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MENSURAL DISCRIMINATION OF THE SKULLS OF ARKANSAS *PEROMYSCUS*

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ABSTRACT

Twelve parameters were measured on skulls of four species of *Peromyscus* from Arkansas. Univariate statistical tests, multivariate analyses of variance, and principal axis factor analyses were performed on the data set and/or subsets in a search for species-level discriminating characters. Total length of skull was found to discriminate between skulls of *P. maniculatus*, *P. leucopus*, and a combined group of *P. attwateri* and *P. gossypinus*. Furthermore, the ratio of interorbital width and length of nasal bone was found to adequately discriminate between skulls of *P. attwateri* and *P. gossypinus*.

INTRODUCTION

Individual specimens of white-footed mice (*Peromyscus*) are notoriously difficult to discriminate to the species level from regions containing two or more species (Choate, 1973; Choate et al., 1979; Thompson and Conley, 1983). Arkansas is such a region, with four species of *Peromyscus* ranging throughout at least portions of the state (Sealander, 1979): the deer mouse, *P. maniculatus* (Wagner), the smallest member of the group and normally having a well furred, short, and distinctly bicolored tail; the white-footed mouse, *P. leucopus* (Rafinesque), somewhat larger and having a relatively longer and less furred tail; the Texas mouse, *P. attwateri* J. A. Allen, a large member of the genus and having a long and terminally tufted tail; and the cotton mouse, *P. gossypinus* (LeConte), another large member of the genus and having a tail with no terminal tuft. A closely related species, the golden mouse, *Ochrotomys nuttalli* (Harlan), superficially complicates the identification dilemma, but is readily discriminated by its more posteriorly lying posterior palatal foramen and its anteriorly perpendicular infra-orbital plate (Lowery, 1974).

While the skins of specimens of the four species of *Peromyscus* are, with practice, relatively easy to discriminate among, and while the species are fairly distinct ecologically (Sealander, 1979; Schwartz and Schwartz, 1981), attempts to accurately identify individual skulls can be frustrating and may result in only low probabilities of accurate classification. This study, then, was designed to search for a character and/or group of characters that would, with a very high degree of probability of accuracy, discriminate among the skulls of the four Arkansas species of *Peromyscus*.

METHODS AND MATERIALS

Adult, unbroken skulls of both sexes were selected from clearly diagnostic skins. Specimens were from throughout the Arkansas ranges of the species, and all are housed in the Collection of Recent Mammals of the Arkansas State University Museum of Zoology (ASUMZ). Our sample included: 41 specimens of *P. maniculatus*, 41 specimens of *P. leucopus*, 40 specimens of *P. attwateri*, and 31 specimens of *P. gossypinus*.

Twelve parameters were measured on each skull to the nearest 20th of a mm with dial calipers. Parameters were as defined by DeBlase and Martin (1974) and included: (A) length of maxillary tooth row, (B) total length of skull, (C) basonasal length, (D) breadth of palate at molar one, (E) breadth of palate at molar three, (F) width of interorbital constriction, (G) length of bony palate, (H) length of nasal bone, (I) zygomatic breadth, (J) greatest rostral width, (K) breadth of braincase, and (L) length of anterior palatine foramen.

All numerical analyses were performed on SAS (SAS Institute Inc.,

1979) through the University of Arkansas Computing Center. Analyses included routines computing simple univariate statistics, multivariate analyses of variance (acronymed MANOVA), and principal axis factor analyses.

RESULTS AND DISCUSSION

Investigation began with a multivariate analysis of variance performed on a combined data set of all four species. All 12 variables generated high F-values indicating that significant (at the 0.0001 level) variation existed among the species over all variables. MANOVA was followed by principal axis factor analysis on the combined data set. Factor loading scores were plotted along the first two principal factor axes (Fig. 1).

