination of vegetation data in Shreve and Wiggins (1964) provided no additional insight into the groupings shown in these two phenograms. None of the groups derived from cluster analyses fall completely within any one of the broad phytogeographic areas they described. Data used in my analyses were from the driest months of the year (June and July). Since many of the plants had lost their leaves this undoubtedly affected the analysis of relationships between localities.

Two main clusters comprise the burrow correlation phenogram (Fig. 5G). The distance phenogram (Fig. 5H) has the localities generally arranged in north to south order. Locality 9 is separate from the other localities, 1 and 3 are grouped together, and the remaining localities form a large central cluster.

Principal Components

The loadings of morphologic characters on the first three component axes are presented in Table 2 and three-dimensional projections are depicted in Fig. 6. The character correlations with principal component I for males are high for all characters except 3 (tail length), 12 (alveolar length), 15 (basioccipital length), and 42 (number of fused vertebrae). For females the only low loadings were for characters 4 (hind foot length), 12 (alveolar length), 19 (nasal width), 23 (ulna length), and 42 (number of fused vertebrae). This component is taken to represent overall size in both sexes, since it accounts for most of the covariation among characters. On principal component II, characters 3 (tail length) and 42 (number of fused vertebrae) have highest loadings for males. Characters 4 (hind foot length), 19 (nasal width), and 23 (ulna length) are highest for females. Component III has highest loadings for character 15 (basioccipital length) for males and 42 (number of fused vertebrae) for females. The three components explain about 80% of the total character variance for each sex (see bottom of Table 2).

Principal component I separates populations in Fig. 6 by size. For males populations 1, 3, and 6 are the smallest and 9 and 11 are the largest. The same is true for females; however, the center cluster is not as distinct as for males. This is due to the missing data for female populations 2 and 8, and to the separation along principal component II. This second component in males generally places the longer tailed forms toward the back of the model. For females populations with shorter hind feet and longer ulnas are in the front of the model. Component III for males separates populations with longer basioccipital lengths from population 2. For females the populations close to the base of the model generally have more fused vertebrae.

Plots of the first three principal components of temperature, precipitation, vegetation, and burrow variation are presented in Fig. 7. All 16 temperature characters for both sexes have high loadings on principal component I (Table 3), which represents 84.2% of the total variance. The parallelism between the mean annual temperature and principal component I is reflected closely in the 3-D model of temperature variation (Fig. 7A). A listing of the localities from lowest to highest mean annual temperature is as follows: 2, 1, 3, 4, 5, 6, 9, 7, 10, 11, 8 (Appendix II, Best 1976a). A similar order appears across the axis representing the first principal component. Principal component II has highest loadings for January, July, August, and Summer means. This component represents 14.6% of the total variation, and separates the northern localities into distinct Pacific coastal (2, 3, 4) and inland (1, 5, 6) groupings. As expected, the weather data for locality 5 has placed it more with the inland than coastal forms. In the southern localities, number 11, representing a Pacific coastal site, is also displaced slightly by this component from the two Gulf of California localities (8 and 10). The third principal component has low loadings for all characters and represents less than one percent of the variation.

Also listed in Table 3 are the results of principal components analyses for the precipitation data, and Fig. 6B depicts a plot of these first three components. Principal component I accounts for 43.3% of the variation in the precipitation data. Highest loadings on this component were for the November through May, Winter, and Spring means. The high character loadings for winter means on component I is shown in the separation of localities along the first axis. Localities on the left have the least winter rainfall and those on the right the greatest. The second component of precipitation variation represents a relatively high percentage of the variation in the data (29.9%). Highest loadings are for July through October, Summer, and Fall means. Along principal component II the placement of localities 2 through 7 toward the back of the plot, 9, 10, and 11 in the middle, and 1 and 8 at the front appears to be primarily attributable to the Summer mean data although the same general groupings of the localities is shown in the Fall means (Appendix III, Best 1976a). The third component represents 7.7% of the variation with the highest loading for the January mean. No general relationship can be detected concerning the distribution of localities along component III.

Character loadings of the first three principal components of interlocality vegetation variation are shown in Table 4. For component I loadings are greater than ±0.6 for 10 of the 14 characters. This component represents 48.5% of the variance and appears to contain characters that primarily relate to the size of the plants. The 11 localities sampled in this study are shown in Fig. 7. Localities with larger plants are on the left for principal component I. The second component has highest loadings for characters 1, 5, 6, and 9, and explains 24.2% of the variance. Along component II smaller values for character 6 (average size of bare areas) and larger values for character 1 (total percent cover) correspond to localities in the back half of the 3-D model. Component III has highest loadings for characters 2, 3, and 9, and represents 10% of the variance. Localities with the least number of plants and least diversity are near the base of the model.

Results of the principal components analyses of interlocality burrow variation are presented in Table 5. Only 36.1% of the variance is explained in component I. There are high loadings for 11 of the 17 characters. This component appears to represent general size and/or complexity of the burrow systems. The 3-D model displaying the 11 localities plotted on the first three principal components of burrow variation is shown in Fig. 7D. Along component I localities 8 and 11 (generally smaller and less complex burrows) are on the left, 1, 3, and 9 on the right, and the others are grouped together in the middle. Component II accounts for 22.6% of the variance. Highest loadings are for characters 2, 3, 11, 12, and 13, which primarily represent width of the burrow system. On the 3-D model this component places locality 9 toward the back and the other localities toward the front of the model. The third principal component represents 12.9% of the variation and has highest loadings for characters 4, 5, and 17. Depth characteristics best exemplify the variation shown along principal component III. Localities depicted by longer sticks generally have deeper burrows.

Environmental-Morphologic Covariation

Results of analyses of covariation of the first three principal components of 19 morphologic characters of Baja California *D. agilis* and 15 ecogeographic variables are presented in Table 6. The first principal component of male *Dipodomys* variation is correlated significantly with latitude, longitude, and the second principal component of burrow variation. Thus, there is clinal variation in body size of males and a definate relationship between body size and general width of the burrow systems. It is not suprising that I found body size and burrow width correlated. At least in *D. spectabilis*, only one adult animal occupies a burrow system (Vorhies and Taylor 1922, Taylor and Vorhies 1923, Monson and Kessler 1940, Best 1972), and when that animal is removed the burrow is not immediately reoccupied (Best 1972). Female morphologic component I also covarys with latitude and longitude, but correlation with the second component of burrow variation was not significant. Perhaps a larger sample would show that female body size and the burrow width component are also significantly correlated.

In Kennedy's (1976) analyses of 16 cranial characters for *D. ordii*, he found latitude, mean annual and January temperatures, and mean annual precipitation to be significantly correlated with his males' principal component I. Latitude, annual and January mean temperatures were significantly correlated with his female component I. Similar results were expected for *D. agilis* in Baja California, since *Dipodomys* are morphologically quite similar (Hall and Kelson 1959). My data show that body size increases as latitude and longitude decrease---larger animals are in the southern populations. Geographically Baja California juts irregularly from near the United States border, near 32°30'N latitude, southeast across the Tropic of Cancer to Cabo San Lucas, near 22°50'. This southeastward projection accounts not only for the latitudinal variation, but also for the longitudinal variation. Latitude is very significantly correlated with longitude (*r*=0.950, P 0.01) in

Baja California. Thus the high correlation with longitude does not represent east-west variation across the peninsula, but simply is a result of changing latitude.

Male component II is not correlated with any of the ecogeographic variables, but principal component II for females is significantly correlated with July mean temperature and January mean precipitation (Table 6). Allen (1877) pointed out that protruding body parts for warm-blooded animals are shorter in cool climates and longer in warm ones. Kennedy (1976) noted that *D. ordii* exhibited at best a weak trend of geographic variation that followed Allen's ecogeographic rule. Since his analyses only included cranial characters, variation in protruding body parts, such as appendages, tail, and ears, were not directly considered. My data for females show that southern populations have longer hind feet. I have taken this to indicate that Allen's rule is being followed by hind foot length, which has a high loading along component II.

Principal component III of *Dipodomys* morphologic variation is not significantly correlated with any of the ecogeographic variables. For males, the only morphologic characters with a high loading for this component was basioccipital length, and for females, number of fused vertebrae in the pelvic girdle (Table 2).

There have been no published studies using statistical techniques to deal with kangaroo rat burrow characters and their interrelationships with morphologic attributes. Results of analyses of covariation of the first three principal components of *Dipodomys* burrow variation with 13 ecogeographic variables are presented in Table 7. Component I of burrow variation is significantly correlated with latitude, longitude, July mean temperature, component I of temperature, January mean precipitation, and component I of precipitation. The most complex burrows are in the northern parts of the peninsula. This region has the lowest temperatures throughout the year and the greatest winter-spring precipitation. The second component has significant correlations with July mean precipitation and the second component of precipitation. Wider, less complex burrows are in the southern areas where there is greatest Summer-Fall precipitation and the largest kangaroo rats occur.

Comparisons of Data Matrices

Results of comparisons of the various data matrices are presented in Fig. 8. The phenogram of male matrices (Fig. 8A) can be considered as three major clusters. The upper cluster contains four morphologic correlation matrices; the second, the two bacular matrices, the precipitation and burrow correlation matrices, and---except for bacular and vegetation---all the distance matrices; and the third has the temperature correlation matrix and the two vegetation matrices. Matrices for females also cluster into three groups (Fig. 8B). SKIN-CORR is very distinct from the other clusters; the second cluster contains the other morphologic matrices and most of the environmental matrices; and the third has the same matrices as the third for males.

Previously, I have taken care to remove the effect of high correlations among the 42 characters originally measured for Baja California *Dipodomys* (Best 1976*b*). The result was 19 characters that were much less correlated among themselves. The present analyses indicate the 19 character (SEL CHAR) and the 42 character (ALL CHAR) data sets are highly correlated. My results probably would not have been appreciably changed if I had used the 42 original characters. Apparently, the 19 character set is at least as adequate in representing the variation as the 42 original characters.

CONCLUSIONS

Analyses of environmental variables elucidated trends in variation in temperature, precipitation, vegetation, and burrow systems of Dipodomys in Baja California. Monthly variation in temperature is relatively parallel among the localities with those in the north being considerably cooler than the southern localities. Hastings and Turner (1965) found the Pacific side of the peninsula received its maximum precipitation in winter, and the Gulf of California side received most of its annual moisture during late Summer and Fall. These data closely agree with my principal components I and II, representing Winter-Spring and Summer-Fall precipitation means, respectively.

In analyses of vegetation variation the groupings of the localities I studied did not correspond to the broad phytogeographic regions designated by Shreve and Wiggins (1964). Perhaps this was due to the time of year when I collected plant data or the characters used in my analyses. However, the vegetative data provided information that allowed for grouping of localities based upon the growth and distribution of plants at each site.

Burrow variation, which to a large degree is a reflection of the morphologic attributes of the animal excavating the system, showed some interesting trends. In the southern Baja California localities---areas with the warmest July and annual mean temperatures---kangaroo rats build wider, less complex burrow systems. In addition, burrows in the north where there is greater winter rainfall and cooler temperatures, are generally more complex.

Larger kangaroo rats are in the more southern populations. For males, larger body size is significantly associated with wider burrow systems. The same correlation might be observed if the female sample were larger. Female component II, which has a high loading for hind foot length, is correlated with July mean temperature and January mean precipitation. Apparently Allen's ecogeographic rule is being followed by hind foot length since the southern populations generally have longer hind feet. Previous studies of Dipodomys morphologic variation have revealed at least some tendency for the variation to follow Bergmann's ecogeographic rule (Nader 1964, Kennedy 1976), but Baja California kangaroo rats are smaller in the northern, cooler areas of the peninsula.

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FIGURES

FIG. 1. Phenograms constructed from the matrices of correlation of 19 male (A) and female (B) skin and skeletal characters measured for Baja California *Dipodomys agilis*. Identification numbers refer to the list of characters presented in Table 2, and the cophenetic correlation coefficients (r) are indicated.

