75-21,189

HELLACK, Jenna Jo, 1945-
A PHENETIC ANALYSIS OF THE SUBFAMILY CARDINALINAE (AVES).

The University of Oklahoma, Ph.D., 1975
Zoology

THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

A PHENETIC ANALYSIS OF THE SUBFAMILY CARDINALINAE (AVES)

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

DOCTOR OF PHILOSOPHY

BY

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Norman, Oklahoma

1975

A PHENETIC ANALYSIS OF THE SUBFAMILY

CARDINALINAE (AVES)

APPROVED BY

DISSERTATION COMMITTEE

A PHENETIC ANALYSIS OF THE SUBFAMILY CARDINALINAE (AVES)

by: Jenna Jo Hellack

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Multivariate statistical techniques were used to evaluate 169 skeletal, external skin and color characters, and determine phenetic affinities among 37 species in the subfamily Cardinalinae. Phenetic similarity was assessed using distances and product moment correlations as similarity coefficients and UPGMA (unweighted pair-group method using arithmetic averages) for clustering. Phenetic relationships are presented in phenograms and 3-D models of species projected onto principal components based on a matrix of correlations among characters.

The 37 resulting phenograms are compared among themselves and with two former classifications. Basic similarity matrices were grouped and within each group, the phenogram which best represented its basic similarity matrix was chosen to represent the group. A "best" phenetic classification was chosen using previously determined guides.

The phenogram chosen in this manner used all characters available. This resulted in seven species not being included in the analysis. As these species should be included in a "best" phenetic classification, a phenogram was constructed using the phenogram chosen as the best representative of this study for the placement of all species it analyzed, and placing the seven remaining species into the clusters they would probably join if they had been included in the analysis. This was accomplished by studying the phenograms and 3-D models in which the seven species had been included.

This phenogram was then used to look at similarities and compare these similarities with two former classifications. Based on phenetic groupings, several saltators (*S. rufiventris*, *S. albicollis*, *S. cinctus*, *S. atricollis*, *S. aurantiirostris*, and *S. orenocensis*) were found to have little similarity to the remaining saltators. In the case of *S. rufiventris*, *S. albicollis* and *S. cinctus*, insufficient data may be the reason for their lack of similarity to the saltator cluster. However, *S. atricollis*, *S. orenocensis* and *S. aurantiirostris* are clearly distinct.

The genus *Pheucticus* clusters much as one would expect from one former classification. The species placed in the genus *Passerina* could be grouped according to either former classification. The results of this study are presented in two papers prepared in the style of the Wilson Bulltin.

ACKNOWLEDGMENTS

I am greatly indebted to the members of my committee: Drs. Harley P. Brown, Charles C. Carpenter, James R. Estes, and Gary D. Schnell. Dr. Hubert H. Frings, an original committee member, also aided in planning my work. I am very grateful to Robert G. Richardson who spent valuable time reviewing my manuscript. I also wish to thank curators of a number of collections who allowed me to use material in their care (they are listed in the acknowledgments of the first paper).

Several other people gave valuable assistance to me in preparation and completion of this study. Elizabeth A. Bergey assisted with the measurement of specimens. Troy L. Best and Dick T. Stalling were a great help with the original planning of the study. Ginna Davidson and Sharon Swift aided in the preparation of figures. I also wish to thank my parents Mr. and Mrs. Joe Hellack and my grandmother Mrs. R. E. Rutherford, without whose encouragement and assistance this study would not have been possible. This study was supported in part by a travel grant from the Smithsonian Institution and a Sigma Xi Grant-in Aid.

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INTRODUCTION

The subfamily Cardinalinae is a group of finches including cardinals, saltators and certain grosbeaks. The subfamily at present is placed in the family Fringillidae. However, a number of authors have proposed sharply differing arrangements for the genera traditionally included in the family Fringillidae (Beecher, 1953; Tordoff, 1954; Stallcup, 1954). The Cardinalinae are closely allied to Thraupidae as well as the fringillid subfamily Emberizinae (de Schauensee, 1966).

There is disagreement on the generic grouping of the species traditionally included in the subfamily Cardinalinae as well as family allocations. The 37 species placed in this subfamily by Paynter (1970) are divided into nine genera. Hellmayr (1938) divides these 37 species into 15 genera. My objectives are to look at interspecific relationships of 37 species in the subfamily Cardinalinae utilizing numerical taxonomic techniques to determine phenetic affinities.

The results and conclusions of this study are presented in two papers prepared in the style of the Wilson Bulletin. The first is a study of phenetic affinities of the subfamily Cardinalinae using skeletal characters; external morphological characters are analyzed in the second paper.

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PAPER I

A PHENETIC ANALYSIS OF THE AVIAN SUBFAMILY CARDINALINAE, BASED UPON SKELETAL CHARACTERS

A PHENETIC ANALYSIS OF THE AVIAN SUBFAMILY CARDINALINAE, BASED UPON SKELETAL CHARACTERS

Jenna J. Hellack

The subfamily Cardinalinae (Fringillidae) is closely allied to Thraupidae (Beecher, 1953; Tordoff, 1954; de Schauensee, 1966). Considerable disagreement exists on which species should be included in the subfamily. In the most recent revision Paynter (1970) included 9 genera and 37 species. Hellmayr's (1938) subfamily included these species (divided into 15 genera) plus 9 others in *Gubernatrix*, *Paroaria*, and *Tiaris*. Tordoff (1954) on the basis of the structure of the palatomaxillaries placed the latter three genera plus *Porphyrospiza* (*Passerina caerulescens* of Paynter, 1970) in the subfamily Emberizinae (Fringillidae). *Spiza americana*, although included in Cardinalinae by both Hellmayr (1938) and Paynter (1970), is of uncertain affinity. Tordoff (1954) and Stallcup (1954) consider it an aberrant cardinal-grosbeak, but Beecher (1953) believed it was an icterid.

While the relationships of the aberrant species have been the subject of considerable debate, few taxonomic studies have been conducted on the affinities of species traditionally included in the subfamily (Ridgway, 1901; Hellmayr, 1938; and Paynter, 1970), these studies include congeneric considerations of such species as the Cardinal (Cardinalis cardinalis) and the Pyrrhuloxia (C. sinuatus) (Bock, 1964), and hybridization in grosbeaks, Pheuticus melanocephalus and P. ludovicianus (West, 1962) and buntings, Passerina cyanea and P. amoena (Sibley and Short, 1959).

This study is a numerical analysis utilizing skeletal measurements to assess phenetic affinities of the species in the subfamily Cardinalinae. Results obtained using restricted character sets will be compared. Several methods to reduce the effect of size in this study were tried and these will also be compared.

MATERIALS AND METHODS

The generic and specific designations used in this study are the same as those used by Paynter (1970). Table 1 lists these 37 species, a brief description of their geographic distribution, the species number assigned to each, and the number of skeletons measured of each. Skeletal measurements were obtained for 31 of the 37 species; thus my analyses excludes Caryothraustes humeralis, Periporphyrus erythromelas, Saltator maxillosus, S. cinctus, S. rufiventris, and Passerina caerulescens. The skeletal characters were the same as those examined by Robins and Schnell (1971), in their analysis of the Ammodramus-Ammospiza grassland sparrow complex, with the addition of the length of the caudal vertebrae (taken from synsacrum to back of pygostyle). These 49 characters were measured on adult specimens to the nearest 0.1 mm with dial calipers. A mean for each species was obtained from the skeletal material available without regard to sex. Original mean character measurements for each species may be found in Appendix IV of Hellack (1975).

Phenetic similarity was assessed using multivariate statistical techniques from the Numerical Taxonomy system of computer programs (NT-SYS) developed by F. J. Rohlf, J. Kishpauph, and D. Kirk. Two types of techniques were used: R-type involving the analysis of correlations among characters; and Q-type an analysis of correlations or distances between pairs of species.

Characters were standardized in the Q-type of analysis so that each would have a mean of zero and a standard deviation of one. Thus character state codes are independent of orginal measurement units and are expressed in standard deviation units. Product moment correlation coefficients and average distance coefficients were calculated for all pairs of species. Cluster analyses, utilizing the unweighted pair-group method using arithmetic averages (UPGMA), were performed on both correlation and distance matrices, and the results summarized in phenograms. The R-type analysis extracts principal components from a matrix of correlation among characters (Sneath and Sokal, 1973).

To eliminate or reduce the size factor, several analyses were undertaken. All measurements (before standardization) were divided by either sternum length, humerus length, or tibiotarsus length. In addition an R-type analysis was performed on unstandardized characters and then the projections on the first principal component (which was considered to be a general size factor) used as the divisors of their respective species characters. Still another method was tried. This involved the removal of the influence of the first component mathematically from a matrix of distance between species (Sneath and Sokal, 1973).

I produced 27 phenetic classifications using various combinations of the two similarity coefficients (correlation and distance) and the six transformations (humerus, sternum, tibiotarsus, principal component I, first component removed mathematically, and untransformed). In 11 of these, 49 characters were used; 8 classifications were produced using 14 skull characters; and 8 produced using 14 pelvic characters.

Matrices were produced from the classifications of Paynter (1970) and Hellmayr (1938) by assigning arbitrary numerical values to different taxonomic ranks (see Schnell, 1970; Robins and Schnell, 1971, and Johnson and Selander, 1971). These two matrices plus 27 matrices (produced from the various combinations mentioned above) were compared by computing the coefficient of correlation between the basic similarity matrices. The correlations were then used to produce a matrix showing the similarities between these matrices. Similarities were summarized in a dendrogram. This summary indicates which matrices are most alike. The 27 phenograms were compared in a similar manner.

The following abbreviations will be used throughout the paper. CORR or DIST refer to the use of correlation or distance to analyze similarity between species. SKEL-SIZE-IN denotes the use of skeletal characters in which no adjustment for size was made. SIZE-OUT refers to the mathematical elimination of size. SKEL/COMP-I indicates characters divided by unstandardized principal component I; SKEL/HUMER characters divided by the humerus length; SKEL/STERN characters divided by the sternum length; and SKEL/TIBIO characters divided by the tibiotarsus length. ALL denotes inclusion of all characters in the analysis, PELVIC the use of only the 14 characters of the pelvic girdle and lower limbs, and SKULL the use of 14 characters of the skull. BSM is used as the abbreviation for basic similarity matrix.

When branches occur in phenograms, the placement of the two branches is arbitrary. Branches may be rotated about their axis without changing relationships implied by the phenograms.

RESULTS

The dendrogram summary of the similarities between the 27 BSMs is shown in Figure 2A. Ten groups of BSMs are labeled. Within each of six groups (C, D, E, G, J, and K) the BSMs are based on the same character groups and similarity coefficients. For example, group C encompasses four BSMs where correlation coefficients were computed and all characters used. However, a different transformation was used for each of the four BSMs (i.e., one where the characters were divided by sternum length, the second where they were divided by the tibiotarsus length, etc.). Groups H and I, in contrast, include BSMs based on the same transformations and similarity coefficients, but differ in character groups. The BSMs in which no transformations were used are found in groups A and B. SIZE OUT (group L) is the BSM in which size was eliminated mathematically from a distance matrix. SKEL/TIBIO SKULL DIST (group F) connects to group E which is composed of BSMs having the same character groups and similarity coefficients as itself.

The dendrogram of similarity between phenograms is shown in Figure 2b. In comparing the dendrogram of similarities between BSMs with that of the phenograms, several changes in groupings can be seen. Clustering enhanced differences between many of the BSMs. Phenograms with lower cophenetic correlation coefficients were more likely to group differently from their BSMs. When both the similarity of BSM to other members of its group and the cophenetic correlation coefficients were low, major group changes are seen. For example, in group C of the BSMs, SKEL/STERN ALL CORR has a cophenetic correlation coefficient of 0.721 and is the most divergent of the four BSMs in this group. In the dendrogram of the phenograms (Fig. 2B), it shows little similarity to the other phenograms.

There is considerable correlation within each group of BSMs (Fig. 2A). As an alternative to presenting each phenogram, I have depicted only one phenogram from each highly correlated group of BSMs--the phenogram with the highest cophenetic correlation coefficient. Any substantial difference in placement of species in phenograms within a particular group of BSMs will be described below.

The single BSM in group A (SIZE IN CORR) has little similarity to the remaining groups (Fig. 2A). The resulting phenogram (Fig. 3A) has five major clusters; the majority of species within these clusters have little similarity to each other. The low cophenetic correlation coefficient (0.674) shows that considerable distortion of the BSM occurred as a result of clustering.

The phenogram representing the one BSM in group B (SKEL SIZE IN DIST) is depicted in Figure 4A. There is little similarity between the four major clusters seen in this phenogram and those found in group A. Size appears to have had considerable effect on the formation of clusters in SKEL SIZE IN DIST. Cluster 3 (Fig. 4A) is composed of the two largest species; Cluster 4 contains the smallest forms.

Group C consists of four very similar BSMs based upon correlation analyses using all characters. All phenograms constructed from these BSMs have relatively low cophenetic correlation coefficients. The phenogram which was chosen to represent the group (SKEL/TIBIO ALL CORR, Fig. 3B) has a cophenetic correlation coefficient of 0.792. The two major clusters found in this phenogram are also found in the other phenograms of the group, but two of the species "switch" major clusters (cluster with a different group of species in different phenograms). Passerina caerulea is found with the grosbeaks (Pheuticus) in the other three phenograms. Cardinalis sinuatus switches clusters in one instance. Other than these two major cluster switches, considerable consistency is found between three of the four phenograms of the group (SKEL/STERN ALL CORR being the exception). The differences among the three similar phenograms are the switching of affinities by species which in Figure 3B show little similarity to the cluster their stem joins. Pitylus grossus is most similar to Rhodothraupis celaeno in the other phenograms.

The four BSMs in group D have the same character group (14 skull characters) and the same similarity coefficient (correlation). The phenogram which represents the group is SKEL/COMP I SKULL CORR (Fig. 3C; cophenetic correlation coefficient= 0.877). As in the phenogram representative of group C (Fig. 3B), this phenogram has two major clusters. The species composition of these three clusters are also much the same. Three of the four phenograms representing the BSMs of group D are very similar. The fourth SKEL/TIBIO SKULL CORR, while having two major clusters, has several switches between these clusters. The branching within smaller clusters, however, is much the same. Five of the species represented in these four phenograms (Cardinalis sinuatus, Caryothraustes canadensis, Rhodothraupis celaeno, Saltator aurantiirostris, and S. atricollis) show different affinities in each phenogram. These five show little similarity to the clusters they join in any of the four phenograms. Spiza americana, which clusters rather closely with the buntings (Passerina), in two of the phenograms (SKEL/COMP I CORR and SKEL/HUMER SKULL CORR), groups with the saltators in the other two.

The three BSMs in group E were produced by using 14 skull characters and distance as a measure of similarity. They differ in the type of transformation used. The correlation between these BSMs is not as high as that found in other groups of BSMs. The phenogram which represents this group (SKEL/COMP I SKULL DIST) is shown in Figure 4B. Its cophenetic correlation coefficient (0.835) is considerably higher than that of the other two phenograms of the group (0.774, 0.742). SKEL/COMP I SKULL DIST can be divided into two large branches, with a third branch composed of the single species Saltator orenocensis. Cluster 1 (Fig. 4B) is much the same in all three phenograms of this group, but Passerina brissonii clusters differently in the two phenograms not figured (SKEL/STERN SKULL DIST and SKEL/HUMER SKULL DIST). The second major branch in Figure 4B is not as easily seen in the other two phenograms. The small cluster bounded by Pitylus grossus and S. atriceps is present in all three phenograms, but the species in the other small clusters of Cluster 2 are not the same in the phenograms not shown. Again, outlying species tend to show different affinities when clustering was undertaken on different BSMs. Cardinalis cardinalis, C. phoeniceus, C. sinuatus, Saltator orenocensis, Passerina cyanoides and as mentioned above P. brissonii, differ in their placement in all three phenograms.

The phenogram constructed from the one BSM in group F is SKEL/TIBIO SKULL DIST (Fig. 4C). The character set (14 skull characters) and the similarity coefficient (distance) are the same as in group D, to which the stem of the BSMs fuses. Comparing SKEL/TIBIO SKULL DIST (Fig. 4C) with SKEL/COMP I SKULL DIST (Fig. 4B), Clusters 1 plus 2 of SKEL/TIBIO SKULL DIST have the same species composition as Cluster 1 of SKEL/COMP I SKULL DIST with the addition of Saltator aurantiirostris and the loss of Passerina brissonii. Cluster 5 of SKEL/TIBIO SKULL DIST is also present in SKEL/COMP I SKULL DIST with Pitylus grossus being the only species missing.

Group H is composed of two BSMs in which the same measure of similarity (distance) and the same transformation (dividing by tibiotarsus length) were used; however, the character sets were different (all characters, 14 pelvic characters). Both phenograms of this group (Fig. 2B) have relatively low cophenetic correlation coefficients. The representative phenogram is SKEL/TIBIO PELVIC DIST (Fig. 4D). The two major branches seen in Figure 4D are also found in the other phenogram. The placement of four species in Figure 4D changes in the phenogram not figured: Saltator atricollis, S. coerulescens, and S. maximus are found in Cluster 1; Passerina amoena in contrast switches to Cluster 2. The small cluster bounded by Spiza americana and Passerina versicolor (Cluster 1, Fig. 4D) is present in both phenograms, but P. brissonii and P. leclancerii are added to the cluster in the phenogram not figured. The cluster bounded by Pheuticus aureoventris and S. aurantiirostris has most of the same species in both phenograms.

Group I is composed of two BSMs with the same character set and similarity coefficient as in group H; the transformation (sternum length) is different. The phenogram with the highest cophenetic correlation coefficient is SKEL/STERN PELVIC DIST (0.815, Fig. 5A). The major branches of this phenogram are not present in the other phenograms of the group; however, smaller clusters are comparable. The cluster (Fig. 5A) bounded by Spiza americana and Passerina amoena is present in both phenograms. The cluster bounded by Pheuticus ludovicianus and Passerina rositae is found in both phenograms with three species (Cardinalis cardinalis, Passerina cyanoides, and Passerina rositae) not being in the cluster in the phenogram not figured. The Cluster bounded by Cardinalis sinuatus and Passerina glaucocaerulea lost Cardinalis sinuatus and gained P. parellina and P. rositae. The cluster bounded by Pheuticus chrysopeplus and Passerina parellina in Figure 5A lost Pheuticus chrysopeplus, P. aureoventris, Passerina brissonii, and P. parellina while it gained P. cyanoides in the phenogram not figured.

The two BSMs of group J have the same character set (ALL) and the same similarity coefficient (distance), but differ in the transformation used (humerus length, component I). SKEL/COMP I ALL DIST is the phenogram representing the group (Fig. 5B). It is highly correlated with SKEL/HUMER ALL DIST (Fig. 2A). Only three species (Cardinalis cardinalis, C. sinuatus, and Pheuticus ludovicianus) do not cluster the same in SKEL/HUMER ALL DIST as they do in Figure 5B. In SKEL/HUMER ALL DIST these three species show little similarity to the clusters they join.

Group K contains two BSMs with the same character set (14 pelvic characters) and the same similarity coefficient (distance). They differ in the transformation used (component I, humerus). The cophenetic correlation coefficients of both phenograms are about the same (SKEL/HUMER PELVIC DIST, 0.883; SKEL/COMP I PELVIC DIST, 0.882). SKEL/HUMER PELVIC DIST is shown in Figure 5C. While the two phenograms of this group are very similar, several species affinities change. In SKEL/COMP I PELVIC DIST, the cluster bounded by Pheuticus chrysopeplus and Rhodothraupis celaeno contains Pheuticus ludovicianus and the cluster bounded by Cardinalis sinuatus and Passerina versicolor contains P. glaucocaerulea.

Group L contains one BSM (SIZE OUT) which shows similarities to the distance BSMs of group J and K (Fig. 2A). The phenogram has a cophenetic correlation coefficient of 0.831 (Fig. 5D). While clusters are present in the phenogram there are no major branches. More of a gradual change in phenetic differences appears to occur.

DISCUSSION

Relationships between BSMs, phenograms, and previous classifications

Several authors (Sokal and Michener, 1967; Schnell, 1970; Robins and Schnell, 1971) have found that correlations tend to give more uniform results than do distances when differently treated data sets are analyzed for the same species. In general, I found that correlation analyses of the same character set but using different transformations gave more uniform results than distance analyses of these same data. However, SIZE IN CORR (the correlation analysis in which no transformation was used) differed considerably from the BSMs of the remaining analyses (Fig.2A).

The correlation analyses, where transformations were used, grouped according to character sets (e.g. group G, Fig. 2A, in which all characters were used). The distance analyses, in which transformations were used, grouped together either by character set or in two instances by the type of transformation. In the BSMs, the similarity within groups of distance was not as great as the within group similarity of the correlation analyses.

The affinities between phenograms (Fig. 2B) were slightly changed from those expressed by the BSMs. The phenograms were less similar to each other than were their BSMs. This reduction in similarities was particularly noticeable in phenograms which had low cophenetic correlation coefficients (e.g. SKEL/TIBIO SKULL DIST, r= 0.662; Fig. 2B).

Schnell (1970) found, when comparing phenograms and BSMs with previous classifications of the Lari, that phenograms were more similar than their BSMs to the results of previous investigations. Robins and Schnell (1971) noted the opposite of this in 9 of 12 comparisons. In comparing the 27 classifications of this study, 14 of the BSMs were more similar to the previous classifications than were their phenograms. For the 27 analyses, 23 BSMs and 22 of the phenograms were more similar to Paynter's classification (1970) than to Hellmayr's (1938). The four BSMs more similar to Hellmayr's classification (1938) are SIZE IN CORR (Fig. 3A), SKEL/STERN ALL DIST (not figured); SKEL/HUMER SKULL DIST (not figured); and SKEL/STERN SKULL DIST (not figured). Correlations between BSMs and previous classifications, or phenograms and previous classifications are very low. In some instances a BSM or a phenogram is more similar to Paynter (1970) than to Hellmayr (1938) by a correlation of less than 0.002.

Comparisons of the representative phenograms

The BSMs produced using correlation as a measure of similarity clustered into four groups (Fig. 2A, groups A, C, D, G). The phenogram which had the highest cophenetic correlation coefficient within each group of BSMs was selected as a representative of the group. When the representative phenograms of these groups (Fig. 3) are compared there are two clusters which are generally found in all four phenograms. These clusters can be seen in SKEL/COMP I SKULL CORR (Fig. 3C). One is composed of seven species and is bounded by *Pitylus grossus* and *Saltator atripennis*. Three of these species--*S. maximus*, *S. similis* (in SKEL/TIBIO PELVIC CORR) and Pitylus grossus (in SIZE IN CORR)-- are not found in the same cluster in all four correlation phenograms. The second cluster as seen in SKEL/COMP I SKULL CORR (Fig. 3C) is composed of seven species which are bordered by Passerina parellina and P. rositae. Several species join this group in the other phenograms. Passerina glaucocaerulea in both SKEL/TIBIO ALL CORR and SKEL/TIBIO PELVIC CORR (Figs. 3B and 3D, respectively). Passerina brissonii and Cardinalis sinuatus are included in the cluster in SKEL/TIBIO PELVIC CORR, while P. rositae is not. This cluster is not found in SIZE IN CORR.

The BSMs constructed using average distances as a measure of similarity formed seven rather distinct groups (Fig. 2A, groups E, F, H, I, J, K, L). The phenograms which represent each of these groups are more heterogeneous than the phenograms representing the groups of correlation BSMs.

The species in the genus Passerina, as found in the cluster bounded by P. glaucocaerulea and P. leclancherii (SKEL/COMP I ALL DIST, Fig. 5B), are present in most of these phenograms. However, the cluster is not always totally intact. Sometimes species are placed in other clusters, while additional species often join the group. For example, in SKEL/HUMER PELVIC DIST (Fig. 5C) the cluster in which most of these species are found does not contain Passerina rositae and P. glaucocaerulea.

Pheuticus ludovicianus and P. melanocephalus cluster together in six of the phenograms (Figs. 4 and 5), but they, as a cluster, differ in affinities to other species or clusters. In five of the phenograms Caryothraustes canadensis and Saltator orenocensis show more similarity to each other than to other species. There is also a tendency for several of the species of the genus Saltator to group together in the different phenograms.