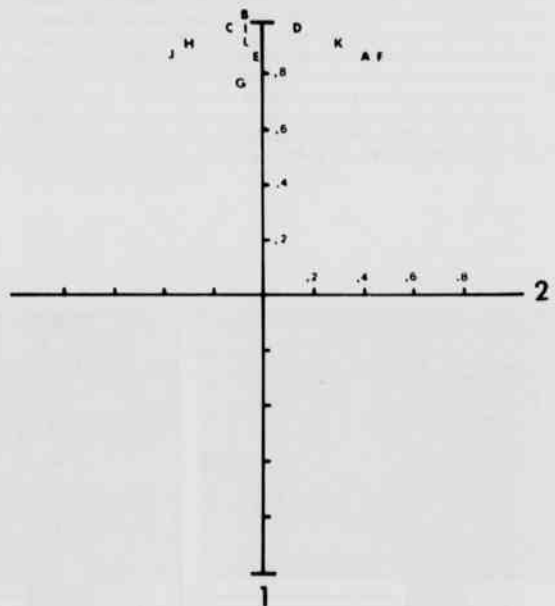


Figure 1. Factor loading scores for four species of *Peromyscus* plotted along the first and second principal factor axes. Alphabetic characters (A-L) as defined in Methods and Materials.

V. Rick McDaniel, Renn Tumison, and Phil McClarty

All variables correlated highly (0.7 or higher) with the first principal axis, and only weakly with the second principal axis (<0.5). This factor pattern is typical for craniometric data and suggests that factor axis 1 represents an axis of general skull size. Factor axis 1 accounted for 80.2% of the observed variation, while the second factor axis accounted for only an additional 6.3% of the observed variation. The lack of any well correlated variables prevents a reasonable biological interpretation of factor axis 2.

A plot of factor scores by species along the first and second principal factor axes revealed good separation along factor axis 1 of *P. maniculatus*, *P. leucopus*, and a combined group of *P. attwateri* and *P. gossypinus* (Fig. 2). In a multivariate sense, then, skulls of Arkansas specimens of *Peromyscus* can be reliably discriminated as belonging to one of three groups on the basis of general size. In this scheme, the smallest skulls are of *P. maniculatus*, the intermediate skulls are of *P. leucopus*, and the largest skulls are of *P. attwateri* and/or *P. gossypinus*.

In subsequent analyses, relationships and multivariate overlaps of pairs of species were examined more closely. Although some degree of

overlap existed among factor scores of *P. maniculatus* and *P. leucopus* (Fig. 3), the degree of overlap is quite small (in a multivariate sense) and discrimination at the species level is acceptably reliable as indicated by MANOVA generated F values at the 0.0001 level. Never-the-less, a check of univariate data revealed that no single parameter totally discriminates between the two species. Several characters, though, approached good (95% level) discriminatory power, including greatest length of skull (Fig. 4).

Slight overlap also existed among factor scores of *P. leucopus* and *P. attwateri* (Fig. 5). Again, multivariate overlap was slight and MANOVA generated F values were high for all variables except length of bony palate and greatest rostral width. Greatest length of skull again discriminated between the species at the 95% level (Fig. 4).

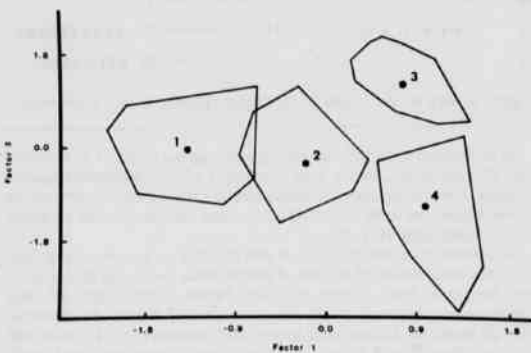


Figure 2. Factor scores by species plotted along the first and second principal factor axes. Polygons represent outlined perimeter values for each species and large dots represent mean values for each species. 1 = *P. maniculatus*, 2 = *P. leucopus*, 3 = *P. attwateri*, and 4 = *P. gossypinus*.