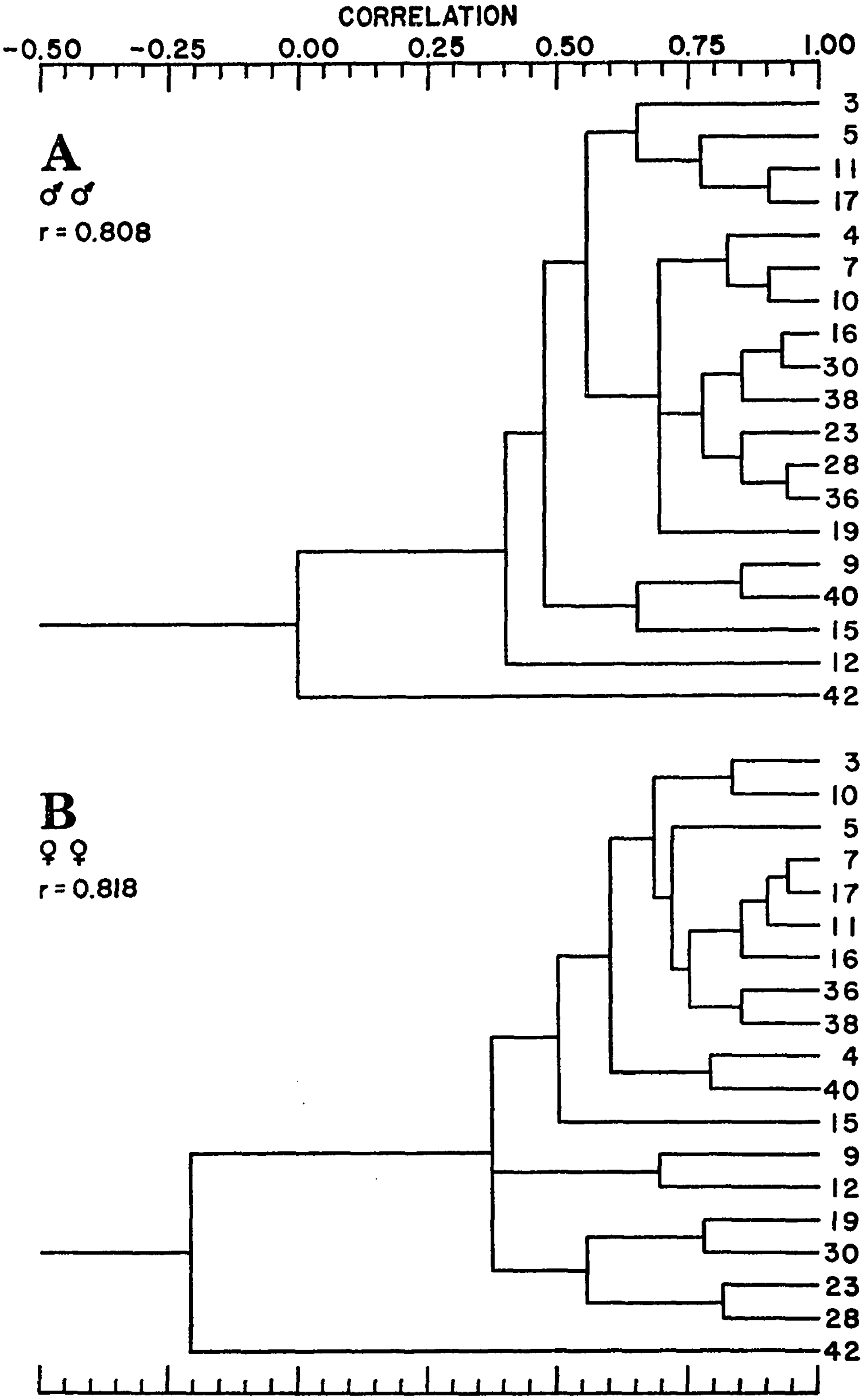

CORRELATION
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
A
♂♂
r = 0.808
3
5
11
17
4
7
10
16
30
38
23
28
36
19
9
40
15
12
42
B
♀♀
r = 0.818
3
10
5
7
17
11
16
36
38
4
40
15
9
12
19
30
23
28
42

FIG. 2. Phenogram constructed from the matrix of correlation of 14 vegetation characters measured at 11 localities in Baja California. Identification numbers and abbreviations refer to the list of characters presented in Table 3.

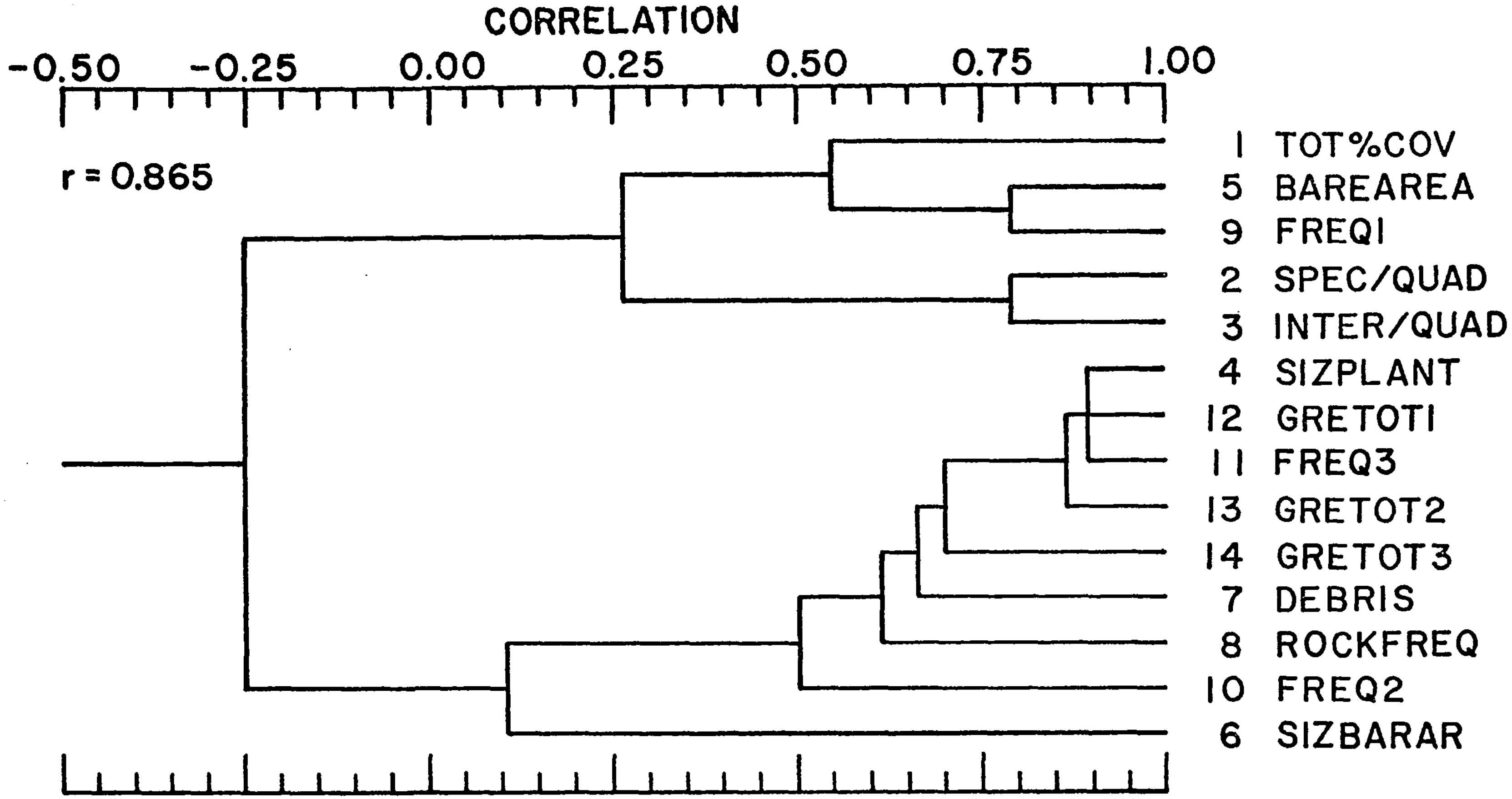

CORRELATION
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
r = 0.865
1 TOT%COV
5 BAREAREA
9 FREQ1
2 SPEC/QUAD
3 INTER/QUAD
4 SIZPLANT
12 GRETOT1
11 FREQ3
13 GRETOT2
14 GRETOT3
7 DEBRIS
8 ROCKFREQ
10 FREQ2
6 SIZBARAR

FIG. 3. Phenogram constructed from the matrix of correlation of 17 burrow characteristics recorded for kangaroo rats (Dipodomys) in Baja California. Identification numbers and abbreviations refer to the list of characters presented in Table 4.

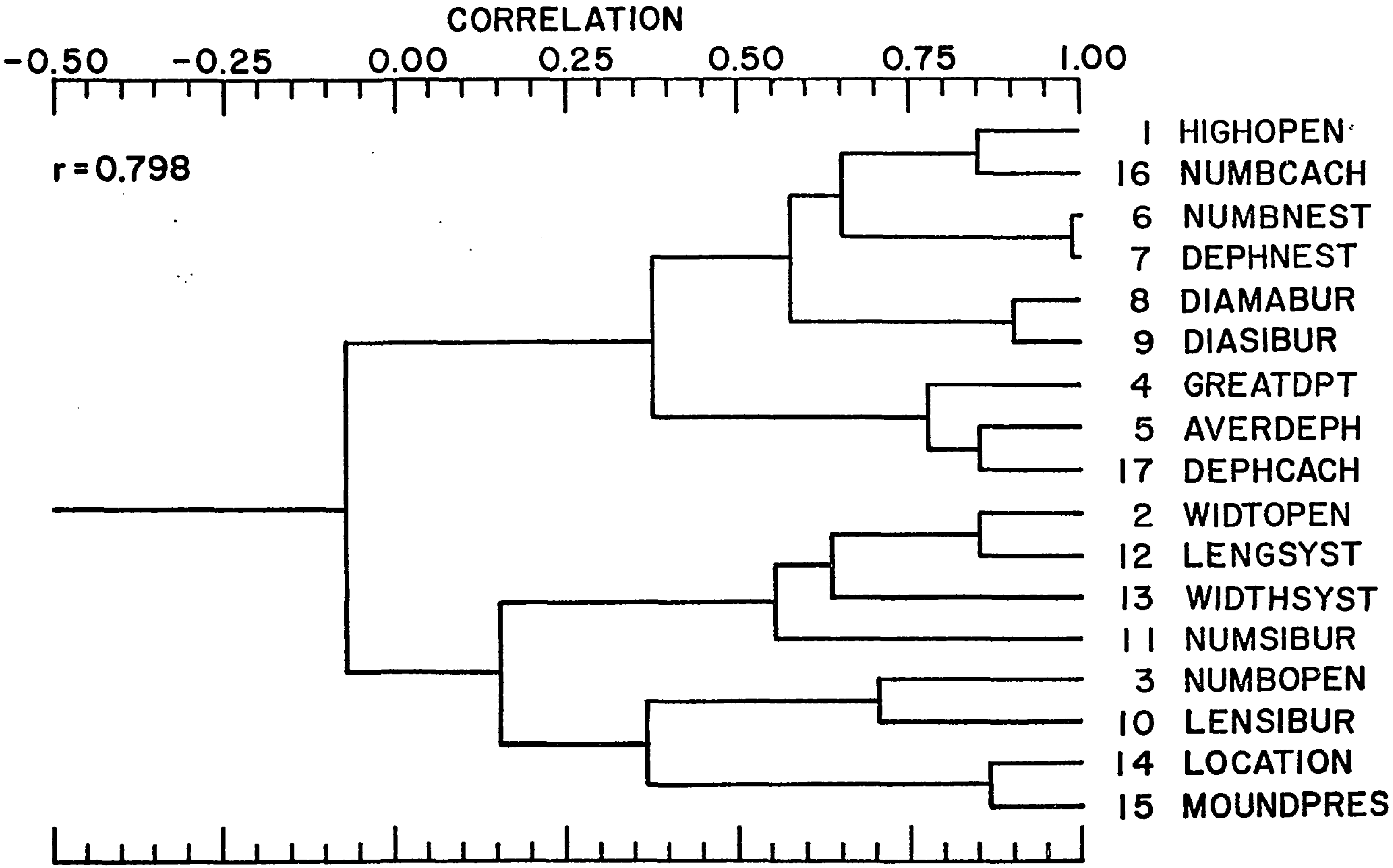

CORRELATION
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
r = 0.798
1 HIGHOPEN
16 NUMBCACH
6 NUMBNEST
7 DEPHNEST
8 DIAMABUR
9 DIASIBUR
4 GREATDPT
5 AVERDEPH
17 DEPHCACH
2 WIDTOPEN
12 LENGSYST
13 WIDTHSYST
11 NUMSIBUR
3 NUMBOPEN
10 LENSIBUR
14 LOCATION
15 MOUNDPRES

FIG. 4. Phenograms constructed from correlation and distance matrices for male (A and C, respectively) and female (B and D, respectively) kangaroo rats from Baja California. Clusters were obtained using the UPGMA. Accuracy of the diagrams in depicting interpopulation relationships increases from left to right. Numeral identifications are the same as listed in Table 1.