Comparison of these representative phenograms (both distance and correlation analyses) indicates two rather distinct clusters of species which are found in most of the phenograms; one composed of several species in the genus Saltator and the other of species in the genus Passerina. The remaining species differ in their affinities in each of the phenograms. This possibly indicates that a gradual cline of variation exists rather than distinct clusters of species.

The "best" single phenetic classification

As should now be evident, many different phenetic classifications of the subfamily Cardinalinae are possible. Each of these classifications expresses a facet of the phenetic relationships present in the group. However, it is often useful to have a single general purpose classification.

Schnell (1970) proposed several guidelines by which he chose the "best" phenetic classification of the Lari, and these seem appropriate for this study. The "best" single phenetic classification of the Cardinalinae (i.e., the phenogram in which a large number of characters was used, a transformation was utilized to reduce the general size factor and there was a relatively high cophenetic correlation coefficient) is SKEL/COMP I ALL DIST (Fig. 5B).

SKEL/COMP I ALL DIST (Fig. 5B) has a cophenetic correlation coefficient of 0.855. While this is the highest of any phenogram which fulfills the other criteria of a "best" phenetic classification, some distortion has occurred as a result of clustering. Comparison of SKEL/COMP I ALL DIST with the other phenograms may indicate where some of this distortion lies. SKEL/COMP I ALL DIST differs considerably from any one of the other phenograms; however, each cluster in SKEL/COMP I ALL DIST is found in at least one of the other phenograms. Pheuticus aureoventris is one species perhaps placed "poorly" in the phenogram. In all of the phenograms representing correlation analyses it shows considerably more similarity to the other species included in the genus Pheuticus by Paynter (1970). Caryothraustes canadensis and Saltator orenocensis are also species for which distortion may have caused poor placement in the phenogram. In most of the other phenograms, these two species are similar.

There are several consistancies between SKEL/COMP I ALL DIST (Fig. 5B) and the other phenograms which should be emphasized. Three saltators (S. aurantiirostris, S. orenocensis and S. atricollis) rarely if ever are found to cluster with the other species placed in the genus Saltator. Two possible explanations for this are: 1) the skeletal material available on these species was limited; 2) they have been misplaced in the past. The second possibility seems more likely. In my study, very little intraspecific variation was found in the skeletal measurements of species in which a large series of skeletons were available. This would probably be true for these species as well. Ridgway (1901) suggested that two of these species (S. aurantiirostris and S. atricollis) were probably distinct genera. The cluster of the remaining saltators are found in almost every phenogram much the same as in SKEL/COMP I ALL DIST.

The three species in the genus Cardinalis cluster together only in the analyses in which the characters were restricted to 14 skull measurements. In the remaining analyses they varied in their placement showing little similarity to any group of species. Passerina cyanoides and P. caerulea also seem to be different from the other species in this study. They tend to change their affinities in each of the phenograms. The cluster of the remaining species in Passerina are found in almost every phenogram much the same as in SKEL/COMP I ALL DIST (Fig. 5B).

Conclusions

Similarities expressed by previous classifications and the phenetic similarities found in this study show somewhat different affiliations among the species in this subfamily. This is particularly noticeable for three saltator species (S. orenocensis, S. aurantiirostris, and S. atricollis) and the genus Cardinalis.

With the exception of a cluster of nine buntings (Passerina) and another of six saltators, species in this subfamily often show different affinities from phenogram to phenogram. This fact--plus the somewhat low cophenetic correlation coefficient of many of the phenograms--may indicate that clustering is forcing species into groups, when in reality distinct clusters do not exist. There are some parts of the phenetic space that have a relatively high correlation of species, but these areas are not distinct from one another. There are species placed between these correlated areas. This is particularly evident in the analyses which were restricted to the 14 pelvic characters; all of the species were very similar in these characters. Stallcup (1954) observed that muscular patterns of the legs exhibit little variation even at the ordinal level in Passeriformes. Therefore it is not surprising to find the attachment site for these muscles showing little variation in the subfamily Cardinalinae. When only the 14 characters of the skull were used, the phenograms had much higher cophenetic correlation coefficients and more distinct clusters were formed. Tordoff (1954) and Bock (1964) have noted the adaptability of the bill in the family Fringillidae and have suggested that most present classifications of the group are based on characters of the bill. The distinct clusters formed in the analyses of skull characters supports this; more specialization has occurred in the skull region in this group of birds.

The use of different similarity coefficients, character sets, and transformations influence the apparent species affinities. There is a tendency for the BSMs and phenograms to form two groups depending on similarity coefficient, but several of the analyses did not follow this trend (e.g. the analysis in which skull characters and distance were used, and the distance analysis in which all characters and no transformations were used). Using a restricted character set had considerable affect on the resulting phenograms. Most of the clusters formed in the phenogram of correlation among BSMs (Fig. 2A) did so on the basis of character sets. The use of transformations to reduce the size factor resulted in some differences, particularly in distance analyses, but caused fewer changes than did the use of restricted character sets or similarity coefficients.

My results indicate that several species (e.g. *S. aurantiirostris*, *S. atricollis*, *S. orenocensis*) are not as similar to each other or to a particular group of species as the classifications proposed by Hellmayr (1938) or Paynter (1970) would suggest. Because of this discrepancy, behavioral and ecological, as well as other morphological characters, should be examined.

SUMMARY

Multivariate statistical techniques were used to evaluate 49 skeletal characters and determine phenetic affinities among 31 species in the subfamily Cardinalinae. Analyses were also made using restricted numbers

of characters; 14 characters of the skull or pelvic region. Phenetic similarity was assessed using distances and product moment correlations as similarity coefficients and UPGMA (unweighted pair-group method using arithmetic averages) for clustering. To reduce or eliminate the effect of size, all measurements were either divided by sternum length, humerus length, or tibiotarsus length, or by the first component in an unstandardized principal component analysis. Another method for reducing the size factor involved the removal of the first principal component from a distance matrix.

The resulting 27 phenograms are compared among themselves and with classifications of Hellmayr (1938) and Paynter (1970). In analyses in which correlation was used as the coefficient of similarity, basic similarity matrices clustered according to character set (e.g. 14 pelvic characters or all characters) and transformations of the data to reduce the size factor had little effect. Distance analyses of the same data resulted in more similarity between analyses which involved character sets of the pelvic and of all characters, but enhanced differences of differently treated data.

Basic similarity matrices were grouped, and within each group the phenogram which best represented its basic similarity matrix was chosen to represent the group. These representative phenograms were compared to one another for differences in placement of species. The guides of Schnell (1970) were used to determine which phenogram was the "best" phenetic classification and this phenogram was used to look at similarity among species. Based on phenetic groupings, three saltators (*S. orenocensis*, *S. aurantiirostris* and *S. atricollis*) show little similarity to the other species in the genus *Saltator*. The three species in the genus *Cardinalis* showed little similarity to one another in analyses in which all characters were utilized, but the three show considerable similarity in 14 skull characters. *Passerina cyanoides* and *P. caerulea* are considerably different from the other species placed in the genus by Paynter (1970). The remaining species of the subfamily cluster into groups of phenetically similar species much as one would expect from either Paynter's (1970) or Hellmayr's (1938) classifications.

ACKNOWLEDGMENTS

I am grateful to the following persons who allowed me to use material in their care: W. E. Lanyon, Amer. Mus. Nat. Hist; E. R. Blake, Field Mus. Nat. Hist.; J. R. Northern, Los Angeles Co. Mus. Nat. Hist.; L. F. Baptista, Moore Lab. Zool. Occidental College; P. Slud and J. S. Weske, Nat. Mus. Nat. Hist.; A. M. Rea, private collection; N. K. Johnson, Univ. California, Berkeley; P. Brodkorb, Univ. Florida; R. M. Mengel, Univ. Kansas; R. B. Payne, Univ. Michigan; J. C. Barlow, Royal Ontario Museum; G. M. Sutton and G. D. Schnell, Univ. Oklahoma. I wish to thank Gary D. Schnell, my major professor and Harley P. Brown, Charles C. Carpenter, and James R. Estes for critically reviewing the manuscript. I also wish to thank Elizabeth A. Bergey who assisted with the measurement of specimens. Ginna Davidson and Sharon Swift aided in the preparation of figures. This study was supported in part by a travel grant from the Smithsonian Institution and a Sigma Xi Grant-in Aid.

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TABLE 1

Number assigned to each species, Number of skeletons measured, and geographic distribution of species[1]

Species No.	Species[2]	No. Skel.	Breeding season distribution
1	Spiza americana	10	Eastern North America
2	Pheucticus chrysopeplus	8	Northern South America and w. Mexico
3	Pheucticus aureoventris	2	Subtropical to temperate zone, South America
4	Pheucticus ludovicianus	10	South Canada, eastern U. S.
5	Pheucticus melanocephalus	10	Sw. Canada, w. U. S. to southern Mexico.
6	Cardinalis cardinalis	10	S. Ontario to gulf states; Sw. U. S. to Guatemala South America
7	Cardinalis phoeniceus	3	Costal northern South America
8	Cardinalis sinuatus	10	Sw. U. S. to central Mexico
9	Caryothraustes canadensis	9	Tropical zone of South America
10	Caryothraustes humeralis	__	Tropical zone of South America
11	Rhodothraupis celaeno	7	Eastern Mexico
12	Periporphyrus erythromelas	__	Tropical zone of South America
13	Pitylus grossus	5	Tropical zone of South America
14	Saltator atriceps	11	Mexico to Panama

15	Saltator maximus	10	Southern Mexico to Brazil
16	Saltator atripennis	4	Upper tropical and subtropical zones of South America
17	Saltator similis	9	South America (se. Brazil, ne. Bolivia, Paraguay and ne. Argentina)
18	Saltator coerulescens	10	Mexico to Costa Rica; Colombia to n. Argentina
19	Saltator orenocensis	1	Tropical zone Venezuela and ne. Colombia
20	Saltator maxillosus	—	E. Brazil, ne. Colombia
21	Saltator aurantiirostris	3	Subtropical to temperate zone South America
22	Saltator cinctus	—	Tropical zone, east Ecuador
23	Saltator atricollis	3	East and south Brazil, Paraguay and ne. Bolivia
24	Saltator rufiventris	—	Tropical zones of n. and e. Bolivia
25	Saltator albicollis	11	Tropical, subtropical zones of South America
26	Passerina glaucocaerulea (Cyanoloxia glaucocaerulea)	2	South Brazil, Uruguay and east Argentina
27	Passerina cyanoides (Cyanocompsa cyanoides)	11	Southeastern Mexico to Amazonia
28	Passerina brissonii (Cyanocompsa cyanea)	3	Tropical and lower subtropical zones of South America

29	*Passerina parellina* (*Cyanocompsa parellina*)	6	Mexico to Nicaragua
30	*Passerina caerulea* (*Guiraca caerulea*)	10	Central and south U. S. south to nw. Costa Rica
31	*Passerina cyanea*	10	Southeastern Canada to gulf States
32	*Passerina amoena*	9	Southwest Canada, west U. S. nw. Mexico
33	*Passerina versicolor*	7	Southwestern border of U. S. to Guatemala
34	*Passerina ciris*	10	South U. S., n. Mexico
35	*Passerina rositae*	7	South Mexico
36	*Passerina leclancherii*	10	Southwestern Mexico
37	*Passerina caerulescens* (*Porphyrospiza caerulescens*)	—	Compos of Brazil and e. Bolivia

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[1] Distributions are summaries from Paynter (1970), de Schauensee (1970) and Peterson and Chalif (1973).

[2] Scientific names are those of Paynter (1970). In parenthesis are names used by other authors (Hellmayr, 1938; Peterson and Chalif, 1973; A.O.U. Check-list, 1957) when at variance with those used by Paynter (1970).

FIGURE LEGENDS

FIGURE 1. Dendrograms depicting two former classifications of the subfamily Cardinalinae: A) classification proposed by Paynter (1970); B) classification proposed by Hellmayr (1938). The following arbitary similarity values were assigned to each taxonomic level: (1) subspecies; (2) species; (3) subgenus; (4) genus; (5) subfamily. Saltator cinctus which was not included in Hellmayr's (1938) classification is represented by a dotted line indicating where it probably would have been placed.

FIGURE 2. Dendrograms showing relationships among: A) basic similarity matrices; B) phenograms. Letters indicate groups of very similar basic similarity matrices. Asterisks indicate the phenogram chosen to represent each of these groups--the phenogram with the highest cophenetic correlation coefficient. The cophenetic correlation coefficients are shown in the dendrogram of phenograms. The representive phenograms are shown in Figures 3, 4, and 5.

FIGURE 3. Phenogram representatives of groups A, C, D, and G (Fig. 2A). Numbers on the branches of the phenograms indicate clusters discussed in the results. These are four correlation analyses in which: A) no attempt was made to reduce size; B) all characters were divided by the tibiotarsus length; C) 14 skull characters were divided by unstandardized principal component I; D) 14 pelvic characters were divided by the tibiotarsus length.

FIGURE 4. Phenogram representatives of groups B, E, F, and H (Fig. 2A). Numbers on the branches of the phenograms indicate clusters discussed in the results. These are four distance analyses in which: A) no attempt was made to reduce size; B) 14 skull characters were divided by unstandardized principal component I; C) 14 skull characters were divided by the tibiotarsus length; D) 14 pelvic characters were divided by the tibiotarsus length.

FIGURE 5. Phenogram representatives of groups I, J, K, and L (Fig. 2A). These are four distance analyses in which: A) 14 pelvic characters were divided by the sternum length; B) all characters were divided by unstandardized principal component I; C) 14 pelvic characters were divided by the humerus length; D) the influence of the first principal component was removed mathematically from the distance matrix.

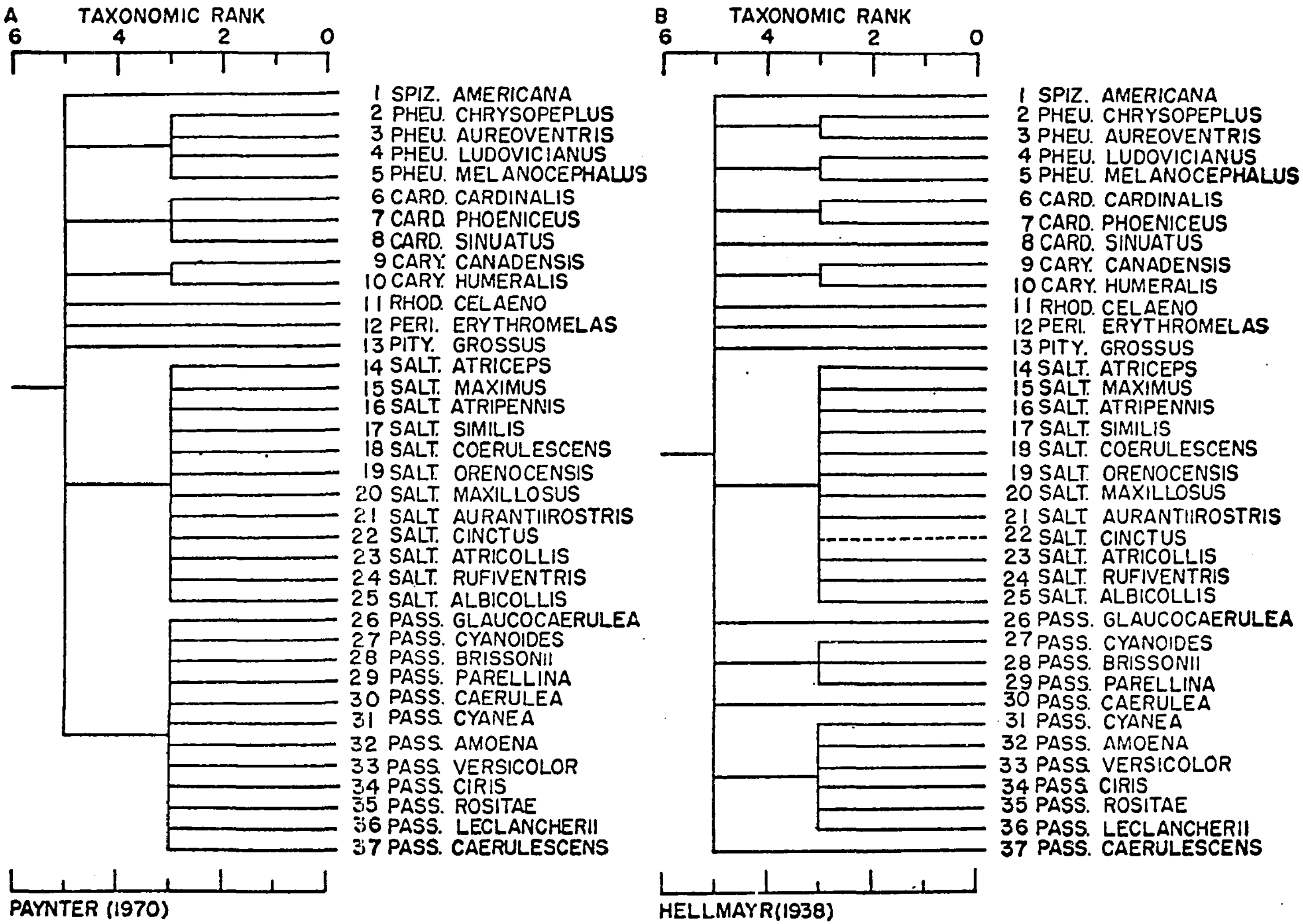
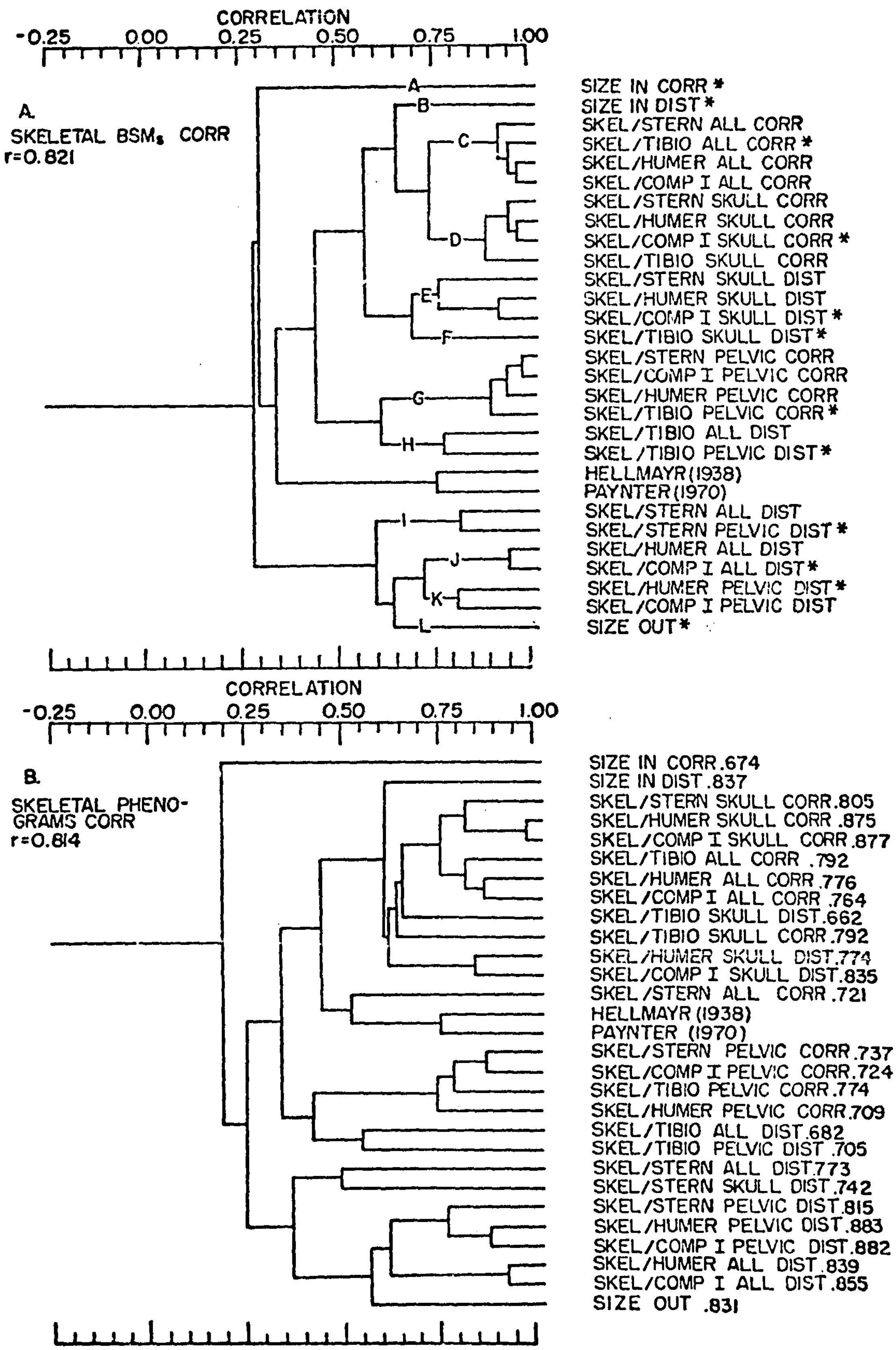

A
TAXONOMIC RANK
6 4 2 0
1 SPIZ. AMERICANA
2 PHEU. CHRYSOPEPLUS
3 PHEU. AUREOVENTRIS
4 PHEU. LUDOVICIANUS
5 PHEU. MELANOCEPHALUS
6 CARD. CARDINALIS
7 CARD. PHOENICEUS
8 CARD. SINUATUS
9 CARY. CANADENSIS
10 CARY. HUMERALIS
11 RHOD. CELAENO
12 PERI. ERYTHROMELAS
13 PITY. GROSSUS
14 SALT. ATRICEPS
15 SALT. MAXIMUS
16 SALT. ATRIPENNIS
17 SALT. SIMILIS
18 SALT. COERULESCENS
19 SALT. ORENOCENSIS
20 SALT. MAXILLOSUS
21 SALT. AURANTIIROSTRIS
22 SALT. CINCTUS
23 SALT. ATRICOLLIS
24 SALT. RUFIVENTRIS
25 SALT. ALBICOLLIS
26 PASS. GLAUCOCAERULEA
27 PASS. CYANOIDES
28 PASS. BRISSONII
29 PASS. PARELLINA
30 PASS. CAERULEA
31 PASS. CYANEA
32 PASS. AMOENA
33 PASS. VERSICOLOR
34 PASS. CIRIS
35 PASS. ROSITAE
36 PASS. LECLANCHERII
37 PASS. CAERULESCENS
PAYNTER (1970)
B
TAXONOMIC RANK
6 4 2 0
1 SPIZ. AMERICANA
2 PHEU. CHRYSOPEPLUS
3 PHEU. AUREOVENTRIS
4 PHEU. LUDOVICIANUS
5 PHEU. MELANOCEPHALUS
6 CARD. CARDINALIS
7 CARD. PHOENICEUS
8 CARD. SINUATUS
9 CARY. CANADENSIS
10 CARY. HUMERALIS
11 RHOD. CELAENO
12 PERI. ERYTHROMELAS
13 PITY. GROSSUS
14 SALT. ATRICEPS
15 SALT. MAXIMUS
16 SALT. ATRIPENNIS
17 SALT. SIMILIS
18 SALT. COERULESCENS
19 SALT. ORENOCENSIS
20 SALT. MAXILLOSUS
21 SALT. AURANTIIROSTRIS
22 SALT. CINCTUS
23 SALT. ATRICOLLIS
24 SALT. RUFIVENTRIS
25 SALT. ALBICOLLIS
26 PASS. GLAUCOCAERULEA
27 PASS. CYANOIDES
28 PASS. BRISSONII
29 PASS. PARELLINA
30 PASS. CAERULEA
31 PASS. CYANEA
32 PASS. AMOENA
33 PASS. VERSICOLOR
34 PASS. CIRIS
35 PASS. ROSITAE
36 PASS. LECLANCHERII
37 PASS. CAERULESCENS
HELLMAYR (1938)