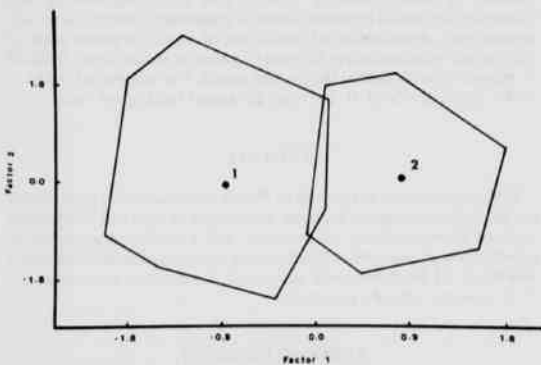


Figure 3. Factor scores of *P. maniculatus* and *P. leucopus*, as represented on Figure 2.

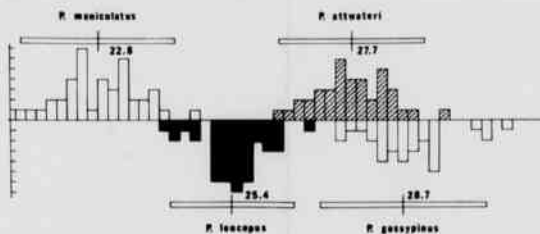


Figure 4. Bar-histogram of values for total length of skull for four species of *Peromyscus*. The mean and two standard deviation units either side of the mean are included.

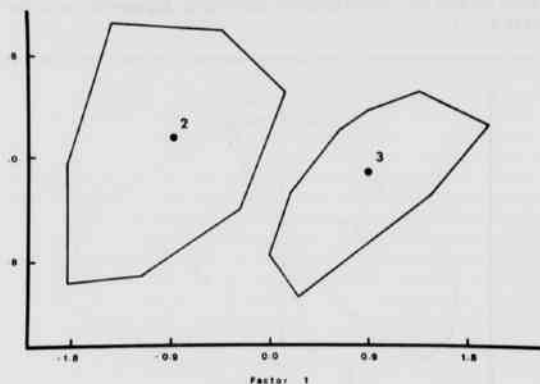


Figure 5. Factor scores of *P. leucopus* and *P. attwateri*, as represented on Fig. 2.

At this point, only *P. attwateri* and *P. gossypinus* remained to be discriminated between. Examination of a plot of factor loading scores for these species (Fig. 6) revealed a considerably different pattern of variation than that observed for all four species together (Fig. 1). Factor axis 1 appears to be related to parameters of skull length, while factor axis 2 appears to correlate best with parameters of post-nasal width of the skull. A plot of the factor scores of these two species (Fig. 7) revealed only fair separation along factor axis 1. Overlap of the species appeared to be visually significant, and in fact, two specimens (6% of the sample) of *P. gossypinus* and four specimens (10% of the sample) of *P. attwateri* are represented in the overlap zone. Testing by MANOVA, however, revealed significant differences between the species

Mensural Discrimination of the Skulls of Arkansas *Peromyscus*

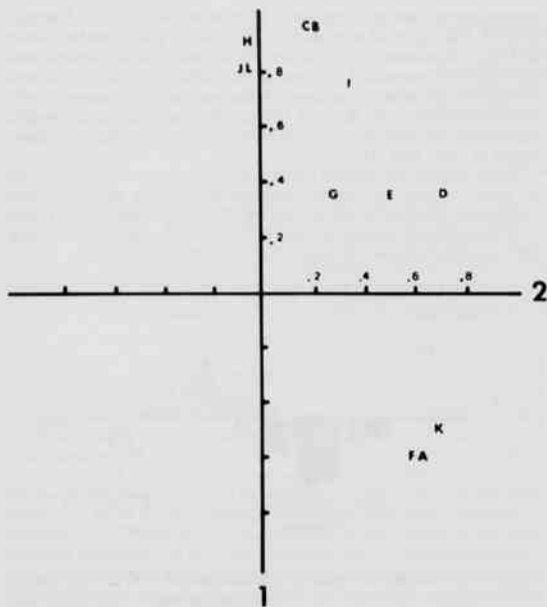


Figure 6. Factor loading scores for *P. attwateri* and *P. gossypinus* plotted along the first and second principal factor axes. Alphabetic characters as in Fig. 1.