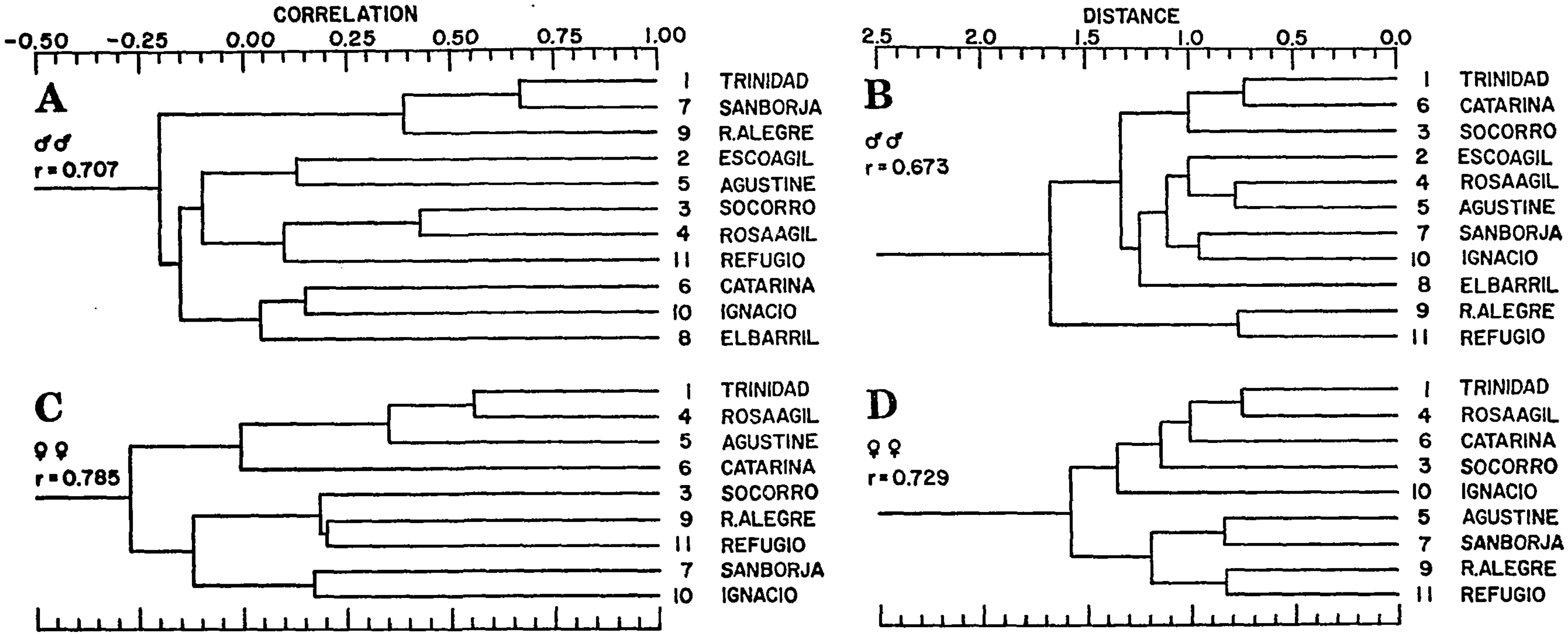

CORRELATION
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
A
♂♂
r = 0.707
1 TRINIDAD
7 SANBORJA
9 R.ALEGRE
2 ESCOAGIL
5 AGUSTINE
3 SOCORRO
4 ROSAAGIL
11 REFUGIO
6 CATARINA
10 IGNACIO
8 ELBARRIL
DISTANCE
2.5
2.0
1.5
1.0
0.5
0.0
B
♂♂
r = 0.673
1 TRINIDAD
6 CATARINA
3 SOCORRO
2 ESCOAGIL
4 ROSAAGIL
5 AGUSTINE
7 SANBORJA
10 IGNACIO
8 ELBARRIL
9 R.ALEGRE
11 REFUGIO
C
♀♀
r = 0.785
1 TRINIDAD
4 ROSAAGIL
5 AGUSTINE
6 CATARINA
3 SOCORRO
9 R.ALEGRE
11 REFUGIO
7 SANBORJA
10 IGNACIO
D
♀♀
r = 0.729
1 TRINIDAD
4 ROSAAGIL
6 CATARINA
3 SOCORRO
10 IGNACIO
5 AGUSTINE
7 SANBORJA
9 R.ALEGRE
11 REFUGIO

FIG. 5. Phenograms constructed from matrices of correlation and distance for 11 localities in Baja California, depicting temperature (A and B, representing correlation and distance phenograms, respectively), precipitation (C and D), vegetation (E and F), and burrow variation (G and H). Numeral identifications are the same as listed in Table 1.

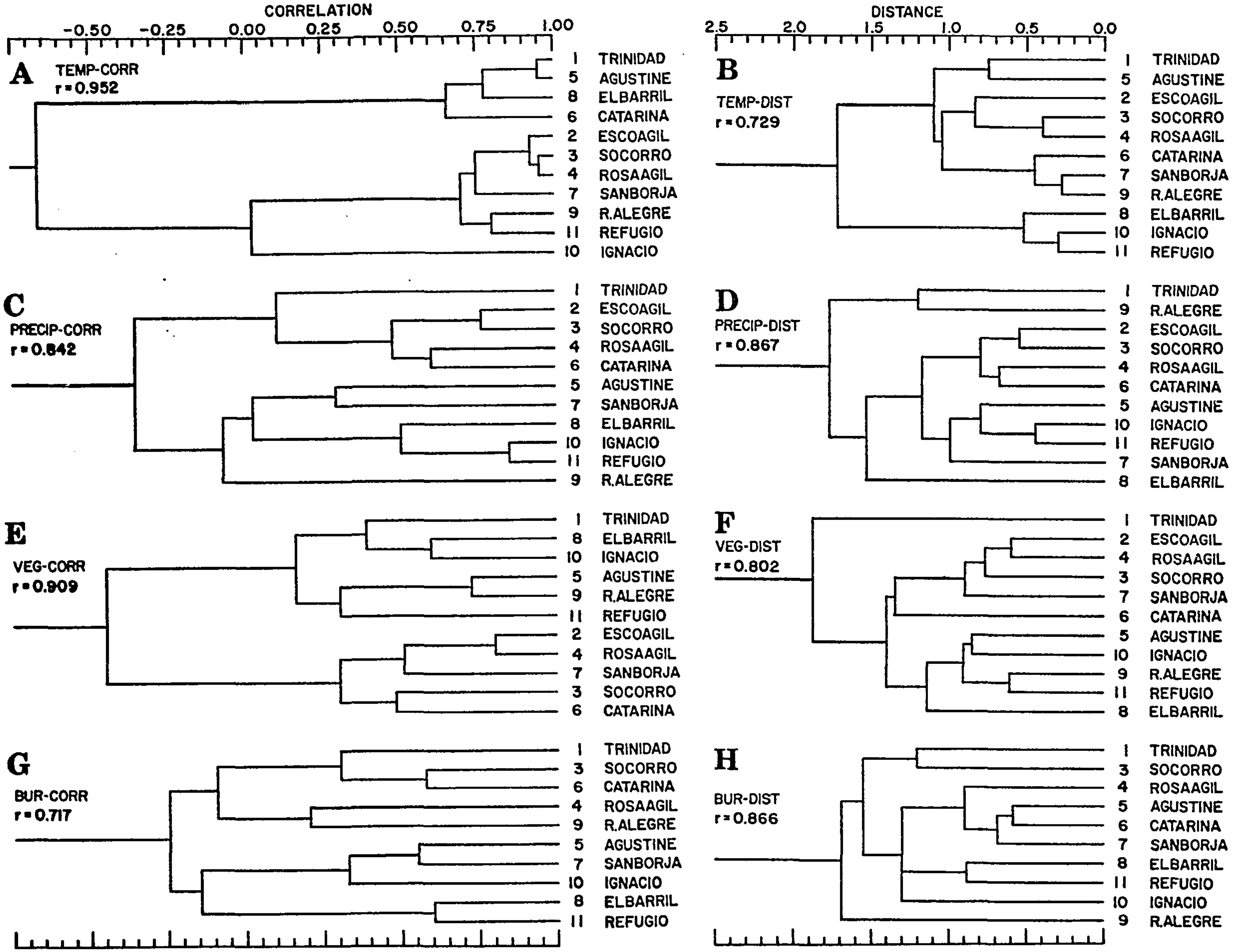
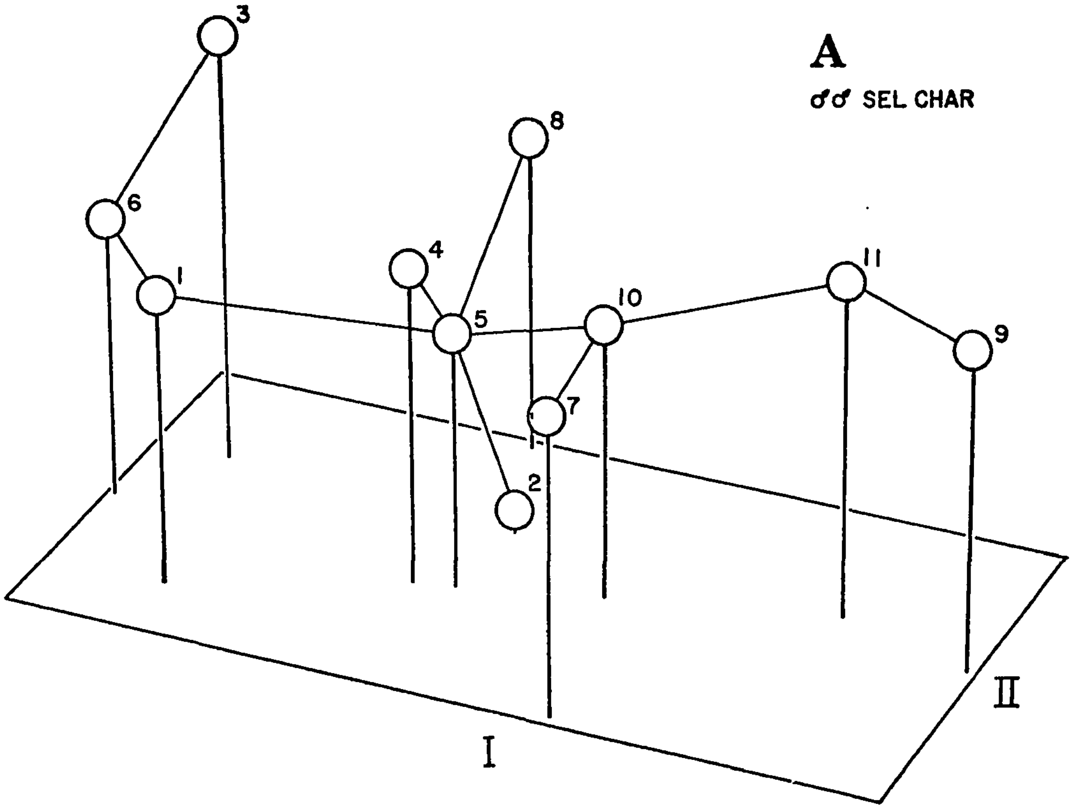

CORRELATION
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
DISTANCE
2.5
2.0
1.5
1.0
0.5
0.0
A
TEMP-CORR
r=0.952
1 TRINIDAD
5 AGUSTINE
8 ELBARRIL
6 CATARINA
2 ESCOAGIL
3 SOCORRO
4 ROSAAGIL
7 SANBORJA
9 R.ALEGRE
11 REFUGIO
10 IGNACIO
B
TEMP-DIST
r=0.729
1 TRINIDAD
5 AGUSTINE
2 ESCOAGIL
3 SOCORRO
4 ROSAAGIL
6 CATARINA
7 SANBORJA
9 R.ALEGRE
8 ELBARRIL
10 IGNACIO
11 REFUGIO
C
PRECIP-CORR
r=0.842
1 TRINIDAD
2 ESCOAGIL
3 SOCORRO
4 ROSAAGIL
6 CATARINA
5 AGUSTINE
7 SANBORJA
8 ELBARRIL
10 IGNACIO
11 REFUGIO
9 R.ALEGRE
D
PRECIP-DIST
r=0.867
1 TRINIDAD
9 R.ALEGRE
2 ESCOAGIL
3 SOCORRO
4 ROSAAGIL
6 CATARINA
5 AGUSTINE
10 IGNACIO
11 REFUGIO
7 SANBORJA
8 ELBARRIL
E
VEG-CORR
r=0.909
1 TRINIDAD
8 ELBARRIL
10 IGNACIO
5 AGUSTINE
9 R.ALEGRE
11 REFUGIO
2 ESCOAGIL
4 ROSAAGIL
7 SANBORJA
3 SOCORRO
6 CATARINA
F
VEG-DIST
r=0.802
1 TRINIDAD
2 ESCOAGIL
4 ROSAAGIL
3 SOCORRO
7 SANBORJA
6 CATARINA
5 AGUSTINE
10 IGNACIO
9 R.ALEGRE
11 REFUGIO
8 ELBARRIL
G
BUR-CORR
r=0.717
1 TRINIDAD
3 SOCORRO
6 CATARINA
4 ROSAAGIL
9 R.ALEGRE
5 AGUSTINE
7 SANBORJA
10 IGNACIO
8 ELBARRIL
11 REFUGIO
H
BUR-DIST
r=0.866
1 TRINIDAD
3 SOCORRO
4 ROSAAGIL
5 AGUSTINE
6 CATARINA
7 SANBORJA
8 ELBARRIL
11 REFUGIO
10 IGNACIO
9 R.ALEGRE

FIG. 6. Three-dimensional projection of localities onto the first three principal component axes of variation in the matrix of correlations of 19 skin and skeletal characters of male (A) and female (B) Dipodomys from Baja California. The shortest simply-connected network, derived from the matrix of distance coefficients for the same characters, is superimposed on the principal component space to indicate where possible distortion may be present. Numeral identifications are the same as listed in Table 1.


3
A
♂♂ SEL CHAR
8
6
4
1
11
5
10
9
7
2
II
I

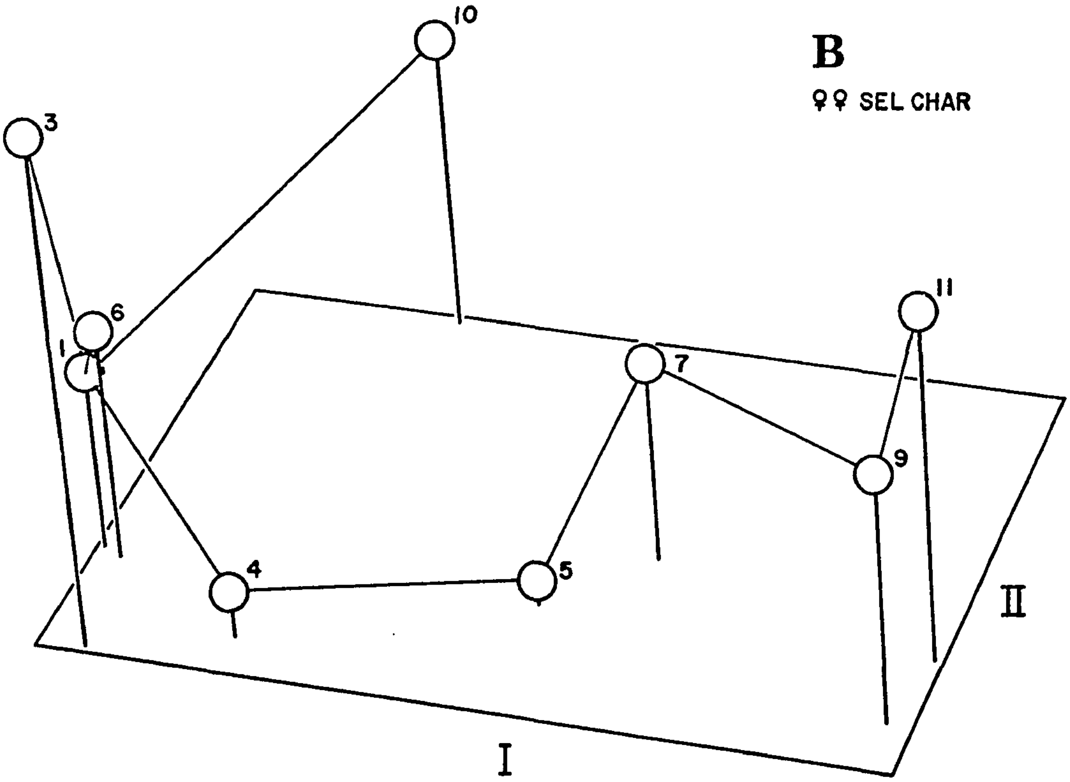

10
B
♀♀ SEL CHAR
3
6
1
11
7
9
4
5
II
I

FIG. 7. Three-dimensional projections of localities onto the first three principal component axes of variation in matrices of correlations of: (A) 16 temperature; (B) 16 precipitation; (C) 14 vegetation; and (D) 17 burrow characters associated with Baja California *Dipodomys*. Numeral identifications are the same as listed in Table 1.