Figure 1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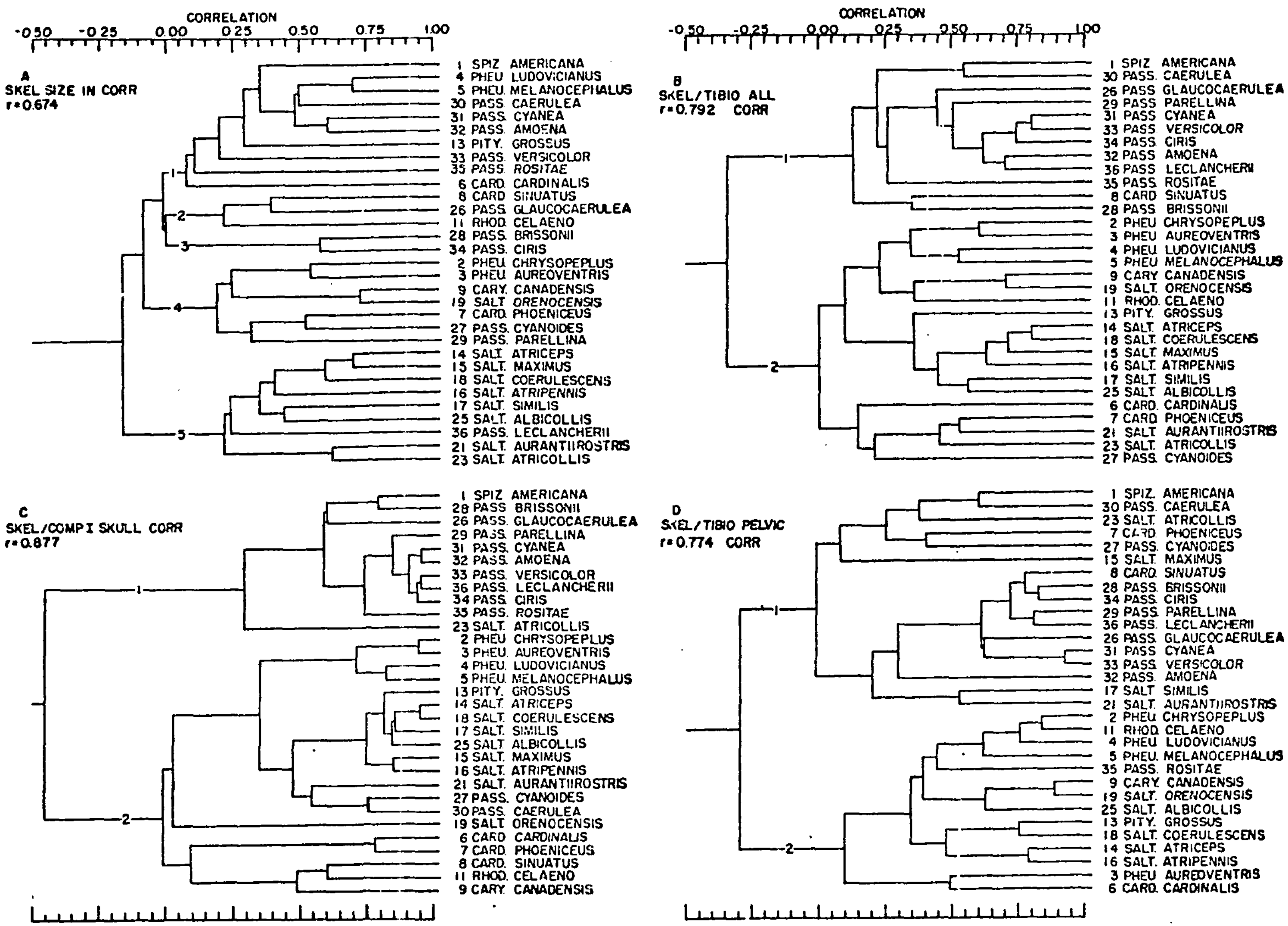
SKELETAL BSMs CORR
r=0.821
SIZE IN CORR *
SIZE IN DIST *
SKEL/STERN ALL CORR
SKEL/TIBIO ALL CORR *
SKEL/HUMER ALL CORR
SKEL/COMP I ALL CORR
SKEL/STERN SKULL CORR
SKEL/HUMER SKULL CORR
SKEL/COMP I SKULL CORR *
SKEL/TIBIO SKULL CORR
SKEL/STERN SKULL DIST
SKEL/HUMER SKULL DIST
SKEL/COMP I SKULL DIST *
SKEL/TIBIO SKULL DIST *
SKEL/STERN PELVIC CORR
SKEL/COMP I PELVIC CORR
SKEL/HUMER PELVIC CORR
SKEL/TIBIO PELVIC CORR *
SKEL/TIBIO ALL DIST
SKEL/TIBIO PELVIC DIST *
HELLMAYR (1938)
PAYNTER (1970)
SKEL/STERN ALL DIST
SKEL/STERN PELVIC DIST *
SKEL/HUMER ALL DIST
SKEL/COMP I ALL DIST *
SKEL/HUMER PELVIC DIST *
SKEL/COMP I PELVIC DIST
SIZE OUT *
A B C D E F G H I J K L
CORRELATION
-0.25 0.00 0.25 0.50 0.75 1.00
B.
SKELETAL PHENO-GRAMS CORR
r=0.814
SIZE IN CORR .674
SIZE IN DIST .837
SKEL/STERN SKULL CORR .805
SKEL/HUMER SKULL CORR .875
SKEL/COMP I SKULL CORR .877
SKEL/TIBIO ALL CORR .792
SKEL/HUMER ALL CORR .776
SKEL/COMP I ALL CORR .764
SKEL/TIBIO SKULL DIST .662
SKEL/TIBIO SKULL CORR .792
SKEL/HUMER SKULL DIST .774
SKEL/COMP I SKULL DIST .835
SKEL/STERN ALL CORR .721
HELLMAYR (1938)
PAYNTER (1970)
SKEL/STERN PELVIC CORR .737
SKEL/COMP I PELVIC CORR .724
SKEL/TIBIO PELVIC CORR .774
SKEL/HUMER PELVIC CORR .709
SKEL/TIBIO ALL DIST .682
SKEL/TIBIO PELVIC DIST .705
SKEL/STERN ALL DIST .773
SKEL/STERN SKULL DIST .742
SKEL/STERN PELVIC DIST .815
SKEL/HUMER PELVIC DIST .883
SKEL/COMP I PELVIC DIST .882
SKEL/HUMER ALL DIST .839
SKEL/COMP I ALL DIST .855
SIZE OUT .831

Figure 2


CORRELATION
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A
SKEL SIZE IN CORR
r=0.674
1 SPIZ AMERICANA
4 PHEU LUDOVICIANUS
5 PHEU MELANOCEPHALUS
30 PASS CAERULEA
31 PASS CYANEA
32 PASS AMOENA
13 PITY GROSSUS
33 PASS VERSICOLOR
35 PASS ROSITAE
6 CARD CARDINALIS
8 CARD SINUATUS
26 PASS GLAUCOCAERULEA
11 RHOD CELAENO
28 PASS BRISSONII
34 PASS CIRIS
2 PHEU CHRYSOPEPLUS
3 PHEU AUREOVENTRIS
9 CARY CANADENSIS
19 SALT ORENOCENSIS
7 CARD PHOENICEUS
27 PASS CYANOIDES
29 PASS PARELLINA
14 SALT ATRICEPS
15 SALT MAXIMUS
18 SALT COERULESCENS
16 SALT ATRIPENNIS
17 SALT SIMILIS
25 SALT ALBICOLLIS
36 PASS LECLANCHERII
21 SALT AURANTIIROSTRIS
23 SALT ATRICOLLIS
CORRELATION
-0.50 -0.25 0.00 0.25 0.50 0.75 1.00
B
SKEL/TIBIO ALL
r=0.792 CORR
1 SPIZ AMERICANA
30 PASS CAERULEA
26 PASS GLAUCOCAERULEA
29 PASS PARELLINA
31 PASS CYANEA
33 PASS VERSICOLOR
34 PASS CIRIS
32 PASS AMOENA
36 PASS LECLANCHERII
35 PASS ROSITAE
8 CARD SINUATUS
28 PASS BRISSONII
2 PHEU CHRYSOPEPLUS
3 PHEU AUREOVENTRIS
4 PHEU LUDOVICIANUS
5 PHEU MELANOCEPHALUS
9 CARY CANADENSIS
19 SALT ORENOCENSIS
11 RHOD CELAENO
13 PITY GROSSUS
14 SALT ATRICEPS
18 SALT COERULESCENS
15 SALT MAXIMUS
16 SALT ATRIPENNIS
17 SALT SIMILIS
25 SALT ALBICOLLIS
6 CARD CARDINALIS
7 CARD PHOENICEUS
21 SALT AURANTIIROSTRIS
23 SALT ATRICOLLIS
27 PASS CYANOIDES
C
SKEL/COMP I SKULL CORR
r=0.877
1 SPIZ AMERICANA
28 PASS BRISSONII
26 PASS GLAUCOCAERULEA
29 PASS PARELLINA
31 PASS CYANEA
32 PASS AMOENA
33 PASS VERSICOLOR
36 PASS LECLANCHERII
34 PASS CIRIS
35 PASS ROSITAE
23 SALT ATRICOLLIS
2 PHEU CHRYSOPEPLUS
3 PHEU AUREOVENTRIS
4 PHEU LUDOVICIANUS
5 PHEU MELANOCEPHALUS
13 PITY GROSSUS
14 SALT ATRICEPS
18 SALT COERULESCENS
17 SALT SIMILIS
25 SALT ALBICOLLIS
15 SALT MAXIMUS
16 SALT ATRIPENNIS
21 SALT AURANTIIROSTRIS
27 PASS CYANOIDES
30 PASS CAERULEA
19 SALT ORENOCENSIS
6 CARD CARDINALIS
7 CARD PHOENICEUS
8 CARD SINUATUS
11 RHOD CELAENO
9 CARY CANADENSIS
D
SKEL/TIBIO PELVIC
r=0.774 CORR
1 SPIZ AMERICANA
30 PASS CAERULEA
23 SALT ATRICOLLIS
7 CARD PHOENICEUS
27 PASS CYANOIDES
15 SALT MAXIMUS
8 CARD SINUATUS
28 PASS BRISSONII
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26 PASS GLAUCOCAERULEA
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17 SALT SIMILIS
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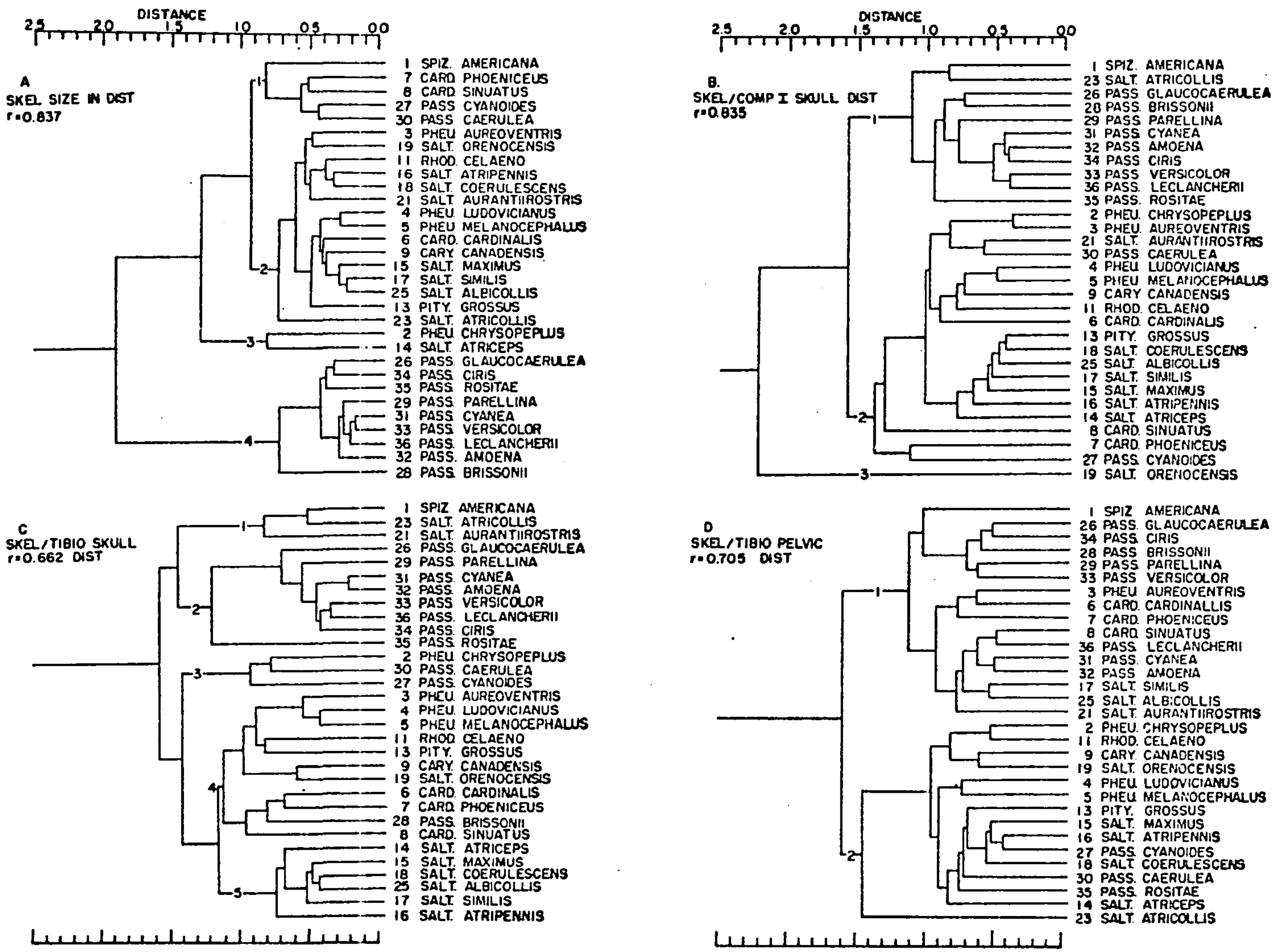
11 RHOD CELAENO
4 PHEU LUDOVICIANUS
5 PHEU MELANOCEPHALUS
35 PASS ROSITAE
9 CARY CANADENSIS
19 SALT ORENOCENSIS
25 SALT ALBICOLLIS
13 PITY GROSSUS
18 SALT COERULESCENS
14 SALT ATRICEPS
16 SALT ATRIPENNIS
3 PHEU AUREOVENTRIS
6 CARD CARDINALIS

Figure 3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7 CARD. PHOENICEUS
8 CARD. SINUATUS
27 PASS. CYANOIDES
30 PASS. CAERULEA
3 PHEU. AUREOVENTRIS
19 SALT. ORENOCENSIS
11 RHOD. CELAENO
16 SALT. ATRIPENNIS
18 SALT. COERULESCENS
21 SALT. AURANTIIROSTRIS
4 PHEU. LUDOVICIANUS
5 PHEU. MELANOCEPHALUS
6 CARD. CARDINALIS
9 CARY. CANADENSIS
15 SALT. MAXIMUS
17 SALT. SIMILIS
25 SALT. ALBICOLLIS
13 PITY. GROSSUS
23 SALT. ATRICOLLIS
2 PHEU. CHRYSOPEPLUS
14 SALT. ATRICEPS
26 PASS. GLAUCOCAERULEA
34 PASS. CIRIS
35 PASS. ROSITAE
29 PASS. PARELLINA
31 PASS. CYANEA
33 PASS. VERSICOLOR
36 PASS. LECLANCHERII
32 PASS. AMOENA
28 PASS. BRISSONII
DISTANCE
2.5 2.0 1.5 1.0 0.5 0.0
B.
SKEL/COMP I SKULL DIST
r=0.835
1 SPIZ. AMERICANA
23 SALT. ATRICOLLIS
26 PASS. GLAUCOCAERULEA
28 PASS. BRISSONII
29 PASS. PARELLINA
31 PASS. CYANEA
32 PASS. AMOENA
34 PASS. CIRIS
33 PASS. VERSICOLOR
36 PASS. LECLANCHERII
35 PASS. ROSITAE
2 PHEU. CHRYSOPEPLUS
3 PHEU. AUREOVENTRIS
21 SALT. AURANTIIROSTRIS
30 PASS. CAERULEA
4 PHEU. LUDOVICIANUS
5 PHEU. MELANOCEPHALUS
9 CARY. CANADENSIS
11 RHOD. CELAENO
6 CARD. CARDINALIS
13 PITY. GROSSUS
18 SALT. COERULESCENS
25 SALT. ALBICOLLIS
17 SALT. SIMILIS
15 SALT. MAXIMUS
16 SALT. ATRIPENNIS
14 SALT. ATRICEPS
8 CARD. SINUATUS
7 CARD. PHOENICEUS
27 PASS. CYANOIDES
19 SALT. ORENOCENSIS
C
SKEL/TIBIO SKULL
r=0.662 DIST
1 SPIZ. AMERICANA
23 SALT. ATRICOLLIS
21 SALT. AURANTIIROSTRIS
26 PASS. GLAUCOCAERULEA
29 PASS. PARELLINA
31 PASS. CYANEA
32 PASS. AMOENA
33 PASS. VERSICOLOR
36 PASS. LECLANCHERII
34 PASS. CIRIS
35 PASS. ROSITAE
2 PHEU. CHRYSOPEPLUS
30 PASS. CAERULEA
27 PASS. CYANOIDES
3 PHEU. AUREOVENTRIS
4 PHEU. LUDOVICIANUS
5 PHEU. MELANOCEPHALUS
11 RHOD. CELAENO
13 PITY. GROSSUS
9 CARY. CANADENSIS
19 SALT. ORENOCENSIS
6 CARD. CARDINALIS
7 CARD. PHOENICEUS
28 PASS. BRISSONII
8 CARD. SINUATUS
14 SALT. ATRICEPS
15 SALT. MAXIMUS
18 SALT. COERULESCENS
25 SALT. ALBICOLLIS
17 SALT. SIMILIS
16 SALT. ATRIPENNIS
D
SKEL/TIBIO PELVIC
r=0.705 DIST
1 SPIZ. AMERICANA
26 PASS. GLAUCOCAERULEA
34 PASS. CIRIS
28 PASS. BRISSONII
29 PASS. PARELLINA
33 PASS. VERSICOLOR
3 PHEU. AUREOVENTRIS
6 CARD. CARDINALLIS
7 CARD. PHOENICEUS
8 CARD. SINUATUS
36 PASS. LECLANCHERII
31 PASS. CYANEA
32 PASS. AMOENA
17 SALT. SIMILIS
25 SALT. ALBICOLLIS
21 SALT. AURANTIIROSTRIS
2 PHEU. CHRYSOPEPLUS
11 RHOD. CELAENO
9 CARY. CANADENSIS
19 SALT. ORENOCENSIS
4 PHEU. LUDOVICIANUS
5 PHEU. MELANOCEPHALUS
13 PITY. GROSSUS
15 SALT. MAXIMUS
16 SALT. ATRIPENNIS
27 PASS. CYANOIDES
18 SALT. COERULESCENS
30 PASS. CAERULEA
35 PASS. ROSITAE
14 SALT. ATRICEPS
23 SALT. ATRICOLLIS

Figure 4

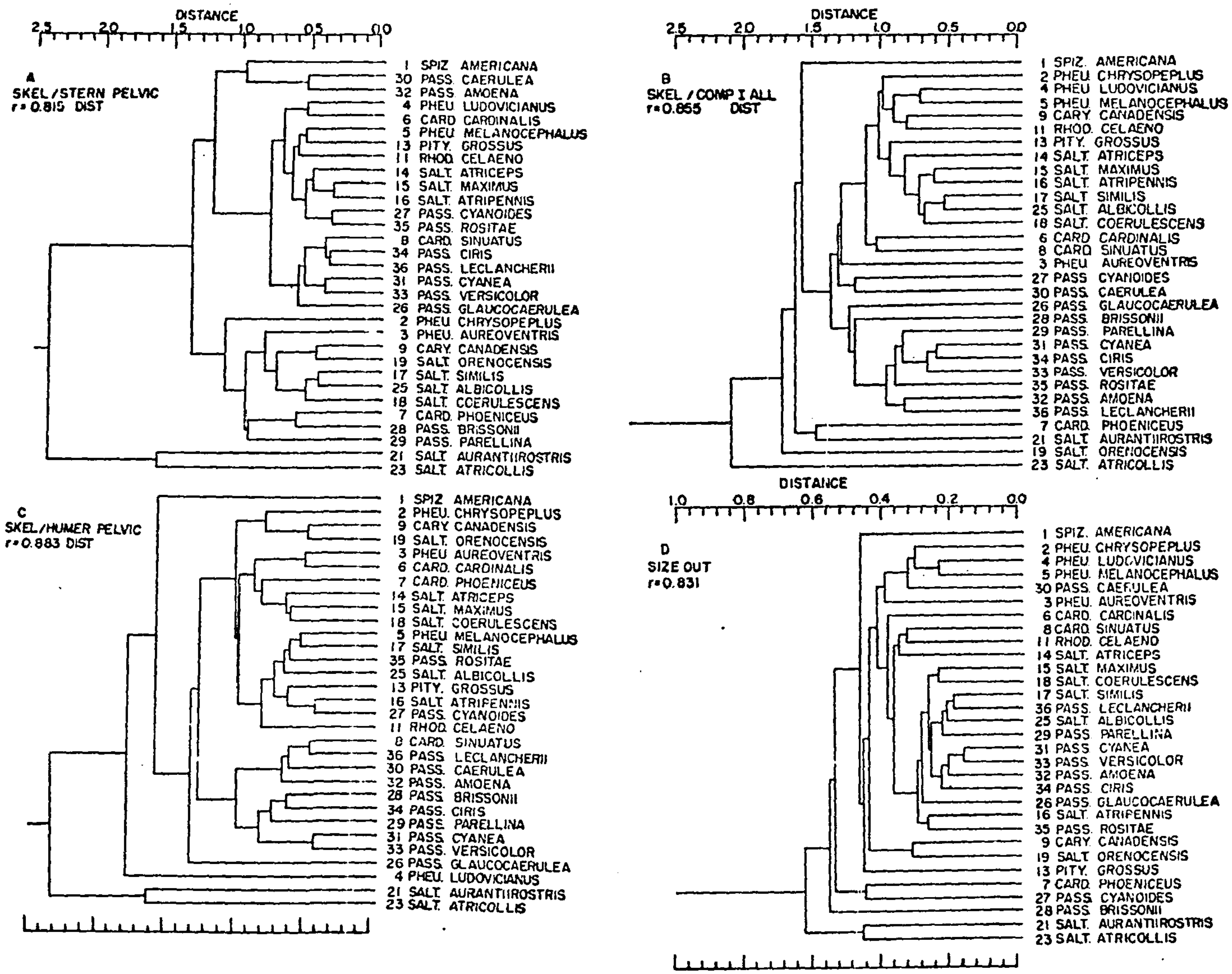
DISTANCE
2.5 2.0 1.5 1.0 0.5 0.0
A
SKEL/STERN PELVIC
r=0.815 DIST
1 SPIZ AMERICANA
30 PASS. CAERULEA
32 PASS AMOENA
4 PHEU LUDOVICIANUS
6 CARD CARDINALIS
5 PHEU MELANOCEPHALUS
13 PITY. GROSSUS
11 RHOD CELAENO
14 SALT ATRICEPS
15 SALT MAXIMUS
16 SALT ATRIPENNIS
27 PASS. CYANOIDES
35 PASS. ROSITAE
8 CARD SINUATUS
34 PASS CIRIS
36 PASS. LECLANCHERII
31 PASS. CYANEA
33 PASS VERSICOLOR
26 PASS GLAUCOCAERULEA
2 PHEU CHRYSOPEPLUS
3 PHEU. AUREOVENTRIS
9 CARY CANADENSIS
19 SALT ORENOCENSIS
17 SALT SIMILIS
25 SALT ALBICOLLIS
18 SALT COERULESCENS
7 CARD. PHOENICEUS
28 PASS BRISSONII
29 PASS. PARELLINA
21 SALT AURANTIIROSTRIS
23 SALT ATRICOLLIS
DISTANCE
2.5 2.0 1.5 1.0 0.5 0.0
B
SKEL / COMP I ALL
r=0.865 DIST
1 SPIZ. AMERICANA
2 PHEU CHRYSOPEPLUS
4 PHEU LUDOVICIANUS
5 PHEU MELANOCEPHALUS
9 CARY CANADENSIS
11 RHOD. CELAENO
13 PITY. GROSSUS
14 SALT. ATRICEPS
15 SALT MAXIMUS
16 SALT ATRIPENNIS
17 SALT SIMILIS
25 SALT ALBICOLLIS
18 SALT. COERULESCENS
6 CARD CARDINALIS
8 CARD SINUATUS
3 PHEU AUREOVENTRIS
27 PASS CYANOIDES
30 PASS CAERULEA
26 PASS GLAUCOCAERULEA
28 PASS BRISSONII
29 PASS. PARELLINA
31 PASS CYANEA
34 PASS CIRIS
33 PASS. VERSICOLOR
35 PASS. ROSITAE
32 PASS. AMOENA
36 PASS LECLANCHERII
7 CARD PHOENICEUS
21 SALT AURANTIIROSTRIS
19 SALT ORENOCENSIS
23 SALT. ATRICOLLIS
C
SKEL/HUMER PELVIC
r=0.883 DIST
1 SPIZ AMERICANA
2 PHEU. CHRYSOPEPLUS
9 CARY CANADENSIS
19 SALT. ORENOCENSIS
3 PHEU AUREOVENTRIS
6 CARD. CARDINALIS
7 CARD. PHOENICEUS
14 SALT. ATRICEPS
15 SALT. MAXIMUS
18 SALT. COERULESCENS
5 PHEU MELANOCEPHALUS
17 SALT. SIMILIS
35 PASS ROSITAE
25 SALT ALBICOLLIS
13 PITY. GROSSUS
16 SALT ATRIPENNIS
27 PASS. CYANOIDES
11 RHOD CELAENO
8 CARD. SINUATUS
36 PASS LECLANCHERII
30 PASS. CAERULEA
32 PASS. AMOENA
28 PASS BRISSONII
34 PASS. CIRIS
29 PASS. PARELLINA
31 PASS CYANEA
33 PASS. VERSICOLOR
26 PASS. GLAUCOCAERULEA
4 PHEU. LUDOVICIANUS
21 SALT AURANTIIROSTRIS
23 SALT. ATRICOLLIS
DISTANCE
1.0 0.8 0.6 0.4 0.2 0.0
D
SIZE OUT
r=0.831
1 SPIZ. AMERICANA
2 PHEU. CHRYSOPEPLUS
4 PHEU LUDOVICIANUS
5 PHEU. MELANOCEPHALUS
30 PASS. CAERULEA
3 PHEU. AUREOVENTRIS
6 CARD. CARDINALIS
8 CARD SINUATUS
11 RHOD. CELAENO
14 SALT. ATRICEPS
15 SALT MAXIMUS
18 SALT. COERULESCENS
17 SALT. SIMILIS
36 PASS. LECLANCHERII
25 SALT ALBICOLLIS
29 PASS PARELLINA
31 PASS CYANEA
33 PASS VERSICOLOR
32 PASS. AMOENA
34 PASS CIRIS
26 PASS. GLAUCOCAERULEA
16 SALT. ATRIPENNIS
35 PASS. ROSITAE
9 CARY CANADENSIS
19 SALT ORENOCENSIS
13 PITY. GROSSUS
7 CARD. PHOENICEUS
27 PASS CYANOIDES
28 PASS BRISSONII
21 SALT. AURANTIIROSTRIS
23 SALT. ATRICOLLIS