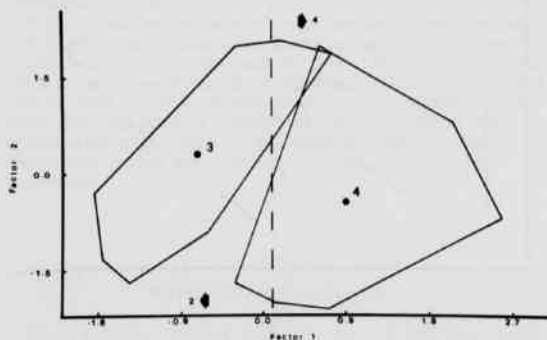


Figure 7. Factor scores of *P. attwateri* and *P. gossypinus*, as represented on Fig. 2. The dashed perpendicular line represents the mid-point along axis 1 between the means of the two species. The heavy arrows indicate the number of individuals from the samples falling beyond the mid-point.

at the 0.0001 level for all parameters except breadth of palate at molars one and three and length of bony palate. However, character overlap was extensive and univariate examination revealed no single parameter having 95% discriminatory power for the skulls of these two species. Two characters, length of nasal bone and greatest rostral width, correlating highly with the first factor axis, had some discriminatory power (80-90%).

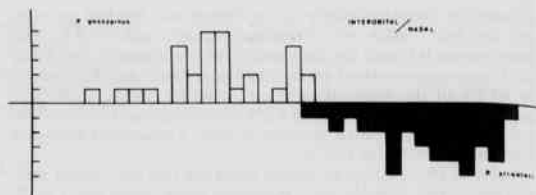


Figure 8. Bar-histogram of values of minimum interorbital distance divided by length of nasal bone for *P. attwateri* and *P. gossypinus*.

- | | | | | |
|-----|------------------------|------|-----------------------|---------------------|
| A. | Total Length Skull < | 24.1 | <i>P. maniculatus</i> | |
| AA. | " | " | B | |
| B. | " | < | 26.4 | <i>P. leucopus</i> |
| BB. | " | " | " | C |
| C. | Interorbital / Nasal < | 0.41 | <i>P. gossypinus</i> | |
| CC. | " | " | " | <i>P. attwateri</i> |

Figure 9. Key to the skulls of Arkansas specimens of *Peromyscus*.

In an attempt to further discriminate among the skulls of *P. attwateri* and *P. gossypinus*, ratios were computed of one parameter against another. Eventually, the ratio demonstrating the highest discriminatory power turned out to be minimum interorbital distance divided by length of the nasal bone (Fig. 8).

As a result of these analyses, it was possible to prepare a key (Fig. 9) to the adult skulls of species of *Peromyscus* occurring in Arkansas and having at least a 95% reliability factor. Total length of skull discriminates between *P. maniculatus* (\bar{X} = 22.8mm), *P. leucopus* (\bar{X} = 25.4mm), and a combined group of *P. attwateri* (\bar{X} = 27.7mm) and *P. gossypinus* (\bar{X} = 28.7mm). The ratio of interorbital width and length of nasal bone discriminates reasonably well between skulls of *P. attwateri* (0.41 to 0.48) and *P. gossypinus* (0.33 to 0.41).

Finally, it must be stressed that results of this analysis are fully predicated on the assumption that initial discrimination among these species was correct. To validate this assumption, specimens were intentionally selected only when skin characteristics made specific assignment positive. A potential problem inherent in this process would be the imposition of artificial limits to the cranial variation present in the samples. It seems doubtful, though, that limits imposed by skin characteristics would represent limits of craniometric variation as well. Interestingly, examination of coefficient of variation values revealed that for all variables except breadth of palate at molar three, skulls of *P. maniculatus* generated the highest values. For breadth of palate at molar three, skulls of *P. leucopus* generated the highest value.

SUMMARY

While the skulls of the species of *Peromyscus* occurring in Arkansas are difficult to distinguish between, total length of skull will discriminate between *P. maniculatus*, *P. leucopus*, and a combined group of *P. attwateri* and *P. gossypinus*. Subsequently, the ratio of interorbital width and length of nasal bone will adequately discriminate between skulls of *P. attwateri* and *P. gossypinus*.

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V. Rick McDaniel, Renn Tumilson, and Phil McClarty

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