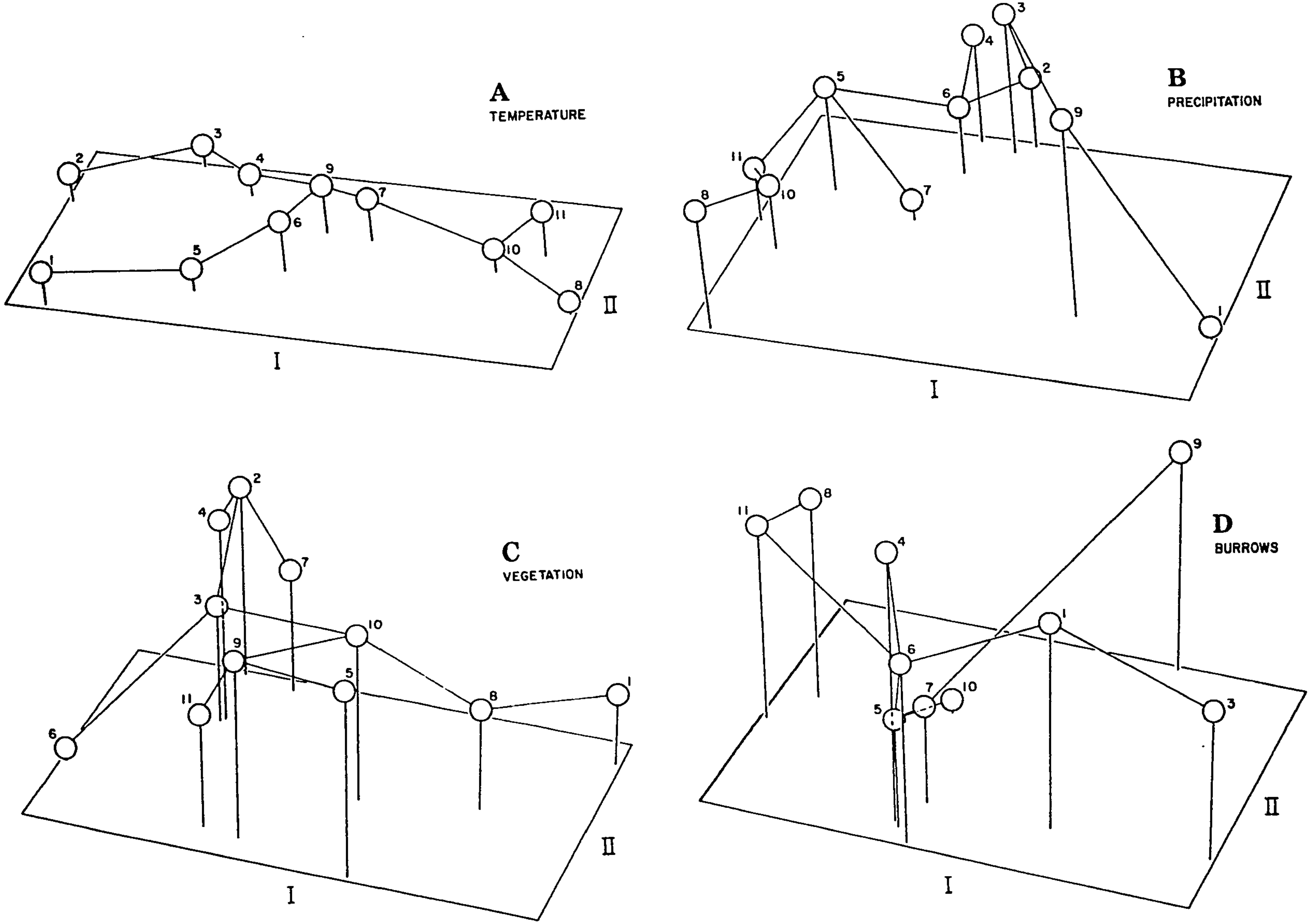
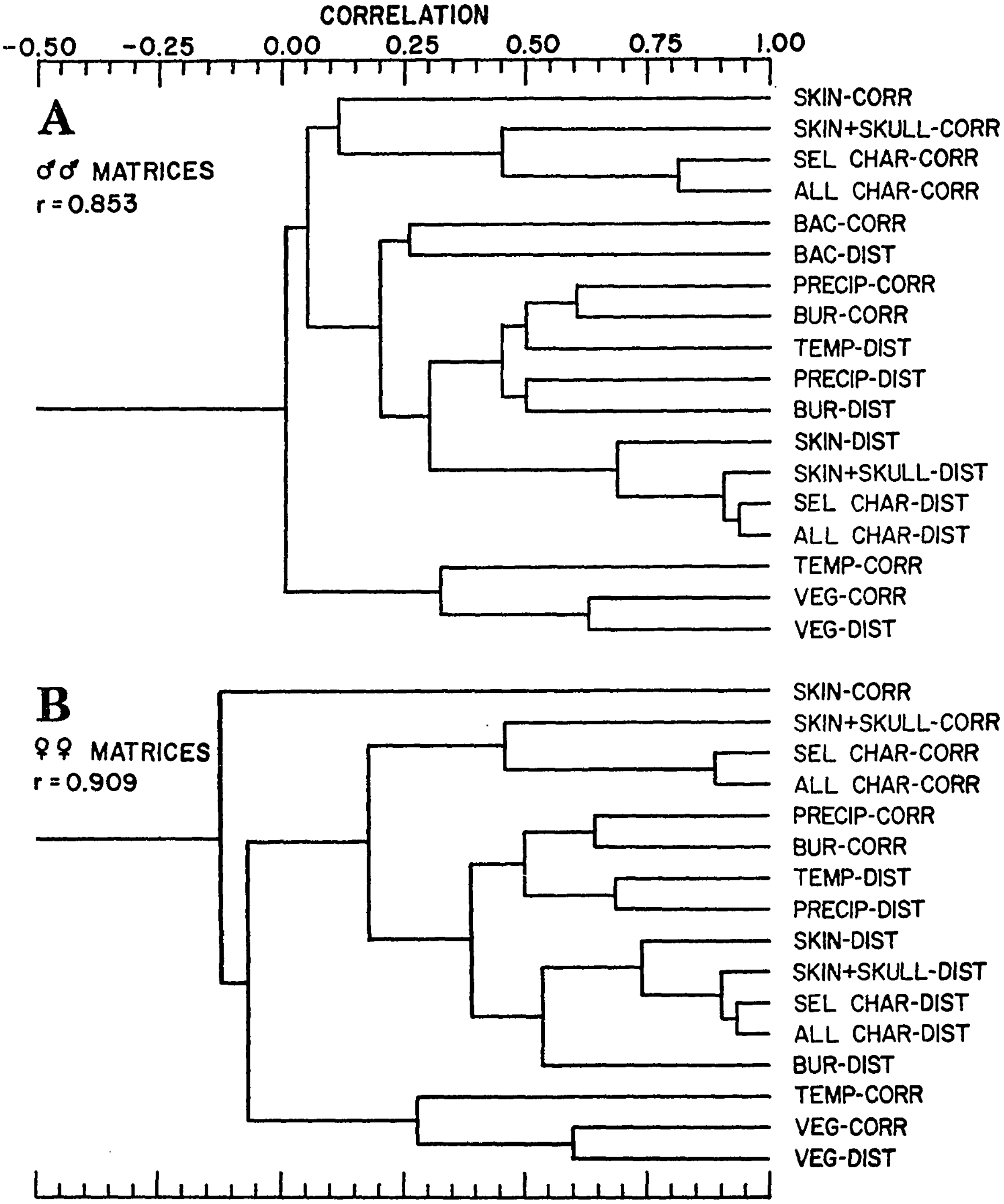

A
TEMPERATURE
1
2
3
4
5
6
7
8
9
10
11
I
II
B
PRECIPITATION
1
2
3
4
5
6
7
8
9
10
11
I
II
C
VEGETATION
1
2
3
4
5
6
7
8
9
10
11
I
II
D
BURROWS
1
3
4
5
6
7
8
9
10
11
I
II

FIG. 8. Phenograms of matrices constructed from matrices of correlation among 18 male (A) and 16 female (B) morphologic and environmental matrices. See the text for the characters included in each matrix.


CORRELATION
-0.50
-0.25
0.00
0.25
0.50
0.75
1.00
A
♂♂ MATRICES
r = 0.853
SKIN-CORR
SKIN+SKULL-CORR
SEL CHAR-CORR
ALL CHAR-CORR
BAC-CORR
BAC-DIST
PRECIP-CORR
BUR-CORR
TEMP-DIST
PRECIP-DIST
BUR-DIST
SKIN-DIST
SKIN+SKULL-DIST
SEL CHAR-DIST
ALL CHAR-DIST
TEMP-CORR
VEG-CORR
VEG-DIST
B
♀♀ MATRICES
r = 0.909
SKIN-CORR
SKIN+SKULL-CORR
SEL CHAR-CORR
ALL CHAR-CORR
PRECIP-CORR
BUR-CORR
TEMP-DIST
PRECIP-DIST
SKIN-DIST
SKIN+SKULL-DIST
SEL CHAR-DIST
ALL CHAR-DIST
BUR-DIST
TEMP-CORR
VEG-CORR
VEG-DIST

TABLES

TABLE 1. Localities where samples of kangaroo rats from Baja California were collected for use in this study and the nearest weather station, locality, and elevation data for each

Pop. No.	Code Name	Collecting Localities	Nearest Weather Station[1]			
			Location	Elevation (m)	Latitude	Longitude
1	TRINIDAD	Valle de Trinidad 4 mi. S Valle de Trinidad W end Valle de Trinidad	Valle de la Trinidad, B.C.N.	900	31°10'30"	115°46'30"
2	ESCOAGIL	2 mi. E Colonia Guerrero 8.5 mi. N San Quintin	Las Escobas, B.C.N.	24	30°20'30"	115°53'30"
3	SOCORRO	12 mi. N El Rosario	El Socorro, B.C.N.	10	30°20'00"	115°49'00"
4	ROSAAGIL	6 mi. E El Rosario	El Rosario, B.C.N.	15	30°00'30"	115°43'30"
5	AGUSTINE	San Agustine	San Agustin, B.C.N.	580	29°50'30"	115°00'00"
6	CATARINA	Santa Catarina Landing	Santa Catarina (Sur), B.C.N.	450	29°40'30"	115°09'30"
7	SANBORJA	Mission de San Borjas	San Borja, B.C.N.	375	28°40'00"	113°56'00"
8	ELBARRIL	7 mi. W San Francisquito Bay	El Barril, B.C.N.	100	28°10'30"	112°54'00"
9	R.ALEGRE	2.5 mi. W Mesquital	Rancho Alegre, B.C.N.	500	28°10'00"	113°53'00"
10	IGNACIO	10 mi. E San Ignacio	San Ignacio, B.C.S.	105	27°10'30"	112°54'00"
11	REFUGIO	4.5 mi. N El Refugio	El Refugio, B.C.S.	29	24°40'30"	111°45'30"

[1] Taken from Hastings and Humphrey (1969).

TABLE 2. Character loadings of the first three principal components of interlocality morphologic variation

Char. No.[1]	Character	Sex	Principal Components		
			I	II	III
Skin					
3	Tail length	♂♂	.548	-.685	.218
		♀♀	.863	-.096	.274
4	Hind foot length	♂♂	.691	.333	.191
		♀♀	.538	-.681	.262
5	Ear length	♂♂	.725	-.167	.391
		♀♀	.803	-.224	.003
Skull					
7	Greatest length	♂♂	.954	.202	-.080
		♀♀	.924	-.161	-.243
9	Interorbital width	♂♂	.702	-.077	-.503
		♀♀	.676	.214	-.570
10	Nasal length	♂♂	.844	.360	-.052
		♀♀	.781	-.541	-.112
11	Intermaxillary width	♂♂	.817	-.032	-.009
		♀♀	.849	-.161	-.469
12	Alveolar length	♂♂	.538	-.316	-.303
		♀♀	.389	.501	-.585
15	Basioccipital length	♂♂	.558	.340	-.684
		♀♀	.653	.212	-.258
16	Greatest depth	♂♂	.950	.108	-.027
		♀♀	.831	-.057	-.289
17	Greatest width	♂♂	.881	-.103	.136
		♀♀	.973	-.114	-.143
19	Nasal width	♂♂	.720	.493	.304
		♀♀	.574	.623	.063
Post-cranial skeleton					
23	Ulna length	♂♂	.784	.277	.250
		♀♀	.531	.754	.211
28	Scapula width	♂♂	.839	-.249	.373
		♀♀	.599	.577	.461
30	Scapula depth	♂♂	.891	-.081	-.022
		♀♀	.637	.094	.309
36	Femur proximal width	♂♂	.894	-.203	.075
		♀♀	.916	.023	.315
38	Pelvis depth	♂♂	.941	-.118	.040
		♀♀	.890	.195	.125
40	Pelvic foramen length	♂♂	.740	-.266	-.563
		♀♀	.728	-.514	.284
42	Number fused vertebrae	♂♂	-.021	-.832	-.053
		♀♀	-.315	-.106	-.833
Percent of total variation explained		♂♂	59.1	11.7	9.0
		♀♀	53.5	14.9	13.3

---

[1] Character numbers correspond to the 19 selected characters used by Best (1976*b*).