Figure 5

PAPER II

A PHENETIC ANALYSIS OF THE SUBFAMILY CARDINALINAE:

USING EXTERNAL MORPHOLOGICAL CHARACTERS AND SKELETAL CHARACTERS

A PHENETIC ANALYSIS OF THE SUBFAMILY CARDINALINAE: USING EXTERNAL MORPHOLOGICAL CHARACTERS AND SKELETAL CHARACTERS

Jenna J. Hellack

The subfamily Cardinalinae includes 37 species of cardinals, buntings, and grosbeaks. The group has been divided into from nine (Paynter, 1970) to 15 genera (Hellmayr, 1938). Previously using skeletal variables, I (Hellack, 1975b) investigated the phenetic relationships of the subfamily using cluster analyses. In that study three species in the genus *Saltator* clustered differently from that suggested in previous classifications (Hellmayr, 1938; Paynter, 1970). The three species in the genus *Cardinalis* were found to cluster together only in analyses utilizing 14 skull characters and all 31 species included in the study were found to be very similar in relative measurements of the pelvic region. In this paper, I wish to examine further the phenetic affinities between species of the subfamily by analyzing an additional set of external characteristics.

MATERIALS AND METHODS

This study involved the utilization of 75 external morphological characters in 10 phenetic analyses and the inclusion in two of these analyses, the 49 skeletal characters used by Hellack (1975b). The generic and specific designations used are those of Paynter (1970). Table 1 of Hellack (1975b) lists the species, a brief description of their geographic distribution, the species number assigned to each, and the number of skeletons measured of each. The 49 measurements are from all regions of the skeleton. Due to the lack of skeletal materials, only 31 of the 37 species (included in the subfamily by Paynter; 1970) were compared.

In the analyses of external morphological characters, similar problems of obtaining materials occurred. The Appendix indicates the 75 external morphological characters selected for this study, which can be separated into three categories: (1) 33 external skin measurements of the tail, wing, phalanges, and bill; (2) color measurements (dominant wave length) from 8 regions of the body; (3) contrast characters in which 34 comparisons were made between various regions of the bird (e.g. contrast between the nape and the crown; 0- no contrast, 1- contrast). All measurements were taken from adult specimens. Original mean character measurements for each species may be found in Appendix IV of Hellack (1975a).

For the external skin characters, I measured 10 males and 10 females of each species, if specimens were available. When more than one race was involved, measurements were taken from specimens of the nominant race. External skin measurements were available for females of all 37 species, but only 36 species are included in the analysis of males (the only known specimen of <u>Saltator cinctus</u> is a female).

Color was measured using the <u>Munsell Book of Color</u> (1973) which specifies a given color in terms of three characters--hue, value, and chroma. These values were then converted to dominant wave lengths, excitation purity, and percent reflectance by using the tables supplied by the Munsell company (anonymous, 1970). For discussions of these conversions the reader is referred to Newhall, Nickerson, and Judd (1943). Only one value, the dominant wave length of each region was included in the analysis.

Color measurements were obtained for males of 34 species and for females of 33 species. Caryothraustes humeralis, Saltator cinctus, and S. albicollis were not included in color analyses of the male species. These species plus S. maxillosus were not included in color analyses of females. When the 49 skeletal characters were combined with the external morphological characters, only 30 of the 37 species had complete data. These analyses therefore do not include the four above mentioned species plus Periporphyrus erythromelas, Saltator rufiventris, and Passerina caerulescens.

For the purpose of assessing phenetic similarity, multivariate statistical programs were employed from the Numerical Taxonomy System (NT-SYS, developed by F. James Rohlf, John Kishpauph, and David Kirk). Both Q- and R-type studies were conducted.

In the Q-type analysis, characters were standardized and either a product moment correlation coefficient or an average distance coefficient was calculated for all pairs of species (Sneath and Sokal, 1973). Species were then clustered by the unweighted pair-group using arithmetic averages (UPGMA), and the results were summarized in phenograms.

Principal components were extracted from a matrix of correlations among characters in the R-type analysis (Sneath and Sokal, 1973). Phenetic relationships were graphically presented as 3-D models of species plotted with respect to the first few principal components extracted from the matrix of correlation among characters (Rohlf, 1968). A shortest minimally connected network (Rohlf, 1970) computed from the original matrix of distances is superimposed on the 3-D models to point out possible distortions.

To eliminate or reduce the size factor, the external morphological characters were used as ratios (see Appendix), and the skeletal measurements were divided by the first principal component extracted from a matrix of unstandardized skeletal characters (Hellack, 1975b). The skeletal data were handled this way because in Hellack (1975b) it was the method which produced what was considered the "best" phenetic classification from the skeletal data.

Ten phenetic classifications were produced using the various combinations of available data sets (external skin characters, contrast characters, color characters, and skeletal characters) and two similarity coefficients (correlation and distance). Males and females were analyzed separately for two reasons: (1) to see if there were major differences between the resulting classifications: (2) to include all species in some analyses without the use of a large number of NCs (no comparison, i.e. no data to compare). Various data combinations were made so as to include all the characters available for any one species in an analysis.

Characters from the skeletal data were averaged for the species without regard to sex; therefore when all available data were utilized, the data were handled in the following manner: external skin characters of both males and females were averaged to produce mean external skin measurements; the contrast characters and the color characters were doubled (male and female averages included separately); and the skeletal characters of the previous study (Hellack, 1975b) were included. This produced

168 "characters" per species.

Matrices were produced from the classification systems of Paynter (1970) and Hellmayr (1938) (see Hellack, 1975b). These two matrices, the 10 matrices produced from the various combinations mentioned above, and two matrices produced from the analyses of skeletal characters (SKEL/COMP I ALL CORR and SKEL/COMP I ALL DIST; Hellack, 1975b) were compared by computing the coefficient of correlation between the basic similarity matrices. These correlations were then used to produce a matrix showing the similarities between these matrices. Similarities were then summarized into a dendrogram that indicates which basic similarity matrices are most alike. The phenograms were compared in a similar manner.

The following abbreviations will be used. CORR or DIST refer to the use of correlation or distance to analyze similarity between species. SKIN will denote the use of external skin measurements and contrast characters. COLOR refers to the use of eight color characters of dominant wave length. SKEL indicates the use of skeletal characters divided by unstandardized principal component I (SKEL/COMP I ALL of Hellack, 1975b). BSM is used as the abbreviation for basic similarity matrix.

RESULTS

Phenograms

The dendrogram which summarizes the similarity between 10 BSMs of this study, two BSMs from the analyses of skeletal characters (Hellack, 1975b), and the classifications of Hellmayr (1938) and Paynter (1970) is shown in Figure 1A. Nine groups of BSMs are labeled. The four BSMs of group A are analyses in which only the males of each species are compared. The BSMs differ in similarity coefficient and/or the number of characters (the BSMs also differ in the number of species compared, although the phenogram, Figure 1A, is comparing placement of only those species each analysis has in common). Group B has three BSMs where only the females for each species were compared. These BSMs like those of group A differ in similarity coefficient and/or the number of characters. Group E is composed of two BSMs. They differ in character set but are alike in the similarity coefficient used. The remaining five groups contain one BSM each.

The dendrogram of similarity between phenograms is shown in Figure 1B. In comparing the dendrogram of similarity between BSMs (Fig. 1A) with that of the phenograms (Fig. 1B), one BSM of group A (SKIN + COLOR DIST ♂♂) is in a different cluster; it shows more similarity to group E. This was the least similar of the four BSMs in group A. The remaining phenograms cluster much as their BSMs do in Figure 1A, although the distance analyses of groups E and F show considerably less similarity to the other clusters of phenograms than they did in Figure 1A. The similarities found in the comparison of BSMs (Fig. 1A) appear to be reduced in the phenogram comparisons (Fig. 1B).

There is considerable correlation of BSMs within groups A, B, and E (Fig. 1A). Instead of presenting all phenograms of these groups, I have depicted only one from each--the phenogram with the highest cophenetic correlation coefficient. Any substantial difference in placement of species in phenograms within each group will be described below.

Group A consists of four very similar BSMs. The phenogram chosen to represent the group (SKIN CORR ♂♂, Fig. 2A) has a cophenetic correlation coefficient of 0.792. There is essentially no difference between this phenogram and that of SKIN DIST ♂♂ (not figured). The addition of eight color characters (SKIN + COLOR CORR ♂♂, not figured) caused two species to cluster differently from that shown in Figure 2A. *Passerina versicolor* groups with *P. ciris* and *Periporphyrus erythromelas* shows little similarity to any cluster of species. SKIN + COLOR DIST ♂♂ (not figured) is the most divergent of the four phenograms. However, major clusters are much the same. The addition of color characters in this case resulted in *Passerina amoena* not being found in the cluster of buntings and *Rhodothraupis caelaeno*, *Periporphyrus erythromelas*, *Saltator orenocensis*, and *S. atriceps* to show little similarity to the other species of the analysis.

The three BSMs of group B are all the result of analyses in which only females of each species were compared. The phenogram which represents this group (SKIN DIST ♀♀, Fig. 2B) has a cophenetic correlation of 0.814. The major clusters found in Figure 2B are much the same in all phenograms of group B. However, in the two phenograms not figured, *Saltator rufiventris* clusters with the other saltators. Another difference is the similarity between *Caryothraustes humeralis* and *C. canadensis*. They are in the same large cluster, but are not as closely affiliated with each other as is seen in Figure 2B.

Group C (Fig. 2C) with its one BSM is an analysis with all characters (SKIN + COLOR + SKEL CORR). The phenogram has a cophenetic correlation of 0.727. Its stem connects with the BSM of SKEL/COMP I ALL CORR which was described in Hellack (1975b) and not figured here. Several major cluster changes occur if the two phenograms are compared. The cluster bounded by *Passerina glaucocaerulea* and *P. parellina* (Fig. 2C) is not found in SKEL/COMP I ALL CORR (the members of the genus *Passerina* form one cluster with the exception of *P. caerulea* and *P. cyanoides*). *Saltator orenocensis* and *Caryothraustes canadensis* cluster with the genus *Pheuticus* in SKEL/COMP I ALL CORR (not figured).

Group E contains two BSMs. The phenogram representative of this group (SKIN + COLOR + SKEL DIST, FIG. 2D) has a cophenetic correlation of 0.819. SKIN + COLOR + ♀♀ DIST (not figured) differs in the placement of several species. The buntings (*Passerina*) cluster much the same in SKIN + COLOR ♀♀ DIST as they do in SKIN + COLOR + SKEL CORR (Fig. 2C), whereas only two of the species in the genus (*P. amoena* and *P. caerulescens*) are not found in the same cluster in SKIN + COLOR + SKEL DIST (Fig. 2D). *Saltator atripennis* shows little similarity to any other species in SKIN + COLOR ♀♀ DIST.

Group F contains the BSM for SKEL/COMP I DIST. The phenogram resulting from this BSM was considered the "best" classification for the Cardinalinae when only skeletal characters were included in the analyses (Hellack, 1975b). Its phenogram (figured in Hellack, 1975b) had a cophenetic correlation of 0.855 and differs from those presented here mainly in the placement of the species in the genus *Cardinalis*. In SKEL/COMP I ALL DIST, the cardinals did not cluster together.

Principal component analyses

The different character sets of this study were also subjected to an R-type analysis. Four representative three-dimensional models of these analyses are shown in Figure 3. Character loadings for the first three principal components of each of the 3-D models are in Appendix I, II, and III of Hellack (1975a).

Figure 3A shows species projected onto the first three principal components from the analysis of males using external skin measurements and contrast characters. The components explain 21.16, 11.73, and 9.01 % of the total character variation, respectively. While only 42 % of the total variation is accounted for, the euclidian distances between species in the 3-D model have a correlation of 0.900 with those in the original distance matrix.

Principal component I has its highest loadings on the amount of tail covered by the tail coverts (Ex9, Ex10) and the shape of the wing (Ex12-16). Species on the left in the 3-D model (Fig. 3A) have less tail exposed and more sharply pointed wings. Component II is a size factor with high loadings on the tail, wing and hallux lengths (Ex1, Ex11, Ex28). This component also has relatively high loadings on the contrast characters for white in the wing and tail (Ex34, Ex36-39). The larger birds with large amounts of white in the wing and tail are in the front of the 3-D model. The third component has its highest loadings on the wing vane widths (Ex17-24). The short sticks represent species with relatively wider primaries.

Figure 3B represents the analysis of females utilizing external skin measurements and contrast characters. The first three components explain 20.24, 11.85, and 9.67 % of the total character variation, respectively. Less than 42 % of the total variation is accounted for in the first three components, however; the 3-D model has a correlation of 0.913 with the original distance matrix. This analysis has high loadings on the same characters as does that of the male analysis (Fig. 3A).

The 3-D model of the analysis utilizing all characters (SKIN + COLOR + SKEL) is shown in Figure 3C. The first three components account for 23.33, 12.96, and 9.22 % of the character variation, respectively (total, 45.51). Because there were many more characters than species in this analysis, Gower's (1966) method for computing projections from a matrix of correlation among species was utilized. As the 3-D model produced is from a matrix of correlation among species, character loadings are not available.

Figure 3D is the 3-D model produced from the analysis of skeletal characters divided by principal component I. The first three components account for 26.97, 18.24, and 11.18 % of the character variation, respectively (total, 56.39). The 3-D model has a correlation of 0.903 with the distance matrix. The first principal component is a contrast with its highest loadings on the keel depth and femur and tibiotarsus widths. Species on the left in the 3-D model (Fig. 3d) have relatively deeper keels and narrower femurs and tibiotarsi. Component II has its highest loadings on the long bones of the wing and leg. It also is a contrast with negative loadings on the long bones of the wing and positive loadings on the long bones of the leg. Species near the front of Figure 3D have relatively shorter legs and longer wings than those at the back. The third component has high positive loadings on the skull width and depth, and high negative loadings on the sternum and keel length. The species with the shorter sticks have relatively narrower skulls and longer sterna and keels.

DISCUSSION

Comparisons of BSMs, phenograms, and previous classifications

Highly correlated skeletal characters with a large size factor were used by Hellack (1975b) in an analysis of Cardinalinae. I found, as in previous studies (Sokal and Michener, 1967; Robins and Schnell, 1971), that using correlation as a measure of similarity tends to give more uniform results than did the use of the distance coefficient. The analyses in this study in which external character sets (SKIN or SKIN + COLOR) were used did not show this tendency. There was considerable correlation between the BSMs of similar character sets irrespective of similarity coefficient (Fig. 1A). The only exception was SKIN + COLOR DIST ♀♀ (not figured). The lack of a tendency for the BSMs to group according to similarity coefficient perhaps indicates there is not a large size factor or other significant trend in the ratios used as external characters.

As found in the analyses of skeletal characters, the affinities between phenograms (Fig. 1B) changed some from those expressed for the BSMs (Fig. 1A). In the comparison of phenograms (Fig. 1B), SKIN + COLOR DIST ♂♂ (not figured) switched (i.e., clustered with a different group of species or in this case phenograms) affinities, and showed more similarity to SKIN + COLOR DIST ♀♀ (not figured) and SKIN + COLOR + SKEL DIST (Fig. 2D). Switching also occurred in some of the major branches (e.g., four distance phenograms show less similarity to the other analyses than did their respective BSMs).

In comparing the 12 classifications in this study with the classifications of Hellmayr (1938) and Paynter (1970), nine of the BSMs were more similar to previous classifications than were their respective phenograms. All 12 BSMs and 10 of the phenograms were more similar to Paynter (1970) than to Hellmayr (1938). The two phenograms more similar to Hellmayr (1938) are SKIN CORR ♂♂ (Fig. 2A) and SKIN + COLOR CORR ♂♂ (not figured). Correlations between the BSMs and previous classifications are very low, indicating that the affinities implied by previous workers are different from those determined in my study.

Comparisons of representative phenograms

Six phenograms were chosen to represent the groups of BSMs shown in Figure 1A. These had relatively high cophenetic correlation coefficients. The phenogram representative of group B (SKIN DIST ♀♀, Fig. 2B) is the only representative phenogram in which all the species included in the subfamily Cardinalinae by Paynter (1970) were analyzed. Below the placement of the species in the other representative phenograms will be compared with their placement in SKIN DIST ♀♀ (Fig. 2B).

The representative phenogram of group A (SKIN CORR ♂♂, Fig. 2A) is very similar to SKIN DIST ♀♀ (Fig. 2b). While some changes in close affinities are evident, the major clusters are composed of many of the same species. *Passerina rositae*, *Saltator albicollis*, *S. rufiventris*, *Periporphyrus erythromelas* and *Caryothraustes humeralis* in SKIN CORR ♂♂ are not placed in the same major groups that they are found in SKIN DIST ♀♀.

The phenogram of group C (SKIN + COLOR + SKEL CORR, Fig. 2C) differs from SKIN DIST ♀♀ (Fig. 2B) primarily in the main stem connections of its smaller clusters. For example, the cluster bounded by *Pheuticus chrysopeplus* and *Passerina caerulea* in SKIN + COLOR + SKEL CORR is found as two clusters in SKIN DIST 00 with *Spiza americana* and a few species in the genus *Passerina* added. *Passerina leclancherii* and *P. versicolor* are not included in the same major groups in SKIN + COLOR + SKEL CORR as they are in SKIN DIST ♀♀. The species showing little affiliation to any of the clusters in SKIN DIST ♀♀ were not included in the phenogram of group C.

SKEL/COMP I CORR (group D, not figured) differs from SKIN DIST ♀♀ (Fig. 2B) in much the same way as SKIN + COLOR + SKEL CORR (Fig. 2C). In addition to the differences discussed above, the genus *Passerina* does not group in the same way as in SKEL/COMP I CORR. There is one cluster of nine species with the other two species *P. caerulea* and *P. cyanea* not clustering with these species.

The phenogram representative of group E (SKIN + COLOR + SKEL DIST) is shown in Figure 2D. Again the majority of the clusters are much the same as those of SKIN DIST ♀♀ (Fig. 2B). *Saltator orenocensis* differs in its placement and the species in the genus *Passerina* do not form two large groups in SKIN + COLOR + SKEL DIST. Only the two species *P. caerulea* and *P. amoena* do not cluster with the other species of this genus.

Group F contains only SKEL/COMP I ALL DIST, which is in Figure 5B of Hellack (1975b). It was the "best" phenetic classification of the Cardinalinae when only skeletal measurements were used (Hellack, 1975b). Several differences are noticeable in comparing this phenogram to SKIN DIST ♀♀ (Fig. 2B). Only two of the species in the genus *Cardinalis* cluster together; the other (*C. phoeniceus*) shows little similarity to them. Most species in the genus *Passerina* cluster together (exceptions being *P. cyanea* and *P. caerulea*) rather than forming two distinct clusters. Two saltators (*S. aurantiirostris* and *S. orenocensis*) are not found with the other saltators in SKEL/COMP I DIST.

The "best" phenetic classification

I have presented a number of phenetic classifications of the subfamily Cardinalinae. Each represents a facet of the phenetic relationships present in the group. However, as mentioned in the study of the skeletal characters (Hellack, 1975b), it may at times be useful to have one "best" classification of a group.

Schnell (1970) proposed several guides for choosing the "best" phenetic classification, when more than one was available. These guides are selection of a phenogram in which: 1) a large number of characters are used; 2) transformations to reduce the general size factor are utilized, and; 3) there is a relatively high cophenetic correlation coefficient. These guides while useful are not totally sufficient for this study. In my opinion, the phenogram used for general purposes should have a relatively high correlation with the other phenetic analyses of this study.

There are two analyses (in this study) in which all available characters were utilized and transformations reduced the size factor--SKIN + COLOR + SKEL CORR (Fig. 2C) and SKIN + COLOR + SKEL DIST (Fig. 2D). The phenogram with the highest cophenetic correlation coefficient is SKIN + COLOR + SKEL DIST (Fig. 2D). However, this phenogram is not as highly correlated to the BSMs and phenograms of the other analyses as is SKIN + COLOR + SKEL CORR. Only SKIN + COLOR DIST ♀♀ (not figured) and SKEL/COMP I DIST (figured in Hellack, 1975b) of the BSMs are more similar to the distance analysis. The two phenograms of these analyses plus SKIN + COLOR DIST ♂♂ (not figured) are more similar to SKIN + COLOR + SKEL DIST in the comparison of phenograms. SKIN + COLOR + SKEL CORR (Fig. 2C), while not having the highest cophenetic correlation coefficient, is probably the best representative phenogram of this study for the above reason and will be used as such here.

Using all available characters resulted in seven species not being included in the analysis SKIN + COLOR + SKEL CORR (Fig. 2C). As these species (*Caryothraustes humeralis*, *Periporphyrus erythromelas*, *Saltator maxillosus*, *S. cinctus*, *S. rufiventris*, *S. albicollis*, and *Passerina caerulescens*) are included in the subfamily by various authors (Hellmayr, 1938; Paynter, 1970), they should be represented in a "best" phenetic classification of the group. To accomplish this, I evaluated their placement in other phenograms and 3-D models of analyses. A phenogram was then constructed utilizing SKIN + COLOR + SKEL CORR (Fig. 2C) for the placement of all species which it included and I placed the seven species into the clusters they probably would have joined had they been included in the analysis. This "best" phenetic classification is shown in Figure 4. The reason or reasons for the placement of each of these species are discussed below.