TABLE 3. Character loadings of the first three principal components of interlocality temperature and precipitation variation

Char. No.	Character	Temperature			Precipitation		
		I	II	III	I	II	III
1	January mean	.853	-.516	-.004	.658	-.446	.503
2	February mean	.893	-.435	-.080	.973	-.113	.067
3	March mean	.951	-.302	-.002	.931	-.036	.105
4	April mean	.993	-.054	-.061	.729	-.380	-.366
5	May mean	.983	.108	-.122	.527	-.353	-.257
6	June mean	.871	.465	-.150	.728	.177	.338
7	July mean	.808	.584	-.004	.511	.817	.006
8	August mean	.818	.565	.082	.202	.835	-.442
9	September mean	.924	.347	.134	-.334	.864	.104
10	October mean	.994	.057	.063	.227	.747	.167
11	November mean	.933	-.327	.066	.912	.240	.304
12	December mean	.908	-.407	.070	.667	-.038	-.371
13	Winter mean	.892	-.452	-.004	.936	-.161	-.030
14	Spring mean	.994	-.081	-.062	.806	-.102	-.295
15	Summer mean	.839	.543	-.024	.228	.869	-.230
16	Fall mean	.993	.050	.099	.169	.865	.201
Percent of total variation explained		84.2	14.6	0.6	43.3	29.9	7.7

TABLE 4. Character loadings of the first three principal components of interlocality vegetation variation

Char. No.	Character	Principal Components		
		I	II	III
1	Total percent cover	.139	-.932	.098
2	Number of species present	-.562	-.402	-.557
3	Number of transect intercepts	-.719	-.211	-.582
4	Average size of plants[1]	.924	-.235	.098
5	Number of bare areas	-.609	-.707	.304
6	Average size of bare areas	.326	.908	-.011
7	Percent covered by debris[2]	.670	-.481	-.329
8	Percent covered by rocks[3]	.643	-.341	-.342
9	No. intercepts of most frequent species	-.344	-.678	.458
10	No. intercepts of 2nd most frequent species	.704	-.010	.341
11	No. intercepts of 3rd most frequent species	.938	-.133	.103
12	Greatest average intercept length	.875	-.294	-.159
13	2nd greatest average intercept length	.912	.055	-.211
14	3rd greatest average intercept length	.807	-.137	-.067
Percent of total variance explained		48.5	24.2	10.0

[1] The total length of plant intercepts divided by the total number of intercepts.

[2] The total length of bare area intercepts divided by the total number of bare area intercepts.

[3] Debris includes dead and decomposing vegetative matter.

TABLE 5. Character loadings of the first three principal components of interlocality burrow variation

Char. No.	Character	Principal Components		
		I	II	III
1	Height of opening	.803	-.463	.210
2	Width of opening	.099	-.906	.219
3	Number of surface openings	-.510	-.539	-.031
4	Greatest depth of system	.784	-.036	-.571
5	Average depth of system	.574	-.114	-.677
6	Number of nests	.838	.324	.039
7	Average depth of nests	.876	.294	-.024
8	Average diameter of main burrow	.737	-.183	.313
9	Average diameter of side burrows	.669	-.334	.457
10	Average length of side burrows	-.116	-.255	-.203
11	Number of side burrows	-.149	-.802	.175
12	Greatest length of system	.077	-.830	.184
13	Greatest width of system	.203	-.796	-.480
14	Location[1]	-.565	-.199	-.421
15	Mound present	-.609	-.287	-.347
16	Number of food caches	.794	-.035	.129
17	Average depth of food caches	.647	-.113	-.593
Percent of total variance explained		36.1	22.6	12.9

[1] I determined whether the burrow was under vegetation or not.

TABLE 6. Product-moment correlation coefficients calculated between the first three principal components of morphologic variation and 15 ecogeographic variables[1]

Variable	Sex	Principal Components I	Principal Components II	Principal Components III
Latitude	♂♂	-.698*	.238	-.232
	♀♀	-.729*	.392	-.314
Longitude	♂♂	-.655*	.250	-.255
	♀♀	-.731*	.530	-.268
Altitude	♂♂	-.137	.586	.026
	♀♀	-.110	.063	-.429
Temperature- January mean	♂♂ ♀♀	.475 .484	-.353 -.282	.453 .441
Temperature- July mean	♂♂ ♀♀	.201 .326	-.133 -.715*	.247 -.154
Temperature- Principal Component I	♂♂ ♀♀	.453 .594	-.325 -.589	.374 .242
Temperature- Principal Component II	♂♂ ♀♀	-.219 -.179	.203 -.258	-.181 -.393
Precipitation- January mean	♂♂ ♀♀	-.109 -.113	.052 .715*	.086 .346
Precipitation- July mean	♂♂ ♀♀	.357 .218	.146 -.190	.155 .055
Precipitation- Principal Component I	♂♂ ♀♀	-.198 -.283	.401 .421	-.066 -.029
Precipitation- Principal Component II	♂♂ ♀♀	.358 .409	-.133 -.431	.246 .015
Vegetation- Principal Component I	♂♂ ♀♀	.026 -.058	.027 -.287	.081 -.266
Vegetation- Principal Component II	♂♂ ♀♀	.385 .533	-.258 -.019	.302 -.076
Burrows- Principal Component I	♂♂ ♀♀	-.309 -.416	.233 .411	.444 .332
Burrows- Principal Component II	♂♂ ♀♀	-.718* -.586	.355 .214	-.114 -.308

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[1] For values marked (*) *r* is significant at $P<0.05$.

TABLE 7. Covariation of the first three principal components of burrow variation with 13 ecogeographic variables[1]

Variable	Principal Components I	II	III
Latitude	.654*	.505	.165
Longitude	.707*	.572	.237
Altitude	.304	.110	.031
Temperature-January mean	-.481	-.429	-.130
Temperature-July mean	-.759*	-.274	-.261
Temperature-Principal Component I	-.770**	-.474	-.213
Temperature-Principal Component II	-.232	.135	-.079
Precipitation-January mean	.900**	-.089	.298
Precipitation-July mean	.131	-.684*	.107
Precipitation-Principal Component I	.716*	-.057	.383
Precipitation-Principal Component II	-.321	-.661*	-.024
Vegetation-Principal Component I	-.101	-.219	-.079
Vegetation-Principal Component II	-.297	-.342	-.013

[1] For values marked (**) $\underline{r}$ is significant at $P \leq 0.01$; for those marked (*) $P \leq 0.05$.

APPENDICES

APPENDIX I

Tables 1 (males) and 2 (females) list the character mean, standard deviation, and sample size for 42 skin and skeletal measurements of kangaroo rats (Dipodomys) for each of the OTUs (There are no data for female OTUs ESCOAGIL and ELBARRIL). Values are given as: sample size (mean; standard deviation). The characters used are as follows: 01, total length of specimen; 02, body length; 03, tail length; 04, hind foot length; 05, ear length; 06, basal length of skull; 07, greatest length of skull; 08, maxillary arch spread; 09, interorbital width; 10, nasal length; 11, intermaxillary width; 12, alveolar length; 13, lacrimal length; 14, maxillary arch spread; 15, basioccipital length; 16, greatest depth of skull; 17, greatest width of skull; 18, zygomatic width; 19, nasal width; 20, mandible length; 21, mandible depth; 22, radius length; 23, ulna length; 24, humerus length; 25, humerus distal width; 26, humerus proximal width; 27, clavicle length; 28, scapula width; 29, scapula length; 30, scapula depth; 31, tibia length; 32, tibia distal width; 33, tibia proximal width; 34, femur length; 35, femur distal width; 36, femur proximal width; 37, pelvis length; 38, pelvis depth; 39, pelvic foramen length; 40, pelvic foramen width; 41, width fused vertebrae; 42, number of fused vertebrae.

Table 1

CHAR.	OTU				
	TRINIDAD	ESCOAGIL	ESCOGRAV	SOCORRO	ROSAAGIL
01	17(276.7;13.20)	1(285.0; —)	7(298.0; 4.24)	0(—; —)	3(278.3; 4.62)
02	20(112.0; 6.22)	2(116.5; 0.71)	8(124.3; 2.82)	2(111.0; 2.83)	3(115.7; 1.53)
03	17(164.9;12.87)	1(169.0; —)	7(173.7; 4.79)	0(—; —)	3(162.7; 5.86)
04	20(41.9; 1.12)	2(41.5; 2.12)	8(44.5; 0.54)	2(41.5; 0.71)	3(43.0; 1.00)
05	20(17.1; 1.36)	2(16.5; 0.71)	8(15.5; 0.93)	2(17.0; 0.00)	3(17.0; 0.00)
06	19(21.3; 0.56)	2(21.5; 0.57)	8(22.0; 0.52)	2(21.3; 0.21)	3(21.9; 0.40)
07	18(38.8; 0.84)	2(39.3; 0.35)	7(39.5; 0.35)	2(38.0; 0.43)	3(39.5; 0.45)
08	20(20.5; 0.89)	2(20.8; 0.00)	7(22.4; 1.11)	2(20.3; 0.07)	3(20.9; 0.69)
09	20(10.4; 0.39)	2(10.9; 0.02)	8(10.7; 0.38)	2(10.2; 0.07)	3(10.2; 0.36)
10	20(13.7; 0.58)	2(13.9; 0.02)	8(14.1; 0.37)	2(13.5; 0.43)	3(13.9; 0.42)
11	20(7.4; 0.19)	2(7.4; 0.07)	8(7.9; 0.08)	2(7.1; 0.14)	3(7.2; 0.21)
12	20(4.8; 0.26)	2(5.1; 0.50)	8(5.4; 0.23)	2(4.9; 0.14)	3(4.9; 0.27)
13	20(3.5; 0.20)	2(3.4; 0.28)	8(4.2; 0.34)	2(3.3; 0.14)	3(3.7; 0.27)
14	20(4.9; 0.25)	2(5.2; 0.00)	8(5.7; 0.42)	2(4.6; 0.07)	3(5.1; 0.21)
15	19(5.5; 0.20)	2(5.8; 0.28)	7(5.9; 0.24)	2(5.1; 0.14)	3(5.5; 0.15)
16	18(13.2; 0.31)	2(13.4; 0.35)	8(13.3; 0.20)	2(13.1; 0.07)	3(13.4; 0.25)
17	19(24.5; 0.60)	2(24.5; 0.35)	8(25.1; 0.61)	2(23.8; 0.28)	3(24.8; 0.56)
18	19(18.9; 0.65)	2(18.4; 1.20)	8(20.8; 0.44)	2(18.0; 0.35)	3(19.4; 1.06)
19	20(3.6; 0.21)	2(3.5; 0.21)	8(3.8; 0.20)	2(3.6; 0.14)	3(3.7; 0.27)
20	20(15.9; 0.47)	2(16.2; 0.02)	8(17.2; 0.31)	2(15.7; 0.02)	3(16.2; 0.46)
21	20(6.9; 0.33)	2(7.1; 0.21)	8(7.7; 0.31)	2(6.9; 0.07)	3(7.1; 0.15)
22	20(17.3; 0.70)	2(17.8; 0.99)	8(19.3; 0.65)	2(17.6; 0.07)	3(17.8; 0.20)
23	20(21.0; 0.69)	2(21.3; 1.06)	8(23.3; 0.73)	2(21.5; 0.05)	3(21.6; 0.32)
24	20(13.9; 0.55)	2(14.1; 0.35)	8(15.7; 0.37)	2(13.9; 0.07)	3(14.4; 0.21)
25	20(4.3; 0.17)	2(4.2; 0.14)	8(4.9; 0.15)	2(4.1; 0.14)	3(4.3; 0.21)
26	20(3.5; 0.17)	2(3.6; 0.00)	8(4.1; 0.13)	2(3.5; 0.28)	3(3.7; 0.10)
27	20(8.7; 0.44)	2(8.9; 0.35)	8(10.0; 0.58)	2(8.2; 0.14)	3(8.8; 0.55)
28	17(7.6; 0.57)	2(7.8; 0.14)	6(8.9; 0.32)	2(8.0; 0.28)	2(7.9; 0.00)
29	18(15.9; 0.84)	2(16.4; 0.35)	6(18.0; 0.69)	2(15.8; 0.35)	2(16.5; 0.07)
30	20(2.5; 0.23)	2(2.7; 0.35)	8(3.0; 0.18)	2(2.6; 0.00)	3(2.7; 0.29)
31	19(36.4; 1.47)	2(37.1; 1.41)	8(41.5; 1.01)	2(37.7; 0.14)	3(38.0; 0.45)
32	20(4.0; 0.17)	2(3.9; 0.07)	8(4.5; 0.15)	2(3.9; 0.14)	3(4.1; 0.15)
33	20(5.0; 0.26)	2(5.0; 0.14)	8(5.9; 0.15)	2(4.9; 0.35)	3(5.2; 0.06)
34	20(26.8; 1.05)	2(27.5; 0.64)	8(30.7; 0.78)	2(27.1; 0.14)	3(28.1; 0.49)
35	20(4.7; 0.21)	2(4.8; 0.00)	8(5.6; 0.14)	2(4.6; 0.21)	3(4.9; 0.25)
36	20(2.9; 0.12)	2(3.1; 0.07)	8(3.3; 0.15)	2(3.0; 0.21)	3(3.1; 0.21)
37	20(29.2; 1.71)	2(30.1; 0.35)	8(33.9; 1.21)	2(29.0; 0.71)	3(31.5; 0.15)
38	20(10.6; 0.75)	2(11.2; 0.14)	8(12.2; 0.61)	2(10.3; 0.07)	3(11.6; 0.40)
39	20(8.6; 0.52)	2(8.9; 0.35)	8(10.6; 0.39)	2(8.9; 0.14)	3(9.4; 0.25)
40	20(3.4; 0.35)	2(4.0; 0.07)	8(4.4; 0.22)	2(3.4; 0.14)	3(3.6; 0.45)
41	20(8.9; 0.62)	2(9.1; 0.42)	8(10.7; 0.71)	1(9.4; —)	3(9.4; 0.51)
42	19(4.6; 0.51)	2(5.0; 0.00)	8(4.9; 0.35)	2(5.0; 0.00)	3(5.0; 0.00)

Table 1 Continued

	OTU				
CHAR.	ROSACRAV	ACUSTINE	CATARINA	SANBORJA	ELBARRIL
01	17(312.2; 6.94)	13(285.2; 9.72)	5(283.8; 7.19)	8(288.6;17.14)	2(300.0; 0.00)
02	17(132.3; 6.71)	19(116.3; 4.25)	7(115.9; 4.53)	8(121.6; 4.17)	2(120.5; 6.36)
03	17(179.9; 3.11)	13(168.2; 8.80)	5(167.0; 4.18)	8(167.0;15.19)	2(179.5; 6.36)
04	17(45.5; 0.94)	19(42.6; 1.21)	7(41.7; 0.76)	8(43.1; 1.13)	2(41.0; 1.41)
05	17(15.8; 0.95)	19(17.1; 0.78)	7(16.9; 0.38)	8(17.5; 0.76)	2(18.0; 0.00)
06	15(23.3; 0.36)	19(21.7; 0.45)	7(21.2; 0.39)	8(21.9; 0.42)	2(21.6; 0.21)
07	14(42.5; 0.41)	19(39.4; 0.84)	7(38.4; 0.84)	7(39.9; 1.10)	2(38.8; 0.28)
08	15(24.2; 0.26)	19(21.3; 0.50)	7(20.6; 0.58)	8(21.8; 0.29)	2(21.7; 0.02)
09	16(11.0; 0.31)	19(10.5; 0.39)	7(10.2; 0.22)	8(10.7; 0.35)	2(10.6; 0.21)
10	17(15.2; 0.40)	19(14.1; 0.42)	7(13.8; 0.49)	8(14.4; 0.30)	2(13.6; 0.21)
11	16(8.0; 0.15)	19(7.5; 0.17)	7(7.2; 0.19)	8(7.7; 0.18)	2(7.7; 0.07)
12	17(5.4; 0.18)	19(5.2; 0.23)	7(4.8; 0.35)	8(4.8; 0.24)	2(4.9; 0.07)
13	17(4.6; 0.25)	19(3.8; 0.22)	7(3.6; 0.26)	8(3.7; 0.31)	2(3.8; 0.07)
14	17(6.4; 0.21)	19(5.0; 0.20)	7(4.8; 0.20)	8(5.0; 0.23)	2(4.9; 0.07)
15	15(6.4; 0.25)	18(5.5; 0.18)	7(5.5; 0.24)	7(5.6; 0.15)	2(5.3; 0.28)
16	14(14.0; 0.24)	17(13.3; 0.29)	7(12.9; 0.28)	7(13.6; 0.40)	2(13.3; 0.02)
17	14(26.7; 0.81)	18(24.8; 0.61)	7(23.9; 0.65)	7(25.6; 0.74)	2(25.8; 0.14)
18	15(21.6; 0.63)	19(18.8; 0.61)	7(18.3; 0.66)	8(19.3; 0.63)	2(19.2; 0.07)
19	17(4.0; 0.12)	19(3.7; 0.18)	7(3.4; 0.16)	8(3.9; 0.16)	2(3.5; 0.28)
20	17(18.3; 0.34)	19(16.1; 0.44)	7(15.9; 0.32)	8(16.4; 0.39)	2(16.2; 0.35)
21	17(8.5; 0.29)	19(7.2; 0.25)	7(6.9; 0.18)	8(7.4; 0.41)	2(7.4; 0.07)
22	17(20.0; 0.34)	19(17.8; 0.48)	6(17.4; 0.39)	8(18.1; 0.44)	2(17.1; 0.07)
23	17(24.4; 0.41)	19(21.5; 0.57)	7(21.0; 0.45)	8(21.9; 0.42)	2(20.7; 0.07)
24	17(16.5; 0.33)	19(14.1; 0.41)	7(14.0; 0.35)	8(14.7; 0.40)	2(14.2; 0.21)
25	17(5.2; 0.13)	19(4.3; 0.11)	7(4.2; 0.12)	8(4.3; 0.08)	2(4.4; 0.00)
26	17(4.3; 0.02)	19(3.5; 0.02)	7(3.6; 0.02)	8(3.7; 0.17)	2(3.6; 0.07)
27	17(10.5; 0.39)	19(8.8; 0.49)	7(8.2; 0.27)	8(9.1; 0.49)	2(8.9; 0.14)
28	11(9.4; 0.45)	16(7.9; 0.35)	7(7.6; 0.28)	5(7.9; 0.34)	0(——; ——)
29	13(19.1; 0.69)	17(16.4; 0.55)	7(15.8; 0.32)	6(16.9; 0.45)	1(16.5; ——)
30	16(3.1; 0.15)	19(2.6; 0.16)	7(2.4; 0.03)	7(2.7; 0.11)	1(2.6; ——)
31	17(44.1; 0.80)	18(37.2; 1.23)	7(37.0; 0.63)	8(38.4; 0.59)	2(37.0; 0.85)
32	17(4.8; 0.18)	19(4.0; 0.19)	7(3.9; 0.18)	8(4.2; 0.14)	2(4.2; 0.28)
33	17(6.1; 0.21)	19(5.0; 0.21)	7(5.2; 0.19)	8(5.3; 0.26)	2(5.0; 0.14)
34	17(32.7; 0.69)	19(27.6; 0.80)	7(27.5; 0.65)	8(28.2; 0.54)	2(27.7; 0.57)
35	17(5.8; 0.23)	19(4.8; 0.16)	7(4.7; 0.12)	8(4.9; 0.13)	2(5.0; 0.14)
36	17(3.5; 0.14)	18(3.1; 0.16)	7(2.9; 0.14)	8(3.1; 0.14)	2(3.1; 0.00)
37	17(37.1; 0.62)	19(30.4; 0.79)	7(30.8; 3.53)	8(31.6; 0.73)	2(30.6; 0.14)
38	17(13.9; 0.29)	19(11.1; 0.51)	7(10.7; 0.61)	8(11.6; 0.58)	2(11.6; 0.07)
39	17(11.1; 0.24)	19(9.1; 0.39)	7(9.0; 0.39)	8(9.6; 0.27)	2(9.7; 0.14)
40	17(4.5; 0.24)	19(3.6; 0.23)	7(3.4; 0.10)	8(3.7; 0.36)	2(3.7; 0.14)
41	16(11.6; 0.46)	17(9.3; 0.48)	7(8.8; 0.35)	8(9.4; 0.25)	1(9.8; ——)
42	17(4.9; 0.59)	18(4.8; 0.38)	7(4.9; 0.38)	8(4.6; 0.52)	1(5.0; ——)

Table 1 Continued

	OTU		
CHAR.	R.ALEGRE	IGNACIO	REFUGIO
01	15(297.6; 9.18)	10(294.2;13.08)	22(301.7;10.92)
02	18(123.5; 4.12)	11(118.7; 8.44)	24(120.5; 4.70)
03	15(174.0; 8.90)	10(176.0; 7.76)	22(181.1;11.39)
04	18(43.2; 1.69)	11(44.4; 1.36)	24(44.2; 1.09)
05	18(18.8; 1.10)	11(18.4; 1.12)	24(17.9; 1.04)
06	17(22.6; 0.38)	11(22.2; 0.82)	24(22.1; 0.39)
07	16(40.9; 0.75)	10(40.0; 1.42)	18(40.2; 0.61)
08	18(22.4; 0.52)	11(21.4; 1.10)	23(21.3; 0.71)
09	18(10.9; 0.42)	11(10.8; 0.54)	24(10.5; 0.46)
10	18(14.4; 0.38)	11(14.4; 0.76)	23(14.4; 0.60)
11	18(7.9; 0.22)	11(7.5; 0.30)	24(7.6; 0.15)
12	18(5.1; 0.24)	11(4.9; 0.19)	24(5.1; 0.26)
13	18(3.9; 0.25)	11(3.7; 0.28)	24(3.8; 0.24)
14	18(5.2; 0.23)	11(4.9; 0.44)	24(5.1; 0.27)
15	16(5.7; 0.20)	10(5.5; 0.23)	21(5.6; 0.19)
16	16(13.7; 0.21)	10(13.4; 0.40)	19(13.7; 0.27)
17	16(26.1; 0.59)	10(25.2; 0.98)	20(25.8; 0.51)
18	17(19.6; 0.75)	11(19.1; 0.68)	24(19.2; 0.54)
19	18(3.9; 0.19)	11(3.6; 0.23)	23(3.7; 0.22)
20	18(17.0; 0.31)	11(16.1; 0.66)	24(16.5; 0.35)
21	18(7.8; 0.24)	11(7.5; 0.38)	24(7.6; 0.20)
22	18(18.6; 0.54)	11(17.6; 0.79)	24(18.2; 0.54)
23	18(22.3; 0.97)	11(21.4; 0.95)	24(22.1; 0.64)
24	18(14.9; 0.39)	11(14.2; 0.63)	24(14.6; 0.49)
25	18(4.6; 0.16)	11(4.4; 0.21)	24(4.6; 0.19)
26	18(3.8; 0.16)	11(3.6; 0.20)	24(3.8; 0.17)
27	17(9.3; 0.34)	11(8.8; 0.58)	24(9.0; 0.44)
28	16(8.6; 0.40)	9(7.8; 0.51)	21(8.4; 0.51)
29	16(17.7; 0.52)	9(16.2; 0.13)	21(16.9; 0.87)
30	15(2.8; 0.16)	11(2.7; 0.25)	24(2.8; 0.17)
31	18(39.6; 1.18)	10(37.8; 1.70)	24(39.2; 1.14)
32	18(4.4; 0.17)	11(4.1; 0.14)	24(4.4; 0.19)
33	18(5.4; 0.25)	11(5.3; 0.42)	24(5.6; 0.25)
34	18(29.5; 0.94)	11(28.0; 11.8)	24(29.1; 1.07)
35	18(5.1; 0.22)	11(4.9; 0.21)	23(5.2; 0.21)
36	18(3.4; 0.48)	11(3.0; 0.15)	24(3.3; 0.18)
37	18(32.9; 1.09)	11(30.7; 1.69)	24(32.2; 1.35)
38	18(12.6; 0.41)	11(11.6; 0.92)	24(12.3; 0.66)
39	18(10.0; 0.31)	11(9.4; 0.60)	24(9.6; 0.46)
40	18(3.8; 0.22)	11(3.8; 0.31)	24(3.8; 0.28)
41	18(10.1; 0.37)	11(9.1; 0.58)	24(9.9; 0.46)
42	18(4.9; 0.32)	11(4.9; 0.30)	24(4.9; 0.28)