Caryothraustes humeralis was included only in the analyses of skin and contrast characters. In SKIN DIST ♀♀ (Fig. 2B) and in the 3-D models of both SKIN ♀♀ (Fig. 3B) and SKIN ♂♂ (Fig. 3A), *C. humeralis* is most similar to *C. canadensis*. The average similarity of these two in the correlation analyses of both SKIN CORR ♀♀ (not figured) and SKIN CORR ♂♂ (Fig. 2A) is 0.577. This average similarity is used for the placement of *C. humeralis* in the "best" classification (Fig. 4).

Periporphyrus erythromelas was placed between *Rhodothraustes celaeno* and *Pitylus grossus* and near the saltators in the "best" classification.

In the analyses in which Periporphyrus erythromelas was included (all of those based on external characters) it was found to be most similar with R. celaeno or with Pitylus grossus. This was true in both the phenograms and the 3-D models with the only exception being SKIN CORR ♂♂ (Fig. 2A).

Saltator maxillosus was included in the analyses of skin and contrast characters (Figs. 2A,B; 3A,B). It varied in affinities in these analyses. In the two cluster analyses where I evaluated male characters (Fig. 2A), S. maxillosus showed close affinity to S. maximus, while in the cluster analyses utilizing female characters (Fig. 2B) it was similar to both S. atripennis and S. similis. In the 3-D models (Fig. 3A,B), S. maxillosus separates from the other saltators primarily in component III--the vanes of its primaries are somewhat wider than found in those species of the major saltator cluster. Based on these analyses, in the "best" classification (Fig. 4) it is placed in the saltator cluster and is depicted as more similar to the central group of species than either S. atripennis or S. atriceps.

Saltator cinctus was included only in the analyses of female skin and contrast characters. Only one specimen is available for this species and considerable feather wear was evident. It is placed in the "best" classification (Fig. 4) as it is found in the analyses of female characters (Figs. 2B,3B), but because of the lack of specimens I am not certain that this represents the true phenetic affinities of this species.

Saltator rufiventris was a part of all the external character analyses. It clustered with the saltators in all analyses; however, it showed no close affinities to any one saltator. Its closest affinities are perhaps to S. aurantiirostris, the species to which it is connected by the mininum connecting network of the 3-D models (Fig. 3A,B). S. rufiventris tends to separate from the other saltators in component III of the 3-D models. The primaries are relatively narrower in S. rufiventris than in the other species in the genus Saltator. Its placement in Figure 4 represents the appearance of more similarity to the major cluster of saltators than to any other species cluster. S. rufiventris is more similar to the saltator cluster than are S. aurantiirostris or S. atricollis.

Saltator albicollis was represented in all analyses except those in which color was included. It clustered with the saltators in the skeletal analyses (Hellack, 1975b) and in the analyses of external male characters (Figs. 2A,3A). In the analyses of female external characters (Figs. 2B,3B), it shows much less similarity to the saltators. Its placement as that of S. rufiventris is rather arbitrary, but it is apparently most similar to the saltators.

Passerina caerulescens was included in all the external character analyses. It always clustered with species in the genus Passerina (Figs. 2A,B; 3A,B), but was relatively less similar to them. In the "best" classification (Fig. 4) it is placed in the cluster which includes P. leclancherii, the species to which it appears most similar. At the same time, its connection is at some distance from that of the other species indicating its relatively low affiliation with the group.

Comparison of former classifications with the "best" phenetic classification

Hellmayr's (1938) and Paynter's (1970) proposed classifications of the 37 species (included in this study) differ in the placement of species that Paynter (1970) assigned to the genera Passerina, Pheuticus and Cardinalis. Hellmayr (1938) divides the eleven species of Paynter's

(1970) genus Passerina into five genera (Passerina, Cyanocompsa, Cyanoloxia, Porphyrospiza, and Guiraca) and the four species of Pheuticus into two genera (Pheuticus and Hedymelas). Hellmayr (1938) places the Pyrrhuloxia (Cardinalis sinuatus) in a genus by itself (Pyrrhuloxia sinuatus).

The "best" phenetic classification of this study (Fig. 4) divides the species in this study into three large clusters. These groups were not found in all the analyses of this study. However, one or more of these three groups occurred in every analysis (Fig. 2). The three groups are: 1) most of the species in the genus Passerina plus Spiza and Caryothraustes; 2) the genus Pheuticus plus Passerina caerulea; 3) the remaining genera in the subfamily (Saltator, Rhodothraustis, Periporphyrus, Pitylus and Cardinalis).

In comparing the "best" phenetic classification to the classifications of Hellmayr (1938) and Paynter (1970), the clusters of the species in the genera Passerina and Pheuticus are most similar to Hellmayr's groupings. It should be pointed out however that, while there is a tendency for Passerina to form more than one cluster in all analyses, these groups were often more similar to each other than to any other species cluster. When this was not true, one of the clusters of Passerina showed more similarity to the genus Caryothraustes or species of the genus Pheuticus.

Passerina caerulea has been considered very similar to the Indigo Bunting (Phillips et al., 1964; Blake, 1969). In this study P. caerulea never grouped with the other species included in the genus Passerina and in most analyses it clustered with the genus Pheuticus. The Pyrrhuloxia (Cardinalis sinuatus) clusters with the other species in the genus Cardinalis, the same as suggested by Paynter's (1970) classification.

The groupings of Hellmayr (1938) and Paynter (1970) are the same for the remaining species in the subfamily, but the phenetic analyses of my study differ from the previous classifications in the similarities of the species they both place in the genus Saltator. The "best" phenetic classification (Fig. 4) shows one cluster of six very similar saltators (S. atriceps, S. maximus, S. coerulescens, S. similis, S. maxillosus, and S. atripennis). The remaining six species included in this genus in previous classifications show little affiliation to any of the species clusters. It is possible that the limited material available was inadequate to get a reliable estimate of similarities for the species S. rufiventris, S. albicollis and S. cinctus. This is not true for S. atricollis, S. aurantiirostris and S. orenocensis. They differ from this cluster in every analysis. Ridgeway (1901) suggested that several of the South American saltators did not belong in the genus, a conclusion which is supported by this study.

Taxonomic Conclusions

In this study the phenetic similarity found between the species in the subfamily Cardinalinae is somewhat different from the affiliations suggested by previous classifications. This is particularly evident in the genus Saltator. Six species of this genus do not show close affinities to any of the other saltators.

The species in the genus Passerina show considerable similarity to each other in their skeletal characters (P. caerulea being the exception), but separate into groups much like those suggested by Hellmayr (1938) when external measures were considered along with these skeletal measurements. Passerina caerulea, which was never found clustering with the other species

Paynter (1970) places in the genus, is particularly noticeable. It has been suggested that this species is closely allied to the Indigo Bunting (Phillips et al., 1964; Blake, 1969; and Mayr and Short, 1970). In this study it was not closely associated with any one group although it clustered most often with the genus *Pheuticus*.

My results indicate that the genus *Saltator* as classified at present is a heterogenous group and consideration should be given to dividing it into several genera. I believe that *S. albicollis* and *S. rufiventris* are saltators and if adequate material were available they would cluster with the major group of saltators. *S. aurantiirostris*, *S. atricollis* and *S. orenocensis* are different and should be removed from the genus *Saltator*. I do not feel in a position to comment on *S. cinctus*.

The species in Paynter's (1970) genus *Passerina* could in my opinion be grouped according to either former classification--with the exception of *P. caerulea* which should remain *Guiraca caerulea*. *Pheuticus* appears to be composed of two rather different groups as indicated by Hellmayr (1938), and I suggest that his recommendations should be followed. I agree with Paynter on the classification of the genus *Cardinalis* (that it contains *Cardinalis sinuatus*) and the remaining species of this subfamily.

SUMMARY

Multivariate statistical techniques were used to determine phenetic affinities of 37 species in the subfamily Cardinalinae. Various analyses were made using 75 external morphological characters and 49 skeletal characters. Phenetic similarity was assessed using distances and product moment correlations as similarity coefficients; UPGMA (unweighted pair-group method using arithmetic averages) was used for clustering. Phenetic relationships are presented in phenograms and 3-D models of species projected onto principal components based on a matrix of correlation among characters.

The resulting 10 phenograms are compared among themselves, with two classifications of skeletal characters (Hellack, 1975b), and with classifications of Hellmayr (1938) and Paynter (1970). Basic similarity matrices grouped together according to the character set utilized or similarity coefficient. The use of different similarity coefficients had little effect on the external character sets.

BSMs were grouped, and within each group the phenogram which best represented its BSM was chosen to represent the group. These representative phenograms were compared to each other for differences in placement of species. The phenogram which best represented the phenetic affinities of the species was determined by utilizing the guidelines of Schnell (1970) and the coefficient of correlation between each of the basic similarity matrices.

The phenogram chosen in this manner used all characters available, but did not include seven of the species. As these species should be represented in a "best" phenetic classification, a phenogram was constructed using the phenogram chosen as the best representative of this study for the placement of all species it analyzed, and placing the seven remaining species into the clusters they would probably join if they had been included in the analysis. This was accomplished by studying the phenograms and 3-D models in which the seven species had been included.

This phenogram was then used to look at similarities and compare these similarities with the classification of Hellmayr (1938) and Paynter (1970). Based on phenetic groupings several saltators (S. rufiventris, S. albicollis, S. cinctus, S. atricollis, S. aurantiirostris, and S. orenocensis) were found to have little similarity to the remaining saltators. In the case of S. rufiventris, S. albicollis and S. cinctus, insufficient data may be the reason for their lack of similarity to the saltator cluster. However, S. atricollis, S. orenocensis and S. aurantiirostris are clearly distinct.

The genus Pheuticus clusters much as one would expect from Hellmayr's (1938) classification. The species placed in the genus Passerina by Paynter (1970) could be grouped according to either former classification.

ACKNOWLEDGMENTS

I am grateful to the curators of a number of collections who allowed me to use material in their care (they are listed in Hellack, 1975b). I wish to thank Gary D. Schnell, Harley P. Brown, Charles C. Carpenter, and James R. Estes for critically reviewing the manuscript. I also wish to thank Elizabeth A. Bergey who assisted with the measurement of specimens. Ginna Davidson and Sharon Swift aided in the preparation of figures. This study was supported in part by a travel grant from the Smithsonian Institution and a Sigma Xi Grant-in Aid.

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FIGURE LEGENDS

FIGURE 1. Dendrograms showing relationships among: A) basic similarity matrices; B) phenograms. Letters indicate groups of very similar basic similarity matrices. Asterisks indicate the phenogram chosen to represent each of these groups--the phenogram which has the highest cophenetic correlation coefficient. These representative phenograms are shown in Figure 2.

FIGURE 2. Phenogram representatives of groups A, B, C, and E. These are four analyses in which: A) skin characters of males were utilized using correlation as a measure of similarity; B) skin characters of females were used with distance as the similarity coefficient; C) all available characters were used and correlation was the measure of similarity; D) all characters were used and distance was the similarity coefficient.

FIGURE 3. Four representative models of species projected onto the first three principal components of a matrix of correlations among characters. A) the 3-D model in which male skin characters were used, B) the 3-D model in which female skin characters were used, C) the 3-D model in which all available characters were used, D) the 3-D model in which skeletal characters were used. Species names corresponding to the numbers on the models are: 1. *Spiza americana*; 2. *Pheuticus chrysopeplus*; 3. *P. aureoventris*; 4. *P. ludovicianus*; 5. *P. melanocephalus*; 6. *Cardinalis cardinalis*; 7. *C. phoeniceus*; 8. *C. sinuatus*; 9. *Caryothraustes canadensis*; 10. *C. humeralis*; 11. *Rhodothraupis celaeno*; 12. *Periporphyrus erythromelas*; 13. *Pitylus grossus*; 14. *Saltator atriceps*; 15. *S. maximus*; 16. *S.*

atripennis; 17. *S. similis*; 18. *S. coerulescens*; 19. *S. orenocensis*; 20. *S. maxillosus*; 21. *S. aurantiirostris*; 22. *S. cinctus*; 23. *S. atricollis*; 24. *S. rufiventris*; 25. *S. albicollis*; 26. *Passerina glaucocaerulea*; 27. *P. cyanoides*; 28. *P. brissonii*; 29. *P. parellina*; 30. *P. caerulea*; 31. *P. cyanea*; 32. *P. amoena*; 33. *P. versicolor*; 34. *P. ciris*; 35. *P. rositae*; 36. *P. leclancherii*; 37. *P. caerulescens*. Principal components I and II are shown and III is the height. The shortest minimally connected network is projected onto the component space in each of the models.

FIGURE 4. The "best" phenetic classification of this study. Seven species not included in the analysis SKIN + COLOR + SKEL CORR (Fig. 2C) are represented by dotted lines.

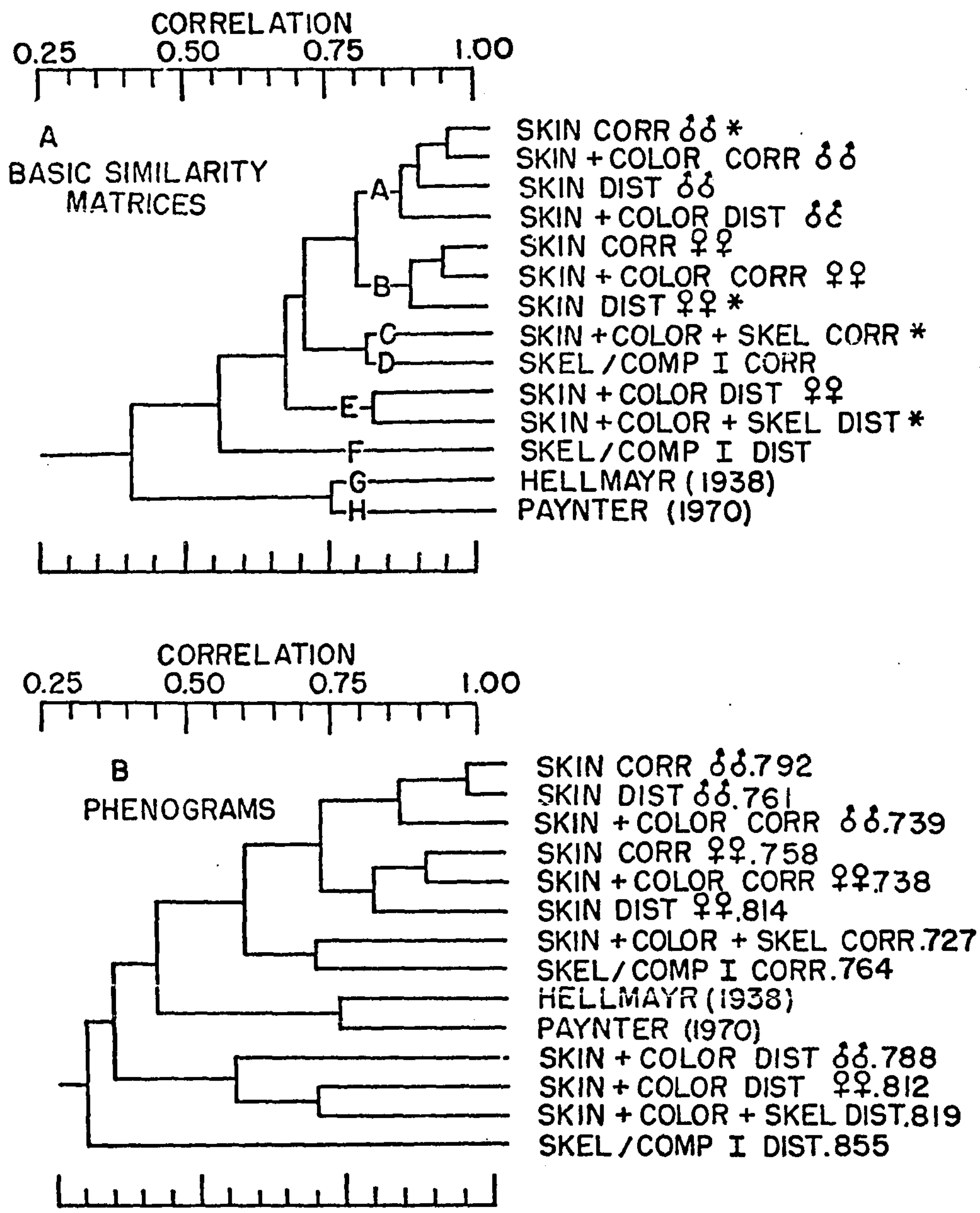
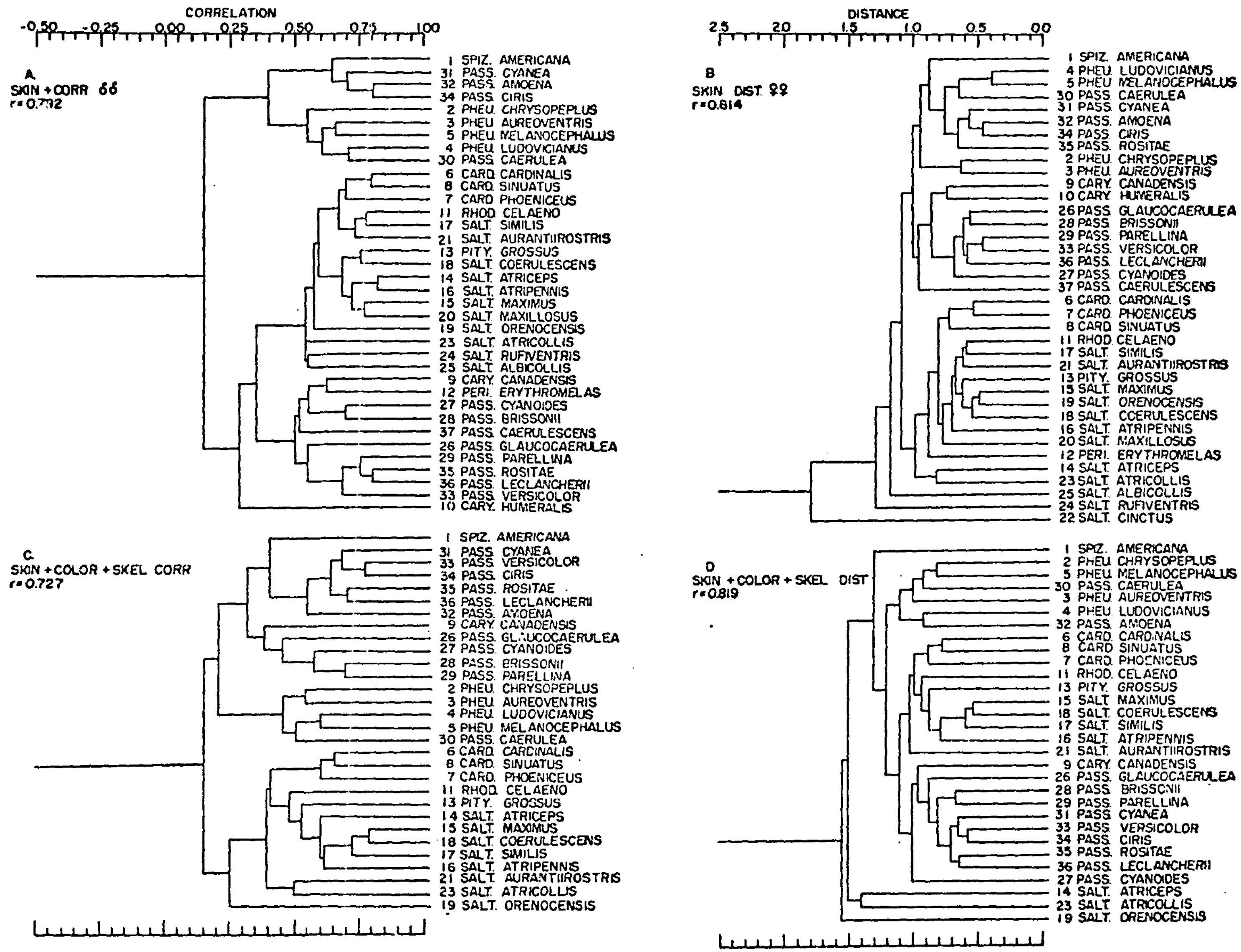

CORRELATION
0.25
0.50
0.75
1.00
A
BASIC SIMILARITY MATRICES
SKIN CORR ♂♂ *
SKIN + COLOR CORR ♂♂
SKIN DIST ♂♂
SKIN + COLOR DIST ♂♂
SKIN CORR ♀♀
SKIN + COLOR CORR ♀♀
SKIN DIST ♀♀ *
SKIN + COLOR + SKEL CORR *
SKEL / COMP I CORR
SKIN + COLOR DIST ♀♀
SKIN + COLOR + SKEL DIST *
SKEL / COMP I DIST
HELLMAYR (1938)
PAYNTER (1970)
A
B
C
D
E
F
G
H
CORRELATION
0.25
0.50
0.75
1.00
B
PHENOGRAMS
SKIN CORR ♂♂.792
SKIN DIST ♂♂.761
SKIN + COLOR CORR ♂♂.739
SKIN CORR ♀♀.758
SKIN + COLOR CORR ♀♀.738
SKIN DIST ♀♀.814
SKIN + COLOR + SKEL CORR.727
SKEL / COMP I CORR.764
HELLMAYR (1938)
PAYNTER (1970)
SKIN + COLOR DIST ♂♂.788
SKIN + COLOR DIST ♀♀.812
SKIN + COLOR + SKEL DIST.819
SKEL / COMP I DIST.855