Table 2

	OTU				
CHAR.	TRINIDAD	ESCOGRAV	SOCORRO	ROSAAGIL	ROSAGRAV
01	21(277.4;10.86)	5(289.0; 7.80)	0(---; ---)	2(283.5;14.90)	12(310.3; 7.04)
02	28(112.2; 5.11)	7(120.0; 7.77)	2(112.0; 7.07)	4(115.0; 5.42)	17(129.9; 6.27)
03	21(165.1; 7.87)	5(172.4; 4.51)	0(---; ---)	2(165.5; 7.78)	12(180.4; 4.54)
04	28(41.5; 1.69)	7(43.6; 1.40)	2(42.0; 1.41)	4(41.5; 1.00)	17(44.7; 1.17)
05	28(17.0; 1.17)	7(15.4; 1.62)	2(17.0; 1.41)	4(17.3; 0.96)	17(16.1; 0.86)
06	26(21.3; 0.51)	6(21.9; 0.55)	2(21.0; 0.71)	4(21.6; 0.18)	16(23.1; 0.42)
07	22(38.1; 2.13)	6(36.6; 7.35)	2(37.8; 0.85)	4(39.2; 0.64)	12(41.8; 0.57)
08	25(20.3; 0.81)	6(22.6; 1.02)	2(21.0; 0.28)	4(21.2; 0.95)	16(23.9; 0.96)
09	26(10.4; 0.45)	6(10.7; 0.54)	2(10.3; 0.14)	4(10.6; 0.14)	16(11.1; 0.56)
10	25(13.8; 0.61)	6(14.1; 0.43)	2(13.7; 0.50)	4(13.8; 0.49)	17(14.9; 0.32)
11	27(7.4; 0.20)	6(7.8; 0.33)	2(7.2; 0.14)	4(7.5; 0.24)	16(8.0; 0.14)
12	27(4.9; 0.33)	6(5.3; 0.22)	2(4.9; 0.64)	4(5.0; 0.14)	17(5.4; 0.18)
13	28(3.5; 0.26)	7(4.1; 0.26)	2(3.6; 0.21)	4(3.7; 0.22)	17(4.7; 0.27)
14	28(5.0; 0.27)	7(5.9; 0.35)	2(5.0; 0.42)	4(4.9; 0.25)	17(6.3; 0.31)
15	26(5.3; 0.25)	7(5.8; 0.17)	2(5.3; 0.07)	4(5.5; 0.13)	13(6.2; 0.17)
16	26(13.1; 0.27)	7(13.4; 0.24)	2(12.8; 0.07)	4(13.1; 0.17)	14(14.0; 0.25)
17	26(24.3; 0.55)	6(25.1; 0.83)	2(23.9; 0.85)	4(24.5; 0.26)	15(26.1; 0.58)
18	28(18.6; 0.65)	7(20.7; 0.62)	2(18.0; 0.78)	4(18.8; 0.38)	15(21.3; 0.82)
19	26(3.6; 0.17)	6(3.7; 0.16)	2(3.7; 0.07)	4(3.6; 0.13)	17(3.9; 0.19)
20	28(15.9; 0.38)	7(17.2; 0.55)	2(15.8; 0.50)	4(16.4; 0.28)	17(18.2; 0.46)
21	28(7.0; 0.38)	7(7.6; 0.43)	2(6.7; 0.07)	4(7.3; 0.16)	17(8.3; 0.29)
22	28(17.1; 0.54)	7(19.3; 0.76)	2(17.8; 0.64)	4(17.7; 0.57)	17(19.6; 0.38)
23	28(20.8; 0.66)	7(23.3; 0.85)	2(21.4; 0.71)	4(21.4; 0.52)	17(23.7; 0.51)
24	28(13.8; 0.41)	6(15.5; 0.46)	2(13.9; 0.64)	4(14.2; 0.63)	17(16.0; 0.35)
25	28(4.2; 0.17)	6(4.9; 0.15)	2(4.3; 0.21)	4(4.3; 0.05)	17(5.1; 0.17)
26	28(3.5; 0.19)	6(4.1; 0.17)	2(3.4; 0.14)	4(3.7; 0.10)	17(4.2; 0.13)
27	28(8.6; 0.35)	7(9.7; 0.79)	2(8.4; 0.50)	4(8.6; 0.26)	17(10.3; 0.26)
28	25(7.7; 0.52)	7(8.7; 0.57)	2(8.0; 0.00)	4(7.5; 0.14)	14(8.9; 0.38)
29	27(15.9; 0.69)	7(17.8; 1.08)	2(15.8; 0.14)	4(16.0; 0.76)	14(18.8; 0.58)
30	27(2.6; 0.16)	7(3.0; 0.21)	2(2.7; 0.14)	4(2.7; 0.06)	17(3.1; 0.11)
31	27(36.2; 1.09)	7(41.1; 0.14)	2(36.5; 1.56)	4(37.2; 0.54)	17(42.8; 0.66)
32	28(4.0; 0.15)	7(4.5; 0.22)	2(3.8; 0.00)	4(4.1; 0.24)	17(4.7; 0.18)
33	28(5.0; 0.24)	7(5.9; 0.22)	2(4.9; 0.00)	4(5.1; 0.22)	17(6.1; 0.22)
34	27(26.7; 0.81)	7(30.2; 1.24)	2(27.1; 1.13)	4(27.6; 0.37)	17(31.8; 0.53)
35	28(4.6; 0.17)	7(5.6; 0.16)	2(4.7; 0.21)	4(4.8; 0.19)	17(5.7; 0.20)
36	28(2.9; 0.15)	7(3.3; 0.14)	2(3.1; 0.07)	4(3.0; 0.13)	17(3.4; 0.21)
37	28(29.2; 1.42)	7(33.7; 1.81)	2(29.0; 0.13)	4(30.1; 0.93)	17(35.9; 0.96)
38	28(10.1; 0.57)	7(12.0; 0.64)	2(10.3; 0.42)	4(10.4; 0.54)	17(12.6; 0.55)
39	28(8.9; 0.49)	7(10.7; 0.63)	2(9.0; 0.14)	4(9.3; 0.38)	17(11.4; 0.39)
40	28(3.3; 0.21)	7(4.2; 0.20)	2(3.3; 0.07)	4(3.1; 0.33)	17(4.4; 0.21)
41	28(8.8; 0.47)	7(10.5; 0.79)	2(8.7; 0.42)	4(9.1; 0.33)	17(11.2; 0.35)
42	28(4.9; 0.36)	7(4.9; 0.38)	2(4.5; 0.71)	4(5.0; 0.00)	17(4.9; 0.24)

Table 2 Continued

			OTU		
CHAR.	AGUSTINE	CATARINA	SANBORJA	R.ALEGRE	IGNACIO
01	12(284.5;12.00)	2(272.5; 3.50)	5(291.0; 5.30)	9(285.7;13.41)	8(283.0; 9.18)
02	13(117.0; 4.16)	3(114.3; 3.06)	5(117.2; 2.17)	17(117.7; 6.11)	9(116.3; 4.82)
03	12(167.1; 9.50)	2(159.5; 0.71)	5(173.8; 6.38)	9(170.1;10.97)	8(167.5; 7.07)
04	13(42.6; 1.45)	3(41.7; 1.16)	5(42.4; 1.14)	17(42.2; 1.13)	9(43.4; 1.01)
05	13(17.3; 0.75)	3(17.0; 0.00)	5(18.2; 1.10)	17(18.5; 1.28)	9(17.7; 0.71)
06	13(21.9; 0.28)	3(21.2; 0.15)	5(22.0; 0.27)	17(22.1; 0.48)	9(21.6; 0.86)
07	12(39.3; 0.85)	3(38.4; 0.69)	4(39.5; 0.40)	17(40.1; 1.00)	8(39.1; 1.28)
08	12(21.4; 0.72)	3(21.2; 0.10)	5(21.3; 0.76)	17(22.0; 0.89)	9(20.6; 1.17)
09	13(10.7; 0.51)	3(10.3; 0.63)	5(10.7; 0.47)	17(10.8; 0.36)	9(10.3; 0.59)
10	13(14.1; 0.47)	3(13.6; 0.36)	4(14.2; 0.50)	17(14.1; 0.43)	9(14.2; 0.57)
11	13(7.6; 0.27)	3(7.4; 0.10)	5(7.6; 0.13)	17(7.7; 0.21)	9(7.4; 0.17)
12	13(5.3; 0.41)	3(4.9; 0.21)	5(5.0; 0.17)	17(5.0; 0.27)	8(4.6; 0.21)
13	13(3.8; 0.22)	3(3.7; 0.21)	5(3.7; 0.19)	17(3.8; 0.36)	9(3.6; 0.39)
14	13(5.1; 0.28)	3(5.0; 0.21)	5(5.0; 0.22)	17(5.2; 0.30)	9(4.8; 0.25)
15	12(5.5; 0.33)	3(5.5; 0.29)	5(5.6; 0.09)	17(5.5; 0.26)	8(5.3; 0.13)
16	12(13.5; 0.25)	3(13.2; 0.06)	5(13.1; 0.22)	17(13.6; 0.30)	9(13.2; 0.34)
17	11(24.9; 0.59)	3(24.3; 0.21)	5(25.1; 0.63)	17(25.4; 0.65)	9(24.6; 0.94)
18	13(19.2; 0.54)	3(18.5; 0.11)	5(18.7; 0.27)	17(19.3; 0.57)	9(18.9; 0.50)
19	13(3.6; 0.19)	3(3.3; 0.12)	4(3.6; 0.24)	17(3.8; 0.18)	9(3.4; 0.19)
20	13(16.2; 0.34)	3(16.1; 0.21)	5(16.2; 0.17)	17(16.5; 0.46)	9(15.8; 0.50)
21	13(7.3; 0.34)	3(6.8; 0.15)	5(7.2; 0.20)	17(7.7; 0.29)	9(7.2; 0.18)
22	13(17.6; 0.44)	3(17.5; 0.57)	5(17.3; 0.59)	17(17.9; 0.58)	9(16.9; 0.50)
23	13(21.1; 0.84)	3(21.2; 0.62)	5(21.1; 0.55)	17(21.6; 0.65)	9(20.5; 0.63)
24	13(14.1; 0.40)	3(13.9; 0.23)	5(14.3; 0.38)	17(14.5; 0.45)	9(13.6; 0.47)
25	13(4.3; 0.14)	3(4.3; 0.10)	5(4.3; 0.11)	17(4.4; 0.14)	9(4.2; 0.14)
26	13(3.6; 0.17)	3(3.6; 0.17)	5(3.6; 0.09)	17(3.7; 0.18)	9(3.6; 0.18)
27	13(8.7; 0.41)	3(8.7; 0.40)	5(9.0; 0.15)	17(8.8; 0.33)	9(8.4; 0.44)
28	8(7.7; 0.53)	2(7.8; 0.14)	4(7.8; 0.17)	17(8.3; 0.42)	8(7.3; 0.54)
29	9(16.1; 0.35)	2(16.5; 0.64)	5(16.5; 0.68)	17(16.9; 0.75)	9(15.6; 1.06)
30	12(2.6; 0.19)	2(2.3; 0.07)	5(2.6; 0.23)	17(2.8; 0.18)	8(2.6; 0.28)
31	13(36.9; 1.08)	3(36.7; 1.36)	5(37.0; 0.74)	17(38.0; 0.95)	9(36.6; 1.10)
32	13(4.1; 0.16)	3(4.2; 0.00)	5(4.1; 0.06)	17(4.2; 0.17)	9(4.0; 0.20)
33	13(5.0; 0.24)	3(5.2; 0.20)	5(5.3; 0.20)	17(5.3; 0.34)	9(5.1; 0.26)
34	13(27.4; 0.76)	3(27.0; 0.67)	5(27.6; 0.37)	17(29.0; 2.89)	9(27.0; 0.92)
35	13(4.8; 0.18)	3(4.7; 0.06)	5(4.9; 0.15)	17(5.0; 0.18)	9(4.8; 0.16)
36	13(3.1; 0.15)	3(3.0; 0.10)	4(3.1; 0.13)	17(3.2; 0.17)	9(3.0; 0.15)
37	13(30.3; 0.96)	3(30.0; 1.45)	5(31.0; 0.86)	17(31.9; 1.58)	9(29.9; 1.56)
38	13(10.5; 0.28)	3(10.3; 0.06)	5(10.4; 0.60)	17(11.2; 0.56)	9(10.3; 0.94)
39	13(9.3; 0.47)	3(9.7; 0.29)	5(9.8; 0.33)	17(10.2; 0.42)	9(9.6; 0.55)
40	13(3.4; 0.41)	3(3.4; 0.17)	5(3.5; 0.45)	17(3.7; 0.24)	9(3.7; 0.21)
41	13(8.9; 0.39)	3(8.8; 0.40)	5(9.0; 0.33)	17(9.5; 0.60)	9(8.9; 0.56)
42	13(4.9; 0.56)	3(4.7; 0.58)	5(4.6; 0.55)	17(4.7; 0.49)	9(4.8; 0.44)

Table 2 Continued

	OTU
CHAR.	REFUGIO
01	14(299.0; 6.16)
02	19(118.6; 4.15)
03	14(179.9; 5.05)
04	19(43.3; 0.65)
05	19(17.6; 0.83)
06	18(22.0; 0.44)
07	18(40.0; 0.74)
08	18(21.0; 0.51)
09	18(10.5; 0.47)
10	19(14.2; 0.48)
11	19(7.6; 0.20)
12	19(5.0; 0.21)
13	19(3.8; 0.22)
14	19(4.5; 0.20)
15	19(5.6; 0.26)
16	19(13.6; 0.23)
17	19(25.6; 0.47)
18	18(19.0; 0.53)
19	19(3.7; 0.15)
20	19(16.3; 0.36)
21	19(7.5; 0.31)
22	19(17.7; 0.50)
23	19(21.6; 0.62)
24	19(14.2; 0.33)
25	19(4.6; 0.11)
26	19(3.8; 0.11)
27	19(8.7; 0.39)
28	17(8.3; 0.34)
29	18(16.9; 0.51)
30	19(2.8; 0.20)
31	17(37.9; 0.78)
32	18(4.3; 0.18)
33	19(5.4; 0.21)
34	19(28.3; 0.48)
35	19(5.1; 0.20)
36	19(3.2; 0.15)
37	19(31.5; 0.86)
38	19(11.1; 0.49)
39	19(9.9; 0.46)
40	19(3.7; 0.31)
41	18(9.5; 0.42)
42	19(4.6; 0.69)

APPENDIX II

Character means (^{o}C) for 16 temperature characters for each of the 11 weather stations used in Baja California. The mean temperature characters used are as follows: 01, January; 02, February; 03, March; 04, April; 05, May; 06, June; 07, July; 08, August; 09, September; 10, October; 11, November; 12, December; 13, Winter; 14, Spring; 15, Summer; 16, Fall. The weather stations are designated as follows: A, Valle de la Trinidad, B. C. N.; B, Las Escobas, B. C. N.; C, El Socorro, B. C. N.; D, El Rosario, B. C. N.; E, San Agustin, B. C. N.; F, Santa Catarina (Sur), B. C. N.; G, San Borja, B. C. N.; H, El Barril, B. C. N.; I, Rancho Alegre, B. C. N.; J, San Ignacio, B. C. S; K., El Refugio, B. C. S.