Figure 1



CORRELATION
-0.50 -0.25 0.00 0.25 0.50 0.75 1.00
A.
SKIN + CORR 66
r = 0.792
1 SPIZ. AMERICANA
31 PASS. CYANEA
32 PASS. AMOENA
34 PASS. CIRIS
2 PHEU. CHRYSOPEPLUS
3 PHEU. AUREOVENTRIS
5 PHEU. MELANOCEPHALUS
4 PHEU. LUDOVICIANUS
30 PASS. CAERULEA
6 CARD. CARDINALIS
8 CARD. SINUATUS
7 CARD. PHOENICEUS
11 RHOD. CELAENO
17 SALT. SIMILIS
21 SALT. AURANTIIROSTRIS
13 PITY. GROSSUS
18 SALT. COERULESCENS
14 SALT. ATRICEPS
16 SALT. ATRIPENNIS
15 SALT. MAXIMUS
20 SALT. MAXILLOSUS
19 SALT. ORENOCENSIS
23 SALT. ATRICOLLIS
24 SALT. RUFIVENTRIS
25 SALT. ALBICOLLIS
9 CARY. CANADENSIS
12 PERI. ERYTHROMELAS
27 PASS. CYANOIDES
28 PASS. BRISSONII
37 PASS. CAERULESCENS
26 PASS. GLAUCOCAERULEA
29 PASS. PARELLINA
35 PASS. ROSITAE
36 PASS. LECLANCHERII
33 PASS. VERSICOLOR
10 CARY. HUMERALIS
DISTANCE
2.5 2.0 1.5 1.0 0.5 0.0
B
SKIN DIST 99
r = 0.814
1 SPIZ. AMERICANA
4 PHEU. LUDOVICIANUS
5 PHEU. MELANOCEPHALUS
30 PASS. CAERULEA
31 PASS. CYANEA
32 PASS. AMOENA
34 PASS. CIRIS
35 PASS. ROSITAE
2 PHEU. CHRYSOPEPLUS
3 PHEU. AUREOVENTRIS
9 CARY. CANADENSIS
10 CARY. HUMERALIS
26 PASS. GLAUCOCAERULEA
28 PASS. BRISSONII
29 PASS. PARELLINA
33 PASS. VERSICOLOR
36 PASS. LECLANCHERII
27 PASS. CYANOIDES
37 PASS. CAERULESCENS
6 CARD. CARDINALIS
7 CARD. PHOENICEUS
8 CARD. SINUATUS
11 RHOD. CELAENO
17 SALT. SIMILIS
21 SALT. AURANTIIROSTRIS
13 PITY. GROSSUS
15 SALT. MAXIMUS
19 SALT. ORENOCENSIS
18 SALT. COERULESCENS
16 SALT. ATRIPENNIS
20 SALT. MAXILLOSUS
12 PERI. ERYTHROMELAS
14 SALT. ATRICEPS
23 SALT. ATRICOLLIS
25 SALT. ALBICOLLIS
24 SALT. RUFIVENTRIS
22 SALT. CINCTUS
C.
SKIN + COLOR + SKEL CORR
r = 0.727
1 SPIZ. AMERICANA
31 PASS. CYANEA
33 PASS. VERSICOLOR
34 PASS. CIRIS
35 PASS. ROSITAE
36 PASS. LECLANCHERII
32 PASS. AMOENA
9 CARY. CANADENSIS
26 PASS. GLAUCOCAERULEA
27 PASS. CYANOIDES
28 PASS. BRISSONII
29 PASS. PARELLINA
2 PHEU. CHRYSOPEPLUS
3 PHEU. AUREOVENTRIS
4 PHEU. LUDOVICIANUS
5 PHEU. MELANOCEPHALUS
30 PASS. CAERULEA
6 CARD. CARDINALIS
8 CARD. SINUATUS
7 CARD. PHOENICEUS
11 RHOD. CELAENO
13 PITY. GROSSUS
14 SALT. ATRICEPS
15 SALT. MAXIMUS
18 SALT. COERULESCENS
17 SALT. SIMILIS
16 SALT. ATRIPENNIS
21 SALT. AURANTIIROSTRIS
23 SALT. ATRICOLLIS
19 SALT. ORENOCENSIS
D
SKIN + COLOR + SKEL DIST
r = 0.819
1 SPIZ. AMERICANA
2 PHEU. CHRYSOPEPLUS
5 PHEU. MELANOCEPHALUS
30 PASS. CAERULEA
3 PHEU. AUREOVENTRIS
4 PHEU. LUDOVICIANUS
32 PASS. AMOENA
6 CARD. CARDINALIS
8 CARD. SINUATUS
7 CARD. PHOENICEUS
11 RHOD. CELAENO
13 PITY. GROSSUS
15 SALT. MAXIMUS
18 SALT. COERULESCENS
17 SALT. SIMILIS
16 SALT. ATRIPENNIS
21 SALT. AURANTIIROSTRIS
9 CARY. CANADENSIS
26 PASS. GLAUCOCAERULEA
28 PASS. BRISSONII
29 PASS. PARELLINA
31 PASS. CYANEA
33 PASS. VERSICOLOR
34 PASS. CIRIS
35 PASS. ROSITAE
36 PASS. LECLANCHERII
27 PASS. CYANOIDES
14 SALT. ATRICEPS
23 SALT. ATRICOLLIS
19 SALT. ORENOCENSIS

Figure 2

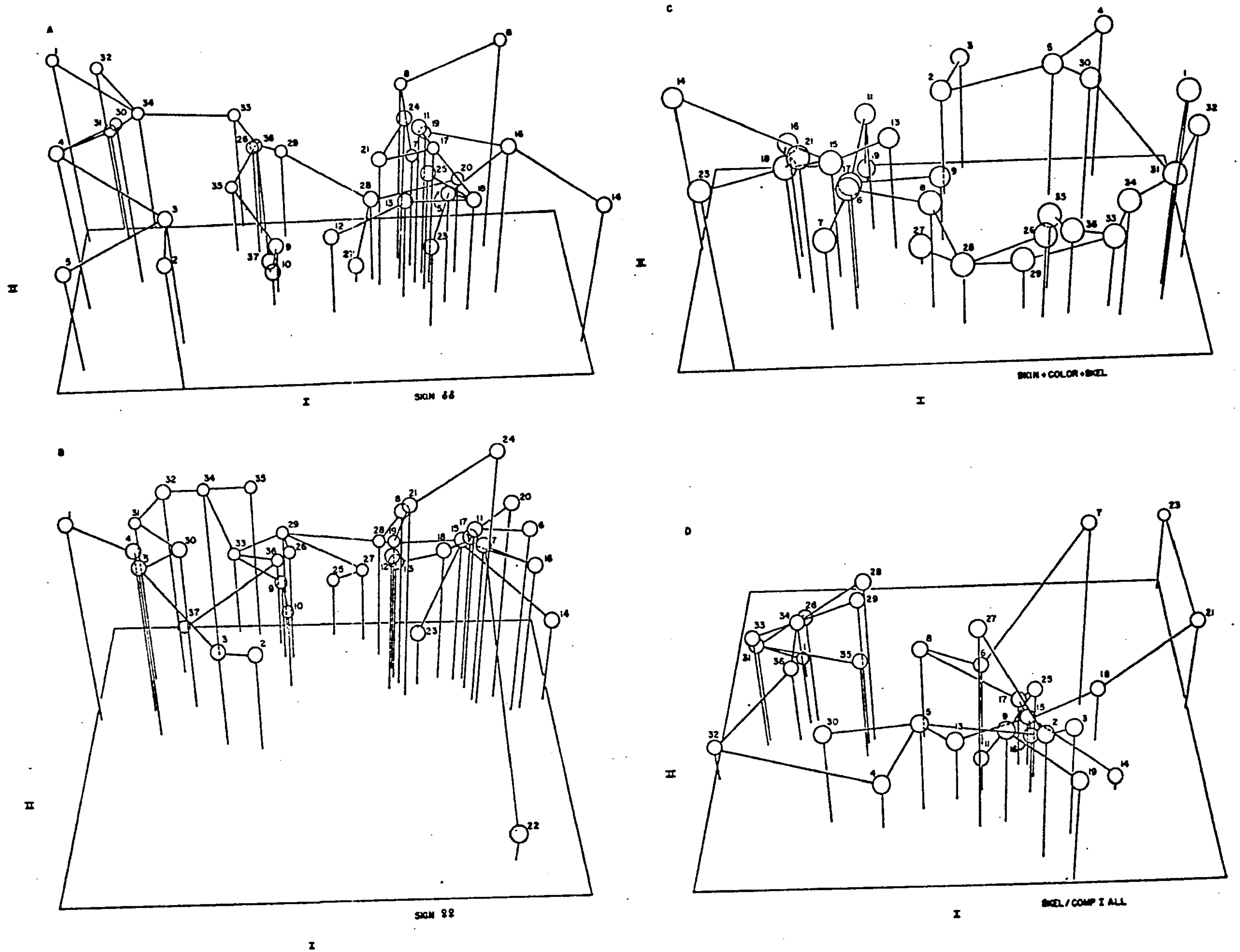


Figure 3

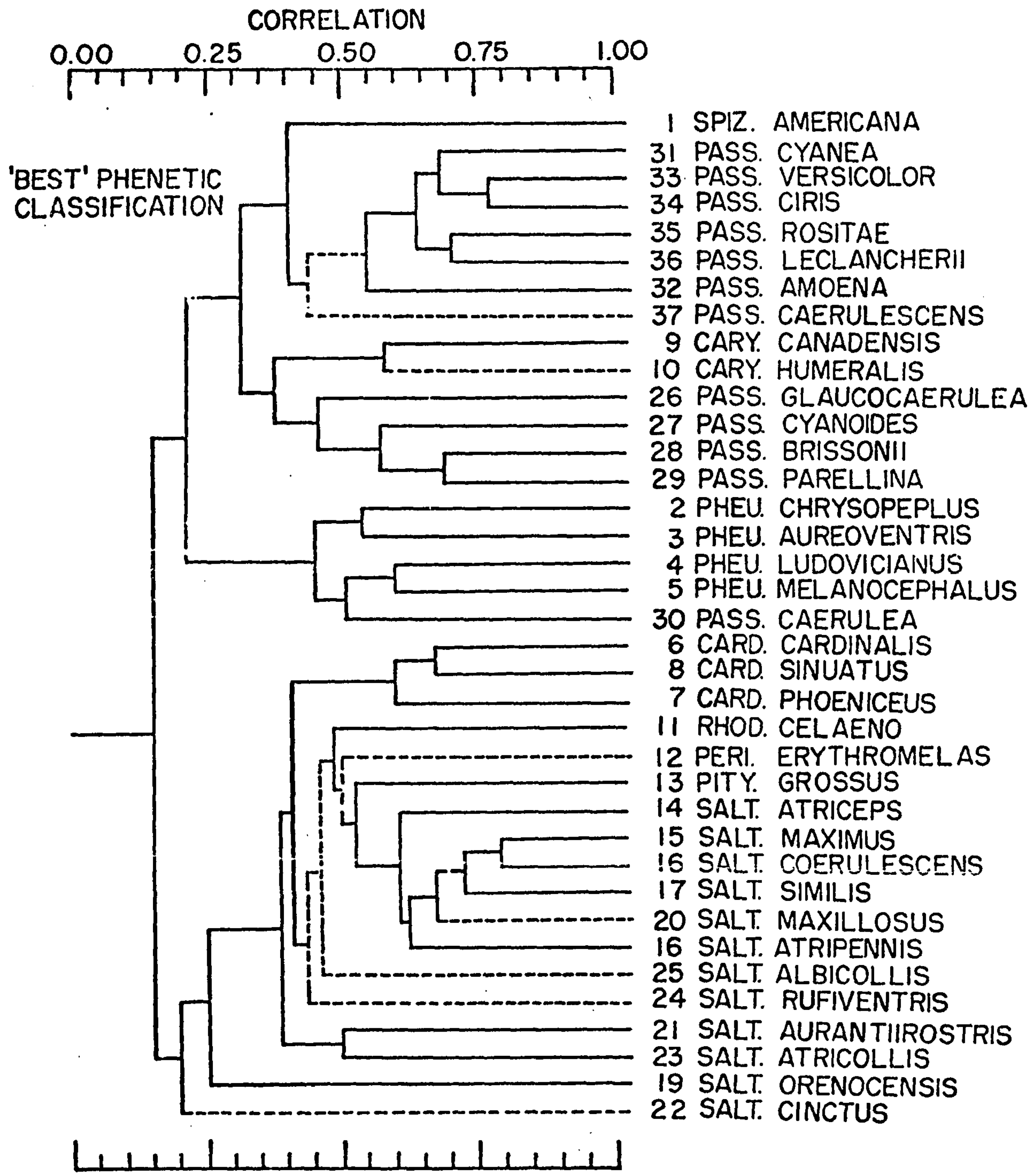

CORRELATION
0.00
0.25
0.50
0.75
1.00
'BEST' PHENETIC CLASSIFICATION
1 SPIZ. AMERICANA
31 PASS. CYANEA
33 PASS. VERSICOLOR
34 PASS. CIRIS
35 PASS. ROSITAE
36 PASS. LECLANCHERII
32 PASS. AMOENA
37 PASS. CAERULESCENS
9 CARY. CANADENSIS
10 CARY. HUMERALIS
26 PASS. GLAUCOCAERULEA
27 PASS. CYANOIDES
28 PASS. BRISSONII
29 PASS. PARELLINA
2 PHEU. CHRYSOPEPLUS
3 PHEU. AUREOVENTRIS
4 PHEU. LUDOVICIANUS
5 PHEU. MELANOCEPHALUS
30 PASS. CAERULEA
6 CARD. CARDINALIS
8 CARD. SINUATUS
7 CARD. PHOENICEUS
11 RHOD. CELAENO
12 PERI. ERYTHROMELAS
13 PITY. GROSSUS
14 SALT. ATRICEPS
15 SALT. MAXIMUS
16 SALT. COERULESCENS
17 SALT. SIMILIS
20 SALT. MAXILLOSUS
16 SALT. ATRIPENNIS
25 SALT. ALBICOLLIS
24 SALT. RUFIVENTRIS
21 SALT. AURANTIIROSTRIS
23 SALT. ATRICOLLIS
19 SALT. ORENOCENSIS
22 SALT. CINCTUS

Figure 4

APPENDIX

DESCRIPTION OF EXTERNAL SKIN, CONTRAST, AND COLOR CHARACTERS

The abbreviation "Ex" is used for skin measurements and contrast characters. "Col" indicates the color measurements.

Ex1- Rectrix length, distance from where skin joins shaft of middle pair of rectrices to tip of longest rectrix.

(Ex2-Ex6 represent the shape of the tail and are divided by Ex1 in order to reduce the size factor; measurement is coded as negative until longest feather is measured then positive from longest feather).

Ex2- Distance from the tip of the outer rectrix to the tip of the second rectrix.

Ex3- Distance from the tip of the second rectrix to the tip of the third rectrix.

Ex4- Distance from the tip of the third rectrix to the tip of the fourth rectrix.

Ex5- Distance from tip of the fourth rectrix to the tip of the fifth rectrix.

Ex6- Distance from the tip of the fifth rectrix to the tip of the sixth rectrix.

Ex7- The width of the outer rectrix measured at the center of the feather and divided by Ex1.

Ex8- The width of the outer vane of the outer rectrix measured at the center of the feather and divided by Ex1.

Ex9- Distance from the tip of the undertail coverts to the tip of the longest rectrix divided by Ex1.

Ex10- Distance from the tip of the uppertail coverts to the tip of the longest rectrix divided by Ex1.

Ex11- Wing length, distance from carpal joint (bend of wing) to tip of longest primary.

(Ex12-Ex16 represent the shape of the tail and are divided by Ex11 in order to reduce the size factor, coded as negative numbers until the longest feather is measured then a positive number.

Ex12- Distance from the tip of the ninth primary to the tip of the eighth primary.

Ex13- Distance from the tip of the eighth primary to the tip of the seventh primary.

Ex14- Distance from the tip of the seventh primary to the tip of the sixth primary

Ex15- Distance from the tip of the sixth primary to the tip of the fifth primary

Ex16- Distance from the tip of the fifth primary to the tip of the fourth primary

Ex17- Width of the ninth primary measured at the center of the feather and divided by Ex11.

Ex18- Width of the outer vane of the ninth primary measured at the center of the feather and divided by Ex11.

Ex19- Width of the eight primary measured at the center of the feather and divided by Ex11.

Ex20- Width of the outer vane of the eight primary measured at the center of the feather and divided by Ex11.

Ex21- Width of the seventh primary measured at the center of the feather and divided by Ex11.

Ex22- Width of the outer vane of the seventh primary measured at the center of the feather and divided by Ex11.

Ex23- Width of the sixth primary measured at the center of the feather and divided by Ex11.

Ex24- Width of the outer vane of the sixth primary measured at the center of the feather and divided by Ex11.

Ex25- Width of the first secondary measured at the center of the feather and divided by Ex11.

Ex26- Width of the outer vane of the first secondary measured at the center of the feather and divided by Ex11.

Ex27- Distance from the tip of the longest secondary to the tip of the longest primary; measurement divided by Ex11.

Ex28- Hallux length.

Ex29- Length of the middle toe divided by Ex28.

Ex30- Length of the second toe divided by Ex28.

Ex31- Length of the fourth toe divided by Ex28.

Ex32- Angle of the commissural point relative to the tomia.

Ex33- An angle measurement of the arc of the mandibular ramus.

Ex34- White spots in the tail. Coded: 0) absent; 1) present.

Ex35- Under-tail coverts contrasting to belly. Coded: 0) no contrast; 1) contrast.

Ex36- White present at apex of primaries. Coded: 0) absent; 1) present.

Ex37- White at base of primaries. Coded: o) absent; 1) present.

Ex38- White on primary coverts. Coded: 0) absent; 1) present.

Ex39- White on secondary coverts. Coded: 0) absent; 1) present.

Ex40- Marginal coverts contrasting to other coverts. Coded: 0) no contrast; 1) contrast.

Ex41- Malar region contrasting to auricular. Coded: 0) no contrast; 1) contrast.

Ex42- Lore region contrasting to forehead. Coded: 0) no contrast; 1) contrast.

Ex43- Forehead contrasting to crown. Coded: 0) no contrast; 1) contrast.

Ex44- Occiput contrasting to nape. Coded: 0) no contrast; 1) contrast.

Ex45- Occiput contrasting to crown. Coded: 0) no contrast; 1) contrast.

Ex46- Nape contrasting to back (base color). Coded: 0) no contrast; 1) contrast.

Ex47- Chin contrasting to gular. Coded: 0) no contrast; 1) contrast.

Ex48- Gular contrasting to jugulum. Coded: 0) no contrast; 1) contrast.

Ex49- Eye ring. Coded: 0) absent; 1) present.

Ex50- Breast streaking. Coded: 0) absent; 1) present.

Ex51- Back streaking. Coded: 0) absent; 1) present.

Ex52- Side of body streaked. Coded: 0) absent; 1) present.

Ex53- Flanks streaked. Coded: 0) absent; 1) present.

Ex54- Abdomen contrasting to breast. Coded: 0) no contrast; 1) contrast.

Ex55- Rump contrasting to back. Coded: 0) no contrast; 1) contrast.

Ex56- Presence of a crest. Coded: 0) absent; 1) present.

Ex57- Color sexual dimorphism. Coded; 0) absent; 1) present.

Ex58- Middle wing coverts contrasting to other coverts. Coded: 0) no contrast; 1) contrast.

Ex59- Superciliary line contrasting to crown. Coded: 0) no contrast; 1) contrast.

Ex60- Auricular white. Coded: 0) no; 1) yes.

Ex61- White spot at base of lower mandible. Coded: 0) absent; 1) present.

Ex62- Stripes on throat. Coded: 0) absent; 1) present.

Ex63- Upper-tail coverts contrasting to rump. Coded: 0) no contrast; 1) contrast.

Ex64- Streaking on the crown. Coded: 0) absent; 1) present.

Ex65- Flanks contrasting to abdomen. Coded: 0) no contrast; 1) contrast.

Ex66- Sides contrasting to breast. Coded: 0) no contrast; 1) contrast.

Color characters (Col) of the bird were recorded using the dominant wave length as the measurement of color. Color measurements were taken from eight regions of the bird: 1) crown; 2) back; 3) rump; 4) upper-tail coverts; 5) gular, jugulum region; 6) breast; 7) abdomen; 8) crissum.

APPENDIX I

The First Three Principal Components Based on Matrices of Correlations

Among Characters treated in Two Different Ways

Ex No.	Male Skin Characters			Female Skin Characters		
	I	II	III	I	II	III
1	0.674	-0.576	0.382	0.726	-0.567	0.036
2	-0.706	-0.084	-0.021	-0.631	0.431	0.355
3	-0.746	0.235	-0.028	-0.573	0.428	0.419
4	-0.638	0.339	-0.023	-0.663	0.159	0.245
5	-0.620	0.238	-0.021	-0.529	0.459	0.443
6	-0.295	0.089	-0.061	-0.353	-0.272	-0.155
7	-0.289	0.077	-0.455	-0.320	0.639	0.005
8	0.353	-0.036	-0.443	0.233	0.343	-0.494
9	0.821	-0.219	-0.189	0.763	-0.166	-0.303
10	0.834	-0.187	-0.124	0.794	-0.193	-0.132
11	0.409	-0.712	0.384	0.483	-0.606	0.093
12	-0.849	-0.103	-0.003	-0.847	-0.299	-0.025
13	-0.886	0.021	0.007	-0.909	-0.082	-0.069
14	-0.628	0.058	0.244	-0.670	-0.179	0.167
15	-0.872	-0.099	0.209	-0.838	-0.340	0.067
16	-0.798	-0.101	0.181	-0.704	-0.270	0.169
17	-0.178	0.009	-0.609	-0.270	0.381	-0.731
18	-0.076	-0.209	-0.505	-0.222	0.454	-0.541
19	-0.439	-0.188	-0.611	-0.313	0.173	-0.729
20	-0.602	-0.205	-0.510	-0.621	0.031	-0.494
21	-0.191	-0.317	-0.688	-0.135	0.124	-0.798

22	-0.358	-0.485	-0.559	-0.432	0.098	-0.634
23	-0.017	-0.261	-0.694	-0.069	0.182	-0.720
24	-0.189	-0.480	-0.574	-0.340	0.031	-0.746
25	0.607	-0.246	-0.437	0.275	0.524	0.028
26	0.010	-0.475	-0.548	-0.010	0.026	-0.224
27	-0.788	-0.215	0.269	-0.488	-0.372	-0.117
28	0.474	-0.682	0.328	0.456	-0.617	0.084
29	-0.192	0.289	0.499	0.221	-0.494	0.271
30	0.195	-0.309	0.140	0.291	-0.470	0.011
31	0.250	-0.256	0.187	0.340	-0.664	0.128
32	0.449	-0.183	-0.185	0.437	-0.029	-0.253
33	-0.480	0.378	0.055	-0.426	0.200	0.262
34	-0.491	-0.651	0.176	-0.318	-0.723	-0.188
35	0.078	-0.684	-0.007	0.183	-0.304	-0.287
36	-0.384	-0.662	0.047	-0.336	-0.458	0.008
37	-0.544	-0.694	0.174	-0.482	-0.547	0.018
38	-0.511	-0.532	0.186	-0.259	-0.451	-0.148
39	-0.612	-0.546	0.255	-0.526	-0.481	0.109
40	0.092	-0.475	0.149	0.065	-0.528	-0.029
41	0.217	-0.043	0.001	-0.037	-0.158	0.252
42	-0.211	0.431	-0.376	-0.111	-0.258	-0.328
43	0.299	0.115	0.324	0.324	-0.094	-0.055
44	0.025	0.006	0.247	0.305	-0.022	-0.040
45	0.133	0.241	0.043	0.468	-0.099	0.236
46	-0.241	0.407	0.032	-0.122	-0.102	0.049
47	-0.113	0.075	0.124	0.139	0.087	0.062

48	-0.243	0.081	-0.048	0.021	-0.216	-0.089
49	-0.237	0.469	-0.135	-0.109	0.319	0.124
50	-0.032	-0.080	0.074	-0.387	0.071	-0.018
51	-0.364	-0.512	0.122	-0.642	-0.327	-0.023
52	-0.176	-0.136	0.153	-0.717	-0.265	-0.049
53	-0.255	-0.047	0.133	-0.731	-0.347	-0.077
54	-0.440	-0.039	0.319	-0.387	-0.262	0.344
55	-0.312	0.279	0.128	-0.079	0.319	-0.165
56	0.282	0.168	0.383	0.288	-0.057	0.257
57	-0.505	0.362	0.043	-0.467	0.133	0.220
58	-0.386	0.273	-0.031	-0.332	-0.273	-0.051
59	0.376	-0.245	0.333	0.184	-0.201	0.317
*1	-0.538	-0.556	0.219	0.016	-0.711	-0.412
60	0.247	-0.038	0.103	0.256	-0.106	0.037
61	0.146	0.003	0.101	0.098	0.041	-0.022
62	-0.038	-0.072	-0.317	-0.049	-0.026	-0.191
*2	0.876	-0.191	-0.065	0.824	0.191	-0.195
63	-0.502	-0.627	0.147	-0.322	-0.278	-0.056
64	-0.290	-0.299	0.106	-0.594	-0.311	-0.057
65	0.081	0.138	0.349	0.185	-0.218	-0.449
66	0.183	0.058	0.260	0.172	-0.323	-0.547

*1- Number of rectrices with large white spots. Coded: 0) none; 1) one; 2) two; 3) three; 4) four; 5) five; 6) six.

*2- Number of primaries which are slotted. Coded; 0) none; 1) one; 2) two; 3) three; 4) four; 5) five; 6) six.

APPENDIX II

The First Three Principal Components Based on Matrices of Correlations among Skeletal Characters/ Comp I

Sk No.	I	II	III	Sk No.	I	II	III
1	0.659	-0.474	0.247	28	0.587	0.245	-0.401
2	0.514	-0.526	0.262	29	0.614	-0.064	-0.241
3	0.033	0.195	0.012	30	0.119	-0.465	0.037
4	0.780	-0.272	-0.022	31	0.849	0.311	-0.276
5	0.385	-0.642	0.379	32	0.727	0.509	-0.192
6	0.225	-0.658	0.339	33	0.824	0.501	-0.090
7	-0.630	0.262	0.262	34	0.479	0.698	-0.176
8	-0.519	0.324	0.644	35	0.841	0.025	-0.190
9	-0.185	0.121	0.499	36	0.075	0.824	0.050
10	-0.592	0.236	0.606	37	-0.108	0.829	0.164
11	-0.256	0.011	0.372	38	0.506	0.687	-0.133
12	0.734	-0.419	0.067	39	0.649	0.488	-0.110
13	0.487	-0.722	0.167	40	0.626	-0.416	-0.191
14	0.580	-0.308	0.444	41	-0.302	0.037	-0.496
15	0.331	-0.389	-0.664	42	0.431	-0.317	-0.279
16	-0.768	0.114	-0.364	43	0.197	0.440	-0.446
17	-0.560	0.130	-0.544	44	-0.267	-0.637	-0.381
18	-0.233	-0.062	-0.141	45	-0.278	-0.653	-0.396
19	-0.655	-0.194	-0.356	46	0.085	-0.524	-0.269
21	-0.440	0.233	-0.618	47	-0.243	-0.586	-0.506

22	-0.299	-0.029	-0.639	48	-0.032	-0.144	-0.039
23	0.351	-0.329	0.019	49	-0.699	-0.275	-0.260
24	-0.867	0.044	-0.028	50	-0.678	-0.192	-0.117
26	0.515	0.520	-0.116	51	-0.426	0.259	-0.034
27	0.465	0.461	-0.181				

APPENDIX III

CARDINALINAE SKELETAL

ORIGINAL MEAN CHARACTERS PER SPECIES

		1-SPIZ A	2-PHEU C	3-PHEU A	4-PHEU L	5-PHEU M	6-CARD C	7-CARO P	8-CARD S	9-CARY C	11RHOD C
1	SKEL	13.840	24.570	22.200	18.250	19.960	17.920	18.630	16.070	17.380	19.180
2	SKEL	7.490	14.610	12.650	9.670	11.170	5.750	10.300	9.040	9.370	9.680
3	SKEL	2.520	5.710	5.250	3.990	4.740	4.430	4.700	4.370	4.760	5.500
4	SKEL	0.980	2.250	2.100	1.460	1.760	1.670	2.670	2.050	2.110	2.870
5	SKEL	8.460	14.660	14.000	12.060	12.500	11.340	11.600	11.740	12.720	13.290
6	SKEL	4.080	9.300	8.850	7.420	7.740	6.250	6.700	7.750	7.610	7.160
7	SKEL	13.210	17.390	16.300	15.660	16.300	14.080	14.900	16.200	16.270	17.970
8	SKEL	14.890	20.560	19.600	17.920	18.510	18.320	18.650	17.990	18.010	19.360
9	SKEL	3.850	4.820	4.800	4.400	4.820	4.470	5.230	4.060	4.480	4.610
10	SKEL	12.490	16.900	16.100	15.180	15.350	15.690	15.570	15.170	15.300	16.470
11	SKEL	30.490	43.200	39.700	36.080	38.000	35.500	34.570	33.530	36.960	38.960
12	SKEL	21.630	34.020	31.500	27.420	28.740	26.310	26.300	23.780	28.690	30.150
13	SKEL	6.100	12.220	10.850	9.230	9.960	8.490	8.470	7.210	9.490	8.700
14	SKEL	3.360	8.050	7.250	5.830	6.130	7.220	7.170	5.780	5.660	6.130
15	SKEL	1.090	1.540	1.350	1.390	1.350	1.300	1.070	1.170	1.480	1.610
16	SKEL	19.450	24.710	23.250	22.110	21.690	20.740	19.430	19.850	20.980	23.530
17	SKEL	22.820	27.990	26.150	25.390	25.980	25.070	22.130	23.640	23.570	27.000
18	SKEL	4.090	5.570	5.050	4.880	5.190	4.940	4.470	4.700	4.880	5.660
19	SKEL	4.860	5.990	4.950	5.520	5.790	4.870	3.900	4.830	4.590	5.380
21	SKEL	22.980	26.740	26.300	26.040	26.460	26.130	23.330	24.600	24.410	27.670
22	SKEL	22.490	26.740	24.650	25.650	25.650	25.000	21.800	23.590	22.740	26.670
23	SKEL	9.360	14.060	15.700	12.400	12.130	11.460	11.270	10.060	12.060	12.480
24	SKEL	10.880	12.210	11.400	11.400	11.400	11.130	10.270	10.290	10.460	11.890
26	SKEL	4.050	5.240	5.350	4.710	4.630	4.690	4.700	4.390	4.630	5.270
27	SKEL	6.090	8.090	7.600	7.000	7.040	6.780	6.600	6.440	6.340	7.530
28	SKEL	10.460	13.900	12.900	12.230	12.140	11.310	11.230	11.290	12.280	13.400
29	SKEL	9.860	15.500	14.350	13.540	13.860	13.140	11.830	11.870	13.960	14.760
30	SKEL	5.680	9.370	8.500	8.270	8.370	7.990	7.400	7.160	8.030	8.540
31	SKEL	3.350	4.700	4.350	3.950	3.990	3.920	3.870	3.680	3.940	4.460
32	SKEL	1.450	1.970	1.950	1.730	1.700	1.800	1.700	1.720	1.760	1.830
33	SKEL	3.270	4.630	4.250	3.900	4.060	3.910	3.970	3.780	3.890	4.400
34	SKEL	19.690	24.990	24.300	21.740	22.650	21.500	21.030	21.290	21.270	23.310
35	SKEL	1.130	1.760	1.700	1.440	1.490	1.500	1.400	1.360	1.520	1.600
36	SKEL	32.550	39.110	36.750	34.680	35.890	35.590	35.000	34.630	33.270	36.760
37	SKEL	22.420	25.540	25.700	22.610	23.790	24.270	23.870	24.300	21.810	24.030
38	SKEL	1.160	1.530	1.400	1.290	1.330	1.300	1.330	1.270	1.320	1.430
39	SKEL	2.180	3.030	2.700	2.460	2.800	2.490	2.630	2.510	2.510	2.950
40	SKEL	6.010	9.260	8.650	8.010	8.070	8.150	7.370	7.580	7.930	8.840
41	SKEL	3.020	4.070	3.750	3.770	3.830	3.860	3.230	3.410	3.560	4.130
42	SKEL	4.630	7.110	6.550	6.160	6.300	6.220	5.500	5.620	5.970	7.000
43	SKEL	19.690	26.640	25.450	23.720	23.940	23.060	22.000	23.210	22.870	25.960
44	SKEL	20.900	29.160	27.900	25.620	25.630	23.230	21.700	23.500	25.040	27.950
45	SKEL	23.500	33.130	30.750	28.870	28.930	26.360	24.430	26.190	28.090	31.330
46	SKEL	1.600	2.300	2.300	2.050	1.970	1.950	1.770	1.820	1.980	2.090
47	SKEL	12.600	17.650	17.150	16.290	16.270	14.000	13.200	14.350	14.560	16.410
48	SKEL	2.550	3.760	3.250	3.270	3.180	3.230	2.900	3.170	3.130	3.500
49	SKEL	6.030	7.900	7.800	7.640	7.270	6.180	5.900	6.290	6.500	7.130
50	SKEL	2.250	3.140	2.700	2.750	2.710	2.250	1.750	2.260	2.440	2.620
51	SKEL	10.560	14.800	-9.500	13.670	13.220	12.940	11.600	13.350	12.070	14.370

Appendix III A,1/4

CARDINALINAE SKELETAL

		13FITY G	14S ATRI	15S MAXI	16S ATRI	17S SIMI	18S COER	19S OFEN	21S AUFA	23S ATFI	25S ALBI
1	SKEL	19.250	24.730	19.420	21.350	18.650	20.930	19.400	21.170	18.330	19.690
2	SKEL	11.350	13.630	11.610	12.400	10.100	11.610	10.800	11.470	9.470	11.020
3	SKEL	6.030	6.150	4.510	4.770	4.450	5.690	-9.900	5.000	4.230	4.860
4	SKEL	2.570	3.920	2.430	2.800	2.040	3.080	2.500	2.170	1.770	2.200
5	SKEL	11.930	14.160	11.320	11.770	11.750	12.420	13.800	12.630	10.270	11.670
6	SKEL	6.170	8.250	6.080	6.620	6.240	6.580	8.700	6.770	5.100	6.030
7	SKEL	15.800	17.330	15.900	16.170	15.390	16.090	17.000	15.950	16.400	15.060
8	SKEL	18.670	19.880	17.570	18.230	18.030	18.760	18.900	19.500	19.350	17.720
9	SKEL	3.870	4.690	3.990	4.900	4.120	4.310	5.300	5.000	4.570	4.200
10	SKEL	15.230	16.450	14.820	15.200	15.240	15.420	16.100	15.600	15.400	14.790
11	SKEL	38.400	46.230	39.070	41.500	36.140	40.470	40.100	39.200	39.170	38.220
12	SKEL	30.200	36.190	29.780	32.320	29.040	30.900	32.700	31.600	30.170	29.300
13	SKEL	9.970	10.850	9.540	10.350	8.460	9.460	12.000	9.000	7.930	9.330
14	SKEL	6.670	7.140	4.950	5.900	5.640	6.480	6.600	6.570	5.570	6.250
15	SKEL	1.340	2.020	1.460	1.520	1.370	1.510	1.500	1.230	1.320	1.350
16	SKEL	22.840	26.900	22.150	23.420	21.730	23.120	21.800	22.430	21.770	21.170
17	SKEL	25.150	30.470	25.080	26.770	24.900	27.060	25.600	25.900	24.970	24.770
18	SKEL	4.980	6.210	4.940	5.570	4.920	5.380	5.200	4.970	4.830	4.790
19	SKEL	6.420	6.260	5.140	4.800	4.530	5.210	4.400	4.000	4.150	4.560
21	SKEL	27.060	32.730	27.020	28.350	25.380	27.570	25.900	24.900	26.650	24.850
22	SKEL	26.640	30.760	25.920	26.530	23.850	25.450	24.300	22.870	24.350	22.480
23	SKEL	11.300	15.500	12.070	11.750	11.850	12.860	12.800	12.570	12.000	12.120
24	SKEL	12.120	12.220	10.700	10.370	10.950	10.950	10.200	10.600	9.250	10.450
26	SKEL	4.720	6.120	5.080	5.170	4.700	5.240	4.700	5.070	5.400	4.630
27	SKEL	6.880	8.310	6.620	7.150	7.020	7.500	6.400	8.100	7.830	6.350
28	SKEL	12.520	15.720	12.620	12.870	12.770	13.960	12.800	13.900	13.170	12.410
29	SKEL	13.650	16.220	13.590	14.230	14.240	14.880	14.400	14.770	14.700	13.410
30	SKEL	8.000	9.630	8.140	8.500	8.310	9.020	8.400	8.400	7.270	8.070
31	SKEL	4.200	5.260	4.240	4.380	4.110	4.560	4.100	4.800	4.600	4.050
32	SKEL	1.840	2.330	1.900	1.970	1.810	2.020	1.800	1.970	2.170	1.750
33	SKEL	4.080	5.190	4.190	4.420	4.170	4.580	4.100	4.630	4.770	3.970
34	SKEL	22.520	27.610	23.040	23.850	23.490	24.930	22.400	26.530	25.800	22.630
35	SKEL	1.480	1.930	1.510	1.630	1.490	1.640	1.700	1.700	1.730	1.520
36	SKEL	35.020	43.650	36.990	37.800	37.760	39.760	35.600	42.800	41.100	36.490
37	SKEL	24.020	29.090	25.460	25.300	25.920	26.670	23.200	29.300	28.200	24.560
38	SKEL	1.360	1.880	1.450	1.520	1.410	1.560	1.400	1.530	1.870	1.370
39	SKEL	2.760	3.500	2.730	2.820	2.630	3.130	2.700	2.900	3.100	2.640
40	SKEL	8.520	10.490	8.500	9.200	8.610	8.890	9.000	8.830	8.130	8.310
41	SKEL	3.720	4.550	3.730	4.000	3.710	3.990	3.800	3.830	3.770	3.710
42	SKEL	6.500	7.990	6.540	6.670	6.300	6.840	6.000	7.070	5.900	5.930
43	SKEL	24.660	29.560	24.450	25.920	24.610	26.040	23.700	24.930	25.300	24.050
44	SKEL	26.940	32.310	26.580	27.950	26.240	27.020	26.600	25.670	23.600	25.590
45	SKEL	30.140	36.250	29.660	31.600	29.670	30.570	29.800	28.970	26.500	28.820
46	SKEL	1.900	2.450	1.960	2.100	2.020	2.080	2.200	2.170	1.800	1.930
47	SKEL	16.200	19.130	15.330	16.630	15.510	16.320	15.500	15.930	14.300	15.240
48	SKEL	3.220	4.010	3.340	3.400	3.340	3.600	3.500	3.430	3.200	3.160
49	SKEL	6.990	8.260	6.580	7.100	6.540	6.980	7.200	6.670	6.170	6.390
50	SKEL	2.400	2.900	2.420	2.650	2.490	2.500	2.400	2.400	2.370	2.380
51	SKEL	13.250	18.380	13.470	14.800	14.100	14.100	-9.900	-9.900	14.000	13.490

Appendix III A,2/4

CARDINALINAE SKELETAL

		26P GLAU	27P CYAN	28P BRIS	29P PARE	30P CAER	31P CYAN	32P AMOE	33P VERI	34P CIRI	35P ROSI
1	SKEL	12.400	19.410	14.530	11.970	18.350	11.460	11.730	10.840	11.500	13.830
2	SKEL	6.350	11.890	8.130	6.380	10.940	6.250	6.420	5.430	6.380	7.600
3	SKEL	2.550	5.010	4.200	2.570	4.550	2.330	2.440	2.030	2.640	2.340
4	SKEL	1.100	2.150	1.400	0.680	1.430	0.600	0.510	0.700	0.760	0.860
5	SKEL	8.250	11.590	8.500	8.200	10.470	7.200	7.320	7.360	7.980	8.710
6	SKEL	4.550	6.750	4.730	4.550	5.840	4.060	4.010	4.450	4.620	4.260
7	SKEL	12.400	13.860	13.250	12.580	13.540	12.000	11.810	11.730	12.620	12.900
8	SKEL	15.100	17.930	15.800	13.980	17.050	13.000	13.470	13.430	14.160	14.750
9	SKEL	3.200	4.220	3.800	2.930	4.330	3.250	3.190	3.230	3.280	4.060
10	SKEL	12.400	14.750	13.200	12.300	13.810	11.120	11.070	11.380	11.900	12.510
11	SKEL	26.950	35.660	30.270	27.570	34.510	26.630	26.620	26.190	27.600	30.510
12	SKEL	18.650	27.030	21.270	18.880	26.380	18.270	18.360	17.600	19.170	21.190
13	SKEL	4.900	9.750	6.430	5.080	9.300	5.210	5.280	4.760	5.690	6.090
14	SKEL	4.500	7.050	4.830	3.550	5.550	2.730	2.680	2.960	2.980	3.410
15	SKEL	0.550	1.090	0.930	0.850	1.270	0.810	0.920	0.810	0.920	0.970
16	SKEL	16.300	19.160	16.730	15.320	20.590	15.340	15.920	14.870	16.050	17.060
17	SKEL	14.350	21.470	19.530	16.560	23.800	17.010	16.610	16.540	17.940	18.760
18	SKEL	4.200	4.350	3.870	3.400	4.470	3.330	3.440	3.220	3.470	3.700
19	SKEL	4.000	4.120	3.550	3.150	5.290	3.750	3.960	3.630	3.690	4.060
21	SKEL	19.100	21.960	18.550	17.200	24.440	17.810	18.970	17.300	18.680	19.260
22	SKEL	17.300	20.350	17.830	15.150	23.790	16.880	18.580	14.030	17.180	17.740
23	SKEL	7.650	10.160	9.000	8.300	10.460	8.150	8.030	7.520	8.530	8.550
24	SKEL	8.800	10.060	7.750	8.080	10.840	8.340	8.860	8.440	8.930	8.890
26	SKEL	3.650	4.170	3.730	3.130	4.100	3.120	3.190	3.050	3.370	3.530
27	SKEL	4.600	5.650	4.950	4.470	6.020	4.520	4.380	4.430	4.710	5.140
28	SKEL	8.900	10.350	8.800	8.200	10.280	8.020	8.070	7.920	8.620	9.390
29	SKEL	9.300	10.920	9.650	9.130	10.710	8.790	8.980	8.660	8.830	9.960
30	SKEL	5.600	6.890	5.750	5.460	6.630	5.430	5.410	5.500	5.600	6.140
31	SKEL	2.800	3.480	2.970	2.730	3.500	2.580	2.690	2.500	2.740	2.970
32	SKEL	1.250	1.510	1.400	1.200	1.540	1.120	1.160	1.090	1.230	1.300
33	SKEL	2.800	3.450	3.070	2.780	3.410	2.590	2.580	2.560	2.820	2.930
34	SKEL	16.100	19.080	17.370	15.050	19.800	15.010	15.140	14.870	15.920	16.770
35	SKEL	1.000	1.270	1.070	0.900	1.230	0.930	0.940	0.900	1.010	1.100
36	SKEL	27.500	30.170	29.230	26.170	30.260	24.890	24.830	25.200	27.170	26.170
37	SKEL	19.200	20.690	20.830	18.580	21.090	17.200	16.820	17.670	19.110	17.470
38	SKEL	1.000	1.220	1.070	0.930	1.210	0.690	0.930	0.900	0.950	1.100
39	SKEL	1.950	2.230	2.100	1.770	2.350	1.730	1.700	1.640	1.890	1.870
40	SKEL	5.500	7.240	6.030	5.530	7.100	4.920	5.520	5.260	5.680	5.970
41	SKEL	2.550	3.110	2.900	2.420	3.360	2.560	2.730	2.490	2.600	2.940
42	SKEL	3.950	5.510	4.530	4.300	5.490	3.940	4.190	3.940	4.310	4.560
43	SKEL	16.700	20.710	18.400	16.580	21.370	15.660	16.660	15.640	17.100	17.900
44	SKEL	17.950	22.620	19.900	17.820	22.990	16.740	18.110	17.060	18.080	18.960
45	SKEL	20.100	25.290	22.650	19.850	25.930	18.860	20.310	19.040	20.330	21.410
46	SKEL	1.350	1.640	1.450	1.350	1.770	1.280	1.430	1.270	1.350	1.440
47	SKEL	11.050	13.070	11.470	10.050	14.060	10.270	11.030	10.270	10.650	11.430
48	SKEL	2.450	2.800	2.700	2.220	2.950	2.120	2.310	2.170	2.290	2.340
49	SKEL	5.100	5.660	5.000	4.600	6.620	5.080	5.430	4.990	5.260	5.010
50	SKEL	1.900	2.200	2.200	1.770	2.470	1.730	1.850	1.800	1.900	1.840
51	SKEL	9.650	11.520	16.400	8.640	11.400	9.470	9.430	9.070	12.640	9.780

Appendix III A,3/4

CARDINALINAE SKELETAL

		36F LECL
1	SKEL	11.000
2	SKEL	5.760
3	SKEL	1.960
4	SKEL	0.580
5	SKEL	7.410
6	SKEL	3.830
7	SKEL	12.100
8	SKEL	13.510
9	SKEL	3.150
10	SKEL	11.630
11	SKEL	26.380
12	SKEL	17.380
13	SKEL	4.600
14	SKEL	2.690
15	SKEL	0.850
16	SKEL	15.350
17	SKEL	17.360
18	SKEL	3.270
19	SKEL	3.040
21	SKEL	17.480
22	SKEL	16.470
23	SKEL	7.920
24	SKEL	8.290
26	SKEL	3.050
27	SKEL	4.520
28	SKEL	7.880
29	SKEL	8.400
30	SKEL	5.360
31	SKEL	2.640
32	SKEL	1.190
33	SKEL	2.630
34	SKEL	14.820
35	SKEL	0.970
36	SKEL	24.960
37	SKEL	17.460
38	SKEL	0.920
39	SKEL	1.720
40	SKEL	5.520
41	SKEL	2.640
42	SKEL	4.220
43	SKEL	16.530
44	SKEL	17.750
45	SKEL	19.640
46	SKEL	1.330
47	SKEL	10.160
48	SKEL	2.160
49	SKEL	4.690
50	SKEL	1.720
51	SKEL	8.740

Appendix III A,4/4

CARDINALINAE MALE 1

	1-SPIZ A	2-PHEU C	3-PHEU A	4-PHEU L	5-PHEU M	6-CARD C	7-CARD P	8-CARD S	9-CARY C	11PHCD C
Ex1	57.700	96.300	84.500	73.300	78.500	102.400	83.200	98.100	67.500	97.500
Ex2	-1.730	73.730	-41.420	-12.280	-19.110	-69.340	-72.120	-55.050	-11.850	-22.560
Ex3	0.0	-11.420	-4.730	-1.360	0.0	-28.320	-14.420	-15.290	1.480	-6.150
Ex4	3.470	-11.420	-10.650	0.0	0.0	-18.550	-2.400	-10.190	2.960	-16.410
Ex5	5.200	-4.150	-4.730	0.0	6.370	-12.700	1.200	-3.060	4.440	3.040
Ex6	17.130	1.040	11.830	17.740	10.190	3.910	18.030	18.350	5.930	-4.100
Ex7	142.110	138.110	142.010	145.980	145.220	123.050	127.400	133.540	149.630	132.310
Ex8	19.060	19.730	21.300	21.830	17.830	15.630	20.430	18.350	32.590	20.510
Ex9	357.020	487.020	454.440	386.080	415.290	567.380	644.230	552.500	527.410	553.850
Ex10	402.080	474.560	467.460	454.300	438.220	576.170	612.980	532.110	567.410	613.330
Ex11	92.300	120.400	108.300	103.200	92.600	95.700	87.000	94.200	89.100	108.600
Ex12	0.0	-41.530	-41.550	-17.440	-30.240	-102.400	-91.950	-77.490	-44.890	-77.350
Ex13	21.870	-8.310	-10.160	-0.970	-3.240	-48.070	-37.180	-26.540	-12.350	-31.310
Ex14	55.890	2.490	0.0	11.630	8.640	-9.400	-3.450	-8.490	2.740	-7.370
Ex15	57.110	25.750	60.940	76.550	59.400	5.220	1.150	7.430	17.960	2.780
Ex16	44.960	57.310	69.250	59.110	63.710	15.670	14.940	13.800	37.040	25.780
Ex17	81.410	86.330	89.640	85.270	97.190	81.500	87.360	81.740	93.150	61.030
Ex18	10.940	14.950	12.930	14.530	17.290	13.580	13.790	14.860	15.710	14.730
Ex19	102.070	106.310	116.340	106.590	115.550	95.090	101.150	98.730	111.110	96.690
Ex20	23.090	25.750	25.850	26.160	26.080	16.720	25.290	19.110	26.940	18.420
Ex21	106.930	117.940	120.960	108.530	116.630	98.220	112.640	107.220	122.330	111.420
Ex22	24.300	30.730	28.620	27.130	32.400	19.650	25.290	23.350	29.180	23.940
Ex23	116.650	121.260	118.190	116.280	122.030	109.720	121.840	112.530	126.820	115.100
Ex24	24.300	32.390	27.700	27.130	31.320	21.940	26.440	24.420	26.940	24.860
Ex25	130.010	141.200	134.810	123.060	145.790	138.980	149.430	136.940	150.390	146.250
Ex26	30.360	35.710	36.930	37.790	42.120	29.260	36.780	37.150	40.400	33.150
Ex27	2.140	2.040	2.030	2.310	2.620	1.250	1.150	1.090	1.560	1.530
Ex28	10.500	12.800	11.000	9.900	10.800	9.900	10.200	10.300	9.200	10.600
Ex29	180.950	164.050	175.450	177.780	174.070	187.880	181.370	182.520	166.300	169.810
Ex30	111.430	111.720	115.450	114.140	112.040	115.150	115.690	110.680	117.390	115.980
Ex31	120.950	128.910	125.450	131.310	128.700	126.260	130.390	131.070	130.430	132.080
Ex32	57.000	53.300	51.300	57.000	53.800	50.100	52.500	38.800	68.300	65.900
Ex33	33.000	27.800	24.000	30.300	28.300	25.500	26.000	37.800	31.600	23.300