CHAR.	A	B	C	D	E	F	G	H	I	J	K
	Locality										
01	9.4	11.3	14.3	14.3	11.2	13.0	15.0	16.0	14.2	16.0	17.0
02	10.0	11.9	14.4	14.9	12.6	13.2	15.3	17.2	15.1	16.6	17.4
03	11.6	12.6	14.9	15.4	13.4	15.1	16.5	18.4	15.8	18.3	18.8
04	14.2	14.3	15.7	16.7	16.6	16.7	18.3	21.3	17.8	20.1	20.6
05	16.2	15.6	16.8	17.8	18.3	19.0	19.1	23.6	18.5	21.9	21.8
06	20.7	17.3	17.4	19.0	22.0	21.5	21.6	27.5	20.4	24.5	23.7
07	25.2	19.7	20.2	21.5	26.0	25.9	25.2	30.3	24.1	27.8	27.3
08	25.9	20.5	20.0	22.6	26.0	26.5	26.1	30.3	25.1	28.4	28.4
09	22.5	19.2	19.2	21.5	24.2	25.2	24.7	29.2	25.0	27.5	28.6
10	18.0	16.6	18.4	19.1	19.3	20.9	22.0	25.6	21.5	24.0	25.1
11	12.1	14.4	16.8	16.5	15.1	17.4	19.2	20.8	17.8	19.7	21.2
12	10.0	12.0	14.5	14.8	12.4	14.8	16.0	17.4	15.6	17.2	18.1
13	9.8	11.7	14.4	14.7	12.1	13.7	15.4	16.9	15.0	16.6	17.5
14	14.0	14.2	15.8	16.6	16.1	16.9	18.0	21.1	17.4	20.1	20.4
15	23.9	19.2	19.2	21.0	24.7	24.6	24.3	29.4	23.2	26.9	26.5
16	17.5	16.7	18.1	19.0	19.5	21.2	22.0	25.2	21.4	23.7	25.0

APPENDIX III

Character means (mm) for 16 precipitation characters for each of the 11 weather stations used in Baja California. The mean precipitation characters and the weather stations follow the same designations as those for temperature in Appendix II.

CHAR.	Locality										
	A	B	C	D	E	F	G	H	I	J	K
01	25.9	31.9	46.9	25.7	19.4	23.1	19.4	7.0	42.8	10.1	12.9
02	33.6	16.8	22.2	18.6	8.4	15.7	16.5	4.0	27.0	6.9	2.4
03	24.3	17.3	12.9	9.2	10.4	13.4	10.6	2.3	24.2	8.8	1.6
04	13.4	10.2	7.3	5.0	2.2	5.0	3.2	0.0	0.6	0.0	0.2
05	0.9	0.5	0.0	1.1	0.0	1.0	0.2	0.0	0.2	0.0	0.0
06	0.7	0.1	0.0	0.7	0.0	0.0	0.0	0.0	1.0	0.0	0.0
07	13.1	0.6	0.0	0.0	0.1	0.6	3.8	6.7	12.7	7.0	3.7
08	24.6	1.1	0.8	0.1	4.7	3.2	18.1	15.6	12.5	16.2	12.2
09	12.8	1.4	0.3	2.1	21.0	11.2	19.4	38.3	22.5	21.2	13.3
10	13.6	5.7	7.2	4.9	6.2	7.5	2.6	16.0	10.0	7.1	7.3
11	25.2	11.0	15.0	8.9	4.2	9.3	5.7	9.3	25.3	5.3	0.3
12	40.4	27.7	25.1	18.7	22.0	29.6	43.0	19.2	26.9	9.5	15.3
13	112.8	74.7	70.9	63.1	50.6	68.3	73.9	31.7	86.6	16.6	17.5
14	42.7	29.5	22.2	16.3	12.5	19.6	14.0	2.6	25.0	20.1	20.4
15	38.4	1.8	0.9	0.9	5.3	3.8	14.1	22.9	27.3	26.9	26.5
16	51.7	16.2	22.6	13.1	31.5	29.4	32.9	75.6	54.9	23.7	25.0

APPENDIX IV

Character means for 14 vegetation characters for each OTU in Baja California. OTU numbers refer to: 1, TRINIDAD; 2, ESCOAGIL; 3, ESCOGRAV; 4, SOCORRO; 5, ROSAAGIL; 6, ROSAGRAV; 7, AGUSTINE; 8, CATARINA; 9, SANBORJA; 10, ELBARRIL; 11, R.ALEGRE; 12, IGNACIO; 13, REFUGIO. The characters used are as follows: 01, total percent cover; 02, number of species present; 03, number of transect intercepts; 04, average size of plants (ft.); 05, number of bare areas; 06, average size of bare areas (ft.); 07, percent cover by debris; 08, percent covered by rocks; 09, number of intercepts of most frequent species; 10, number of intercepts of second most frequent species; 11, number of intercepts of third most frequent species; 12, greatest average intercept length (ft.); 13, second greatest average intercept length (ft.); 14, third greatest average intercept length (ft.).

	OTU												
	1	2	3	4	5	6	7	8	9	10	11	12	13
<u>CHAR.</u>													
01	50.2	60.5	22.6	45.2	29.9	30.1	12.7	13.3	42.9	30.5	10.2	31.5	12.9
02	3.7	6.0	2.4	7.4	5.1	2.7	2.0	9.3	8.9	6.9	3.4	4.3	5.7
03	16.2	51.7	38.9	63.8	25.9	17.4	8.4	113.2	42.9	17.0	9.4	18.0	24.4
04	6.5	2.4	1.2	1.4	2.3	3.5	3.6	0.3	2.0	3.6	2.2	3.6	1.1
05	11.2	28.8	45.8	23.5	24.6	25.0	9.2	15.6	20.9	9.7	11.4	12.4	10.5
06	8.4	2.8	3.4	4.7	5.7	5.6	23.3	11.5	5.5	14.3	15.8	11.2	16.8
07	4.1	1.4	0.0	1.4	1.4	4.4	1.5	1.3	3.6	3.6	1.7	1.9	1.3
08	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
09	26.8	122.2	221.4	21.9	122.2	222.6	23.0	20.2	121.5	22.0	21.5	24.4	20.1
10	2.5	1.9	0.8	2.4	1.6	3.7	2.9	0.1	2.2	4.3	2.6	3.9	1.0
11	7.5	2.9	0.4	2.4	2.5	4.0	5.9	0.1	4.2	6.4	3.5	3.3	2.2
12	6.8	2.2	1.4	2.3	2.2	2.6	4.2	1.6	4.2	4.5	1.5	4.4	2.1
13	7.5	2.9	0.8	2.0	1.6	3.7	5.5	2.1	2.2	8.0	2.6	3.9	3.3
14	4.6	1.9	0.4	2.7	2.5	4.0	2.0	0.7	1.5	5.1	1.8	3.3	3.1

APPENDIX V

Character mean, standard deviation, and sample size for 17 burrow characteristics of kangaroo rats (Dipodomys) for each of the OTUs (There are no burrow data for OTU ESCOAGIL). Values are given as: sample size (mean; standard deviation). The characters used are as follows: 01, height of opening (cm); 02, width of opening (cm); 03, number of openings; 04, greatest depth of the system (cm); 05, average depth of the system (cm); 06, number of nests; 07, average depth of nests (cm); 08, average diameter of main burrow (cm); 09, average diameter of side burrows (cm); 10, average length of side burrows (cm); 11, number of side burrows; 12, greatest length of system (cm); 13, greatest width of system (cm); 14, location (i.e., whether the burrow was under vegetation or not); 15, mound present; 16, number of food caches; 17, average depth of food caches (cm).

	OTU					
CHAR.	TRINIDAD	ESCOGRAV	SOCORRO	ROSAAGIL	ROSAGRAV	AGUSTINE
01	10(5.9; 0.99)	6(8.4; 1.88)	8(6.8; 1.01)	6(5.9; 1.28)	4(6.0; 1.47)	10(5.5; 1.34)
02	10(5.5; 0.89)	6(7.6; 0.87)	8(5.6; 0.73)	5(5.9; 1.56)	4(6.9; 1.75)	10(5.4; 0.82)
03	10(3.1; 2.60)	6(4.7; 5.09)	8(2.5; 0.76)	7(1.4; 0.79)	4(1.8; 0.50)	11(2.3; 1.68)
04	10(49.4; 12.57)	6(39.8; 5.64)	8(56.3; 16.42)	7(35.9; 10.54)	4(49.5; 24.77)	11(45.3; 19.47)
05	10(32.3; 6.54)	6(29.2; 4.36)	8(35.4; 6.99)	7(24.6; 7.14)	4(32.8; 10.81)	11(33.6; 7.99)
06	10(1.2; 1.81)	6(3.3; 2.07)	8(1.6; 1.06)	7(0.4; 0.54)	4(1.5; 1.29)	11(0.3; 0.47)
07	10(24.3; 21.36)	6(31.6; 7.05)	8(42.3; 23.75)	7(11.4; 14.51)	4(25.8; 20.04)	11(8.6; 15.10)
08	10(7.8; 3.15)	6(8.7; 0.52)	8(7.3; 0.38)	7(6.3; 0.81)	4(8.0; 0.82)	11(5.7; 0.75)
09	10(7.6; 0.83)	6(8.2; 0.98)	8(6.8; 0.53)	7(6.2; 0.76)	4(8.9; 2.84)	11(5.6; 0.70)
10	10(48.9; 15.69)	6(40.2; 10.31)	8(38.9; 16.91)	7(31.7; 14.93)	4(41.7; 3.04)	11(35.7; 10.49)
11	10(5.3; 5.19)	6(24.7; 11.89)	8(8.0; 3.97)	7(6.3; 1.89)	4(16.8; 3.95)	11(6.5; 4.06)
12	10(295.1;136.25)	6(584.8;459.29)	8(193.9; 49.43)	7(282.9;246.15)	4(353.8; 92.68)	11(225.6;116.15)
13	9(127.9; 71.25)	6(318.5;224.20)	8(170.1; 49.09)	7(125.7; 53.15)	4(280.0; 47.43)	11(138.7; 93.00)
14	10(0.3; 0.48)	6(0.0; 0.00)	8(0.0; 0.00)	7(0.3; 0.49)	4(0.0; 0.00)	11(0.3; 0.47)
15	10(0.0; 0.00)	6(0.0; 0.00)	8(0.0; 0.00)	7(0.1; 0.38)	4(0.3; 0.50)	11(0.1; 0.30)
16	10(1.8; 2.62)	6(10.7; 5.32)	8(4.4; 2.26)	7(2.9; 4.26)	4(9.0; 6.06)	11(2.2; 2.14)
17	10(18.1; 19.91)	6(29.2; 4.36)	8(27.5; 13.34)	7(14.5; 14.21)	4(37.4; 19.76)	11(27.7; 15.91)

Appendix V Continued

		OTU			OTU	
CHAR.	CATARINA	SANBORJA	ELBARRIL	R.ALEGRE	IGNACIO	REFUGIO
01	10(5.5; 0.44)	9(5.4; 0.64)	5(5.7; 1.18)	3(6.8; 0.58)	10(5.8; 1.28)	9(5.3; 1.20)
02	10(5.5; 0.78)	9(5.9; 1.61)	5(6.2; 0.59)	3(8.7; 4.04)	10(6.3; 0.93)	9(6.3; 0.81)
03	10(2.8; 1.14)	9(2.7; 0.87)	5(5.6; 4.04)	3(3.3; 0.58)	10(3.6; 1.78)	10(4.2; 2.70)
04	10(42.3; 18.81)	9(44.1; 13.30)	5(35.6; 17.01)	3(45.3; 10.50)	10(52.5; 16.65)	10(34.8; 10.20)
05	10(33.5; 10.96)	9(37.3; 12.29)	5(25.8; 11.32)	3(35.3; 4.16)	10(36.1; 8.81)	10(27.7; 5.27)
06	10(0.6; 0.70)	9(0.2; 0.44)	5(0.0; 0.00)	3(0.3; 0.58)	10(0.3; 0.48)	10(0.0; 0.00)
07	10(20.0; 25.59)	9(7.3; 14.97)	5(0.0; 0.00)	3(11.3; 19.63)	10(10.8; 17.69)	10(0.0; 0.00)
08	10(5.8; 0.88)	9(6.1; 0.49)	5(5.8; 0.23)	3(7.1; 0.36)	10(6.0; 0.99)	10(6.2; 0.63)
09	10(6.3; 2.04)	9(5.9; 0.64)	5(5.7; 0.25)	3(7.7; 2.08)	10(5.8; 0.68)	10(6.2; 0.63)
10	10(34.8; 11.53)	9(37.2; 10.89)	5(48.1; 7.08)	3(35.7; 12.16)	10(44.6; 10.55)	9(38.9; 7.18)
11	10(6.0; 2.06)	9(5.3; 2.74)	5(9.0; 8.89)	3(10.3; 5.51)	10(7.8; 3.46)	10(9.6; 4.97)
12	10(212.5; 63.20)	9(264.1; 86.52)	5(311.0;152.38)	3(436.0;325.37)	10(315.6;102.38)	10(224.9; 68.11)
13	10(136.5; 45.00)	9(177.0; 77.63)	5(167.2;101.69)	3(212.3;110.35)	10(211.6; 92.94)	10(140.5; 63.39)
14	10(0.1; 0.32)	9(0.0; 0.00)	5(0.4; 0.55)	3(0.0; 0.00)	10(1.0; 0.00)	10(0.6; 0.52)
15	10(0.0; 0.00)	9(0.0; 0.00)	5(0.2; 0.45)	3(0.0; 0.00)	10(0.8; 0.42)	10(0.9; 0.32)
16	10(1.9; 2.42)	9(0.7; 0.50)	5(1.4; 2.19)	3(3.0; 3.61)	10(2.0; 2.11)	10(0.4; 0.52)
17	10(15.6; 19.35)	9(27.7; 23.54)	5(11.4; 17.60)	3(26.5; 22.95)	10(25.4; 25.09)	10(9.8; 13.22)