Appendix III B,1/8

CARCINALINAE MALES

	1-SPIZ A	2-PHEU C	3-PHEU A	4-PHEU L	5-PHEU M	6-CARD C	7-CARD P	8-CARD S	9-CARY C	10CARY H
Ex34	0.0	1.000	1.000	1.000	1.000	0.0	0.0	0.0	0.0	0.0
Ex35	0.0	1.000	1.000	0.0	1.000	0.0	0.0	0.0	0.0	1.000
Ex36	0.0	1.000	0.0	0.0	1.000	0.0	0.0	0.0	0.0	0.0
Ex37	0.0	1.000	1.000	1.000	1.000	0.0	0.0	0.0	0.0	0.0
Ex38	0.0	1.000	1.000	0.0	1.000	0.0	0.0	0.0	0.0	0.0
Ex39	0.0	1.000	1.000	1.000	1.000	0.0	0.0	0.0	0.0	0.0
Ex40	1.000	1.000	1.000	0.0	1.000	1.000	0.0	1.000	1.000	1.000
Ex41	1.000	0.0	0.0	0.0	1.000	1.000	0.0	1.000	1.000	1.000
Ex42	1.000	0.0	0.0	0.0	0.0	0.0	1.000	0.0	1.000	1.000
Ex43	0.0	0.0	0.0	0.0	0.0	1.000	0.0	1.000	0.0	0.0
Ex44	1.000	0.0	0.0	0.0	1.000	1.000	0.0	0.0	0.0	0.0
Ex45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex46	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.000
Ex47	1.000	0.0	0.0	0.0	1.000	0.0	1.000	0.0	0.0	0.0
Ex48	0.0	0.0	0.0	1.000	0.0	0.0	0.0	0.0	1.000	0.0
Ex49	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex50	0.0	0.0	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex51	1.000	1.000	0.0	0.0	1.000	0.0	0.0	0.0	0.0	0.0
Ex52	0.0	0.0	1.000	1.000	0.0	0.0	0.0	0.0	0.0	0.0
Ex53	0.0	0.0	1.000	1.000	0.0	0.0	0.0	0.0	0.0	0.0
Ex54	1.000	0.0	1.000	1.000	1.000	0.0	0.0	1.000	0.0	0.0
Ex55	0.0	0.0	0.0	1.000	0.0	0.0	0.0	0.0	0.0	0.0
Ex56	0.0	0.0	0.0	0.0	0.0	1.000	1.000	1.000	0.0	0.0
Ex57	1.000	1.000	0.0	1.000	1.000	1.000	1.000	1.000	0.0	0.0
Ex58	1.000	0.0	1.000	0.0	0.0	0.0	0.0	0.0	0.0	1.000
Ex59	1.000	0.0	0.0	0.0	1.000	0.0	0.0	1.000	0.0	0.0
Ex60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex61	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.000
Ex62	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex63	1.000	0.0	0.0	0.0	1.000	0.0	0.0	0.0	0.0	0.0
Ex64	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.000	0.0	0.0
Ex65	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.000	0.0	0.0
Ex66	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Appendix III B,2/8

CARDINALINAE MALES

	11PPOD C	12PERI E	13PITY G	14S ATRI	15S MAXI	16S ATRI	17S SIMI	18S CCER	19S OREN	20S MAXI
Ex1	97.500	89.500	83.900	118.900	83.700	93.100	97.400	103.300	81.300	95.000
Ex2	-22.560	-39.110	-54.830	-61.400	-45.400	-60.150	-23.610	-44.530	-49.200	-34.740
Ex3	-6.150	-17.880	-33.370	-37.010	-21.510	-27.930	-18.480	-19.360	-33.210	-28.420
Ex4	-16.410	-16.760	-26.220	-31.960	-19.120	-15.040	-12.320	-22.270	-9.840	-15.790
Ex5	3.000	-11.170	-3.580	-31.960	-1.190	-18.260	-6.160	-6.780	-20.910	-10.530
Ex6	-4.100	-5.590	-13.110	-9.250	1.190	-8.590	-2.050	5.810	24.600	-2.110
Ex7	132.310	148.600	150.180	144.660	146.950	142.930	128.340	145.210	147.600	140.000
Ex8	20.510	23.460	33.370	28.600	29.870	36.520	18.480	28.070	30.750	17.890
Ex9	553.350	539.660	501.790	605.550	536.440	558.540	529.770	484.030	500.610	554.740
Ex10	613.330	603.350	528.010	654.330	591.400	644.470	554.410	513.070	538.750	621.050
Ex11	108.600	102.000	97.600	122.100	96.400	106.300	104.300	111.000	91.700	100.000
Ex12	-77.350	-53.920	-76.840	-85.180	-86.100	-73.380	-85.330	-87.390	-57.800	-93.000
Ex13	-31.310	-22.550	-29.710	-33.580	-29.050	-37.630	-36.430	-29.640	-25.080	-43.000
Ex14	-7.370	-8.820	-8.200	-5.730	-6.220	0.940	-15.340	-10.810	0.0	-8.000
Ex15	2.760	19.610	13.320	3.280	8.300	8.470	3.840	5.410	3.270	0.0
Ex16	25.780	51.960	34.840	13.920	23.860	30.100	23.970	15.320	18.540	17.000
Ex17	91.030	88.240	82.990	81.080	84.020	82.780	86.290	85.590	87.240	50.000
Ex18	14.730	19.610	15.370	13.100	10.370	14.110	13.420	15.320	14.180	12.000
Ex19	96.690	110.780	103.480	98.280	101.660	97.840	104.510	104.500	98.150	110.000
Ex20	19.420	28.430	23.570	21.290	22.820	17.870	19.180	19.820	21.810	20.000
Ex21	111.420	117.650	113.730	107.290	107.880	109.130	113.140	111.710	109.050	117.000
Ex22	23.940	28.430	27.660	27.030	26.970	23.520	25.890	24.320	21.810	28.000
Ex23	115.100	120.590	116.800	113.840	117.220	111.950	117.930	123.420	116.680	123.000
Ex24	24.800	29.410	28.690	28.670	31.120	23.520	26.850	27.930	21.610	27.000
Ex25	148.250	135.290	146.520	153.150	153.530	143.930	151.490	149.550	143.950	150.000
Ex26	33.150	38.240	38.930	37.670	38.380	33.870	34.520	38.740	32.720	33.000
Ex27	1.530	1.810	1.350	1.180	1.220	1.460	1.350	1.070	1.420	1.130
Ex28	10.600	9.500	9.930	13.900	11.000	12.400	10.900	12.200	10.300	11.700
Ex29	165.810	161.050	171.720	166.190	168.180	163.710	183.490	174.590	171.840	164.960
Ex30	116.980	113.680	116.160	111.510	111.820	114.520	118.350	116.390	114.560	106.840
Ex31	132.080	131.580	135.350	128.780	126.360	128.230	127.520	136.890	138.630	117.090
Ex32	65.900	64.800	68.400	71.400	77.700	79.500	71.300	67.500	68.200	72.000
Ex33	23.300	30.000	19.700	20.000	21.900	20.200	29.000	20.000	29.300	24.700

Appendix III B,3/8

CARCINALINAE MALES

	11RHOD C	12PERI E	13PITY G	14S ATRI	15S MAXI	16S ATRI	17S SIMI	18S CCFF	19S OREN	20S MAXI
E34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E35	0.0	0.0	0.0	1.000	1.000	1.000	0.0	0.0	1.000	0.0
E36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E39	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E40	1.000	1.000	0.0	1.000	1.000	0.0	0.0	1.000	1.000	1.000
E41	0.0	0.0	0.0	1.000	1.000	0.0	1.000	1.000	0.0	1.000
E42	0.0	0.0	0.0	0.0	0.0	1.000	0.0	0.0	0.0	0.0
E43	0.0	0.0	0.0	0.0	0.0	1.000	0.0	0.0	0.0	0.0
E44	1.000	1.000	0.0	1.000	0.0	0.0	1.000	0.0	0.0	0.0
E45	0.0	0.0	0.0	0.0	0.0	1.000	1.000	0.0	0.0	0.0
E46	1.000	0.0	0.0	0.0	0.0	0.0	1.000	0.0	0.0	0.0
E47	0.0	0.0	0.0	1.000	1.000	0.0	0.0	0.0	0.0	0.0
E48	0.0	1.000	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E49	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E50	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E51	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E52	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E53	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E54	0.0	0.0	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E56	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E57	1.000	1.000	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E58	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E59	0.0	0.0	0.0	1.000	1.000	1.000	1.000	1.000	0.0	1.000
E60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.000	0.0
E61	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E62	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E64	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.000	0.0
E65	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
E66	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Appendix III B,4/8

CARDINALINAE MALES

	21S AURA	23S ATRI	24S RUFI	25S ALBI	26P GLAU	27P CYAN	28P BRIS	29P PARE	30P CAER	31P CYAN
Ex1	90.300	91.600	95.500	94.000	65.200	64.200	69.800	53.000	66.400	51.600
Ex2	-29.900	-62.230	-36.650	-58.510	-27.610	-52.960	-32.950	-22.640	-13.550	0.0
Ex3	-3.320	-21.830	0.0	-21.280	-16.870	-23.360	-14.330	-1.890	-12.050	0.0
Ex4	-11.070	-24.020	5.240	-10.640	-12.270	-17.130	-17.190	0.0	-10.540	1.940
Ex5	-5.540	-7.640	5.240	-10.640	-3.070	-17.130	-8.600	-1.890	-6.020	5.810
Ex6	0.0	32.750	0.0	0.0	-15.340	12.460	2.870	15.090	-4.520	15.500
Ex7	127.350	131.000	120.420	122.340	141.100	174.450	141.830	150.940	143.070	147.290
Ex8	19.930	20.740	20.940	21.280	21.470	42.060	27.220	30.190	16.570	17.440
Ex9	523.810	594.930	523.560	537.230	452.450	501.560	537.250	422.640	396.090	374.030
Ex10	551.490	540.390	492.150	563.830	483.130	560.750	547.280	498.110	426.200	422.480
Ex11	94.800	91.700	115.000	103.500	73.700	81.800	78.900	69.300	90.100	69.100
Ex12	-68.570	-70.830	-82.610	-86.960	-77.340	-63.570	-83.650	-63.690	-32.190	-36.180
Ex13	-24.260	-19.630	-39.130	-28.990	-20.350	-34.230	-29.150	-25.970	3.330	0.0
Ex14	-3.150	-3.270	0.0	0.0	-4.070	-8.560	-6.340	-8.660	9.990	5.790
Ex15	0.0	4.360	0.0	4.850	25.780	8.560	3.800	8.660	58.620	60.780
Ex16	21.100	8.720	34.780	38.650	43.420	30.560	17.740	37.520	65.480	56.440
Ex17	87.550	92.690	86.960	106.280	89.550	97.800	92.520	93.800	87.690	94.070
Ex18	14.770	15.270	11.300	14.490	13.570	15.890	13.940	12.990	11.100	14.470
Ex19	110.760	105.780	98.260	106.280	108.550	119.800	109.000	105.340	108.770	108.540
Ex20	22.150	23.990	21.740	19.320	25.780	24.450	22.810	18.760	25.530	23.150
Ex21	105.490	114.500	104.350	115.940	119.400	121.030	115.340	111.110	113.210	118.670
Ex22	26.370	27.260	21.740	19.320	28.490	28.120	25.350	23.090	25.530	21.710
Ex23	110.760	117.780	117.390	125.600	118.050	125.920	116.600	119.770	118.760	120.120
Ex24	26.370	27.260	24.350	28.990	29.850	26.890	26.620	27.420	26.640	24.600
Ex25	145.570	157.030	143.480	135.270	131.610	154.030	157.160	144.300	133.190	123.010
Ex26	36.920	42.530	34.780	33.820	28.490	36.670	34.220	37.520	31.080	36.180
Ex27	1.370	0.850	1.610	1.450	1.740	1.200	1.100	1.280	2.040	2.140
Ex28	11.000	12.800	13.500	11.000	8.400	9.800	9.000	7.600	9.200	7.800
Ex29	180.000	175.780	170.370	168.180	179.760	162.240	170.000	168.420	193.480	176.920
Ex30	116.360	136.250	137.410	118.180	111.930	108.160	103.330	111.840	118.480	114.100
Ex31	136.360	121.880	125.930	136.360	122.620	119.390	126.670	131.580	136.960	121.790
Ex32	66.000	86.800	90.000	68.000	50.300	51.900	51.800	61.800	55.300	56.700
Ex33	22.000	17.400	22.500	17.000	39.300	27.200	32.800	34.000	29.700	29.800

Appendix III B,5/8

CARDINALINAE MALES

	21S AURA	23S ATRI	24S RUFI	25S ALBI	26P GLAU	27P CYAN	28P BRIS	29P PAFE	30P CAER	31P CYAN
Ex34	0.200	1.000	0.0	0.0	0.0	0.0	0.0	0.0	1.000	0.0
Ex35	0.0	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex39	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex40	0.0	1.000	0.0	0.0	0.0	0.0	0.0	1.000	1.000	0.0
Ex41	0.0	0.0	0.0	0.0	0.0	0.0	1.000	1.000	0.0	0.0
Ex42	1.000	1.000	0.0	1.000	0.0	1.000	1.000	1.000	1.000	1.000
Ex43	0.0	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex44	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex46	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.000	1.000	0.0
Ex47	0.0	0.0	1.000	1.000	0.0	0.0	1.000	0.0	1.000	1.000
Ex48	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex49	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex50	0.0	0.0	0.0	1.000	0.0	0.0	0.0	0.0	0.0	0.0
Ex51	0.0	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex52	0.0	0.0	0.0	1.000	0.0	0.0	0.0	0.0	0.0	0.0
Ex53	0.0	0.0	0.0	1.000	0.0	0.0	0.0	0.0	0.0	1.000
Ex54	0.0	0.0	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex55	0.0	0.0	0.0	1.000	0.0	0.0	0.0	1.000	1.000	0.0
Ex56	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex57	1.000	0.0	0.0	0.0	1.000	1.000	1.000	1.000	1.000	1.000
Ex58	0.0	0.0	0.0	0.0	0.0	0.0	1.000	1.000	1.000	0.0
Ex59	1.000	0.0	1.000	1.000	0.0	0.0	0.0	0.0	0.0	0.0
Ex60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex61	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex62	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex63	0.0	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex64	0.0	0.0	0.0	1.000	0.0	0.0	0.0	0.0	0.0	0.0
Ex65	0.0	0.0	0.0	1.000	0.0	0.0	0.0	0.0	0.0	0.0
Ex66	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Appendix III B,6/8

CAP INALINAS MALES

	32P AMCE	33P VERI	34P CIRI	35P POSI	36P LECL	37P CAEF
Ex1	54.300	54.200	53.5C0	52.300	52.800	55.00C
Ex2	1.840	-16.610	-14.950	-11.470	-7.580	-32.73C
Ex3	3.680	-5.540	-1.870	-1.91C	0.0	-7.27C
Ex4	1.340	1.850	1.870	0.0	-1.890	-1C.91C
Ex5	3.680	C.0	1.870	0.0	5.68C	1.820
Ex6	22.100	11.070	7.480	15.30C	11.360	C.0
Ex7	145.170	147.600	140.190	152.96C	145.830	145.45C
Ex8	18.420	22.140	18.65C	24.860	24.62C	18.18C
Ex9	395.950	439.110	407.480	445.51C	431.060	556.360
Ex10	484.350	431.550	429.510	443.590	454.550	498.18C
Ex11	73.300	68.300	71.00C	71.70C	68.600	64.60C
Ex12	-28.650	-52.960	-40.850	-72.52C	-71.430	-35.63C
Ex13	2.730	-14.640	-4.230	-19.53C	-21.870	-1C.84C
Ex14	9.550	-2.930	7.040	1.39C	-2.920	-3.10C
Ex15	53.210	14.640	47.890	11.160	13.120	9.290
Ex16	61.330	41.030	49.300	34.87C	34.930	27.86C
Ex17	83.220	89.310	85.920	93.440	93.290	102.170
Ex18	13.640	14.640	14.080	15.34C	14.580	15.48C
Ex19	99.590	102.490	108.450	115.760	103.500	113.60C
Ex20	24.56C	23.430	28.170	23.710	21.870	27.86C
Ex21	1CC.950	108.350	107.C40	115.76C	112.240	117.65C
Ex22	24.56C	26.350	26.760	26.500	26.240	3C.96C
Ex23	102.320	111.27C	109.86C	122.73C	122.450	130.030
Ex24	24.560	27.820	25.350	26.50C	27.700	32.51C
Ex25	124.150	133.240	133.800	149.23C	141.400	154.80C
Ex26	33.740	32.210	32.390	36.26C	34.99C	43.34C
Ex27	2.200	1.430	1.890	1.49C	1.360	C.74C
Ex28	7.8C0	7.900	8.2C0	7.80C	7.300	7.30C
Ex29	176.920	172.150	173.170	171.79C	175.340	18C.82C
Ex30	1CC.0C0	10C.000	104.880	110.26C	109.590	105.48C
Ex31	119.230	124.05C	113.410	130.770	124.660	115.07C
Ex32	57.000	66.000	56.5C0	55.600	55.400	69.50C
Ex33	32.000	24.800	31.CC0	28.50C	29.000	26.00C

Appendix III B,7/8

CARDINALINAE MALES

	32F AMGE	33P VERI	34P CIRI	35P ROSI	36P LECL	37P CAER
Ex34	0.0	0.0	0.0	0.0	0.0	0.0
Ex35	0.0	0.0	0.0	0.0	0.0	0.0
Ex36	0.0	0.0	0.0	0.0	0.0	0.0
Ex37	0.0	0.0	0.0	0.0	0.0	0.0
Ex38	1.000	0.0	0.0	0.0	0.0	0.0
Ex39	1.000	0.0	0.0	0.0	0.0	0.0
Ex40	0.0	0.0	0.0	0.0	0.0	0.0
Ex41	0.0	0.0	0.0	0.0	1.000	0.0
Ex42	1.000	0.0	1.000	1.000	1.000	1.000
Ex43	0.0	1.000	0.0	0.0	0.0	0.0
Ex44	0.0	1.000	0.0	0.0	1.000	0.0
Ex45	0.0	1.000	0.0	0.0	1.000	0.0
Ex46	0.0	1.000	1.000	0.0	1.000	0.0
Ex47	0.0	1.000	0.0	1.000	0.0	0.0
Ex48	1.000	1.000	0.0	0.0	0.0	0.0
Ex49	0.0	1.000	1.000	1.000	1.000	0.0
Ex50	0.0	0.0	0.0	1.000	0.0	0.0
Ex51	0.0	0.0	0.0	0.0	0.0	0.0
Ex52	0.0	0.0	0.0	1.000	0.0	0.0
Ex53	0.0	0.0	0.0	1.000	0.0	0.0
Ex54	1.000	0.0	0.0	1.000	1.000	0.0
Ex55	0.0	1.000	1.000	0.0	0.0	0.0
Ex56	0.0	0.0	0.0	0.0	0.0	0.0
Ex57	1.000	1.000	1.000	1.000	1.000	1.000
Ex58	0.0	1.000	1.000	0.0	0.0	0.0
Ex59	0.0	0.0	0.0	0.0	0.0	0.0
Ex60	0.0	0.0	0.0	0.0	0.0	0.0
Ex61	0.0	0.0	0.0	0.0	0.0	0.0
Ex62	0.0	0.0	0.0	0.0	0.0	0.0
Ex63	0.0	0.0	0.0	0.0	0.0	0.0
Ex64	1.000	0.0	0.0	0.0	0.0	0.0
Ex65	0.0	0.0	0.0	0.0	0.0	0.0
Ex66	0.0	0.0	0.0	0.0	0.0	0.0

Appendix III B,8/8

CARDINALINAE MALES

	1-SPIZ A	2-PHEU C	3-PHEU A	4-PHEU L	5-PHEU M	6-CARD C	7-CARD P	8-CARD S	9-CARY C	10CARY H
Col 1	574.000	579.000	0.0	0.0	0.0	605.000	605.000	575.800	574.000	0.0
Col 2	581.500	576.000	0.0	0.0	291.000	605.000	606.000	575.800	574.000	0.0
Col 3	578.000	576.000	0.0	0.0	582.000	605.000	602.000	575.800	574.000	0.0
Col 4	578.000	578.400	0.0	0.0	0.0	605.000	602.000	575.800	574.000	0.0
Col 5	0.0	576.000	0.0	0.0	562.000	605.000	605.000	605.000	574.000	0.0
Col 6	575.000	576.000	574.000	611.700	578.500	605.000	602.000	585.000	574.000	604.800
Col 7	575.000	574.000	574.000	0.0	575.000	605.000	602.000	585.000	574.000	597.000
Col 8	578.000	573.500	568.000	0.0	575.000	605.000	602.000	574.500	574.000	600.000

	12PIRI E	13PITY G	14S ATRI	15S MAXI	16S ATRI	17S SIMI	18S CUCR	19S OPEN	20S MAXI	21S AURA
Col 1	0.0	481.200	577.000	574.000	0.0	572.000	572.000	0.0	0.0	576.000
Col 2	606.000	481.400	574.100	574.000	574.100	572.000	572.000	0.0	572.000	575.300
Col 3	606.000	481.400	574.100	574.000	574.000	572.000	572.500	0.0	576.000	575.300
Col 4	606.000	481.400	574.100	574.000	574.100	572.000	572.500	0.0	572.000	575.300
Col 5	0.0	0.0	0.0	580.000	575.000	572.000	579.600	576.000	572.000	577.700
Col 6	605.000	0.0	0.0	577.000	574.000	578.000	577.300	576.000	576.000	577.000
Col 7	605.000	481.900	0.0	577.000	573.000	578.000	581.300	576.000	572.000	578.700
Col 8	603.000	481.000	581.800	581.000	578.800	578.000	581.500	581.300	572.000	580.000

	23S ATRI	24S RUFI	25S ALBI	26P GLAU	27P CYAN	28P GRIS	29P PARE	30P CYER	31P CYAN	32P AMOE
Col 1	582.000	576.000	481.500	478.800	476.000	470.000	470.000	469.000	481.500	597.000
Col 2	583.000	485.500	481.300	478.600	476.000	468.000	470.000	481.000	481.000	597.000
Col 3	578.000	485.500	481.300	478.600	476.000	470.000	470.000	481.000	481.500	470.000
Col 4	583.000	485.500	481.300	478.600	476.000	468.000	470.000	481.000	481.000	470.000
Col 5	0.0	576.000	461.500	478.200	475.000	468.200	470.000	469.000	481.500	546.000
Col 6	579.500	574.500	481.500	478.200	475.000	468.200	470.000	469.000	581.000	546.000
Col 7	579.500	574.500	481.500	478.500	475.000	468.900	470.000	481.000	0.0	475.000
Col 8	582.000	574.500	481.500	478.200	475.000	468.000	470.000	481.000	0.0	561.000

	33P VERI	34P CIRF	35P RCSI	36P LECL
Col 1	455.000	469.000	566.000	475.000
Col 2	570.000	476.800	481.000	475.000
Col 3	555.000	476.800	481.000	475.000
Col 4	555.000	476.800	481.000	475.000
Col 5	555.000	476.000	579.000	475.200
Col 6	555.000	595.000	574.000	475.500
Col 7	555.000	593.500	574.000	475.500
Col 8	555.000	592.500	574.000	475.200

Appendix III C,1/1

CARDINALINAE FEMALES 1

	1-SPIZ A	2-PHEU C	3-PHEU A	4-PHEU L	5-PHEU M	6-CARD C	7-CARD P	8-CARD S	9-CARY C	10CARY H
Ex1	52.300	89.700	83.500	71.500	77.500	97.800	76.300	95.000	65.600	69.300
Ex2	-3.820	-30.100	-33.530	-18.180	-16.770	-71.570	-74.710	-57.890	-9.150	-21.650
Ex3	-5.740	-14.490	-19.160	-1.400	-7.740	-30.670	-22.280	-18.950	3.050	-10.100
Ex4	-1.910	-5.570	4.790	0.0	-1.290	-18.400	-13.110	-8.420	0.0	10.100
Ex5	-1.910	-11.150	4.790	4.200	1.290	-5.200	-9.900	-1.050	0.0	-4.330
Ex6	21.030	8.920	11.980	12.590	12.900	8.180	12.110	8.420	9.150	33.190
Ex7	126.200	139.350	137.720	139.860	145.810	118.610	115.330	130.530	147.670	129.870
Ex8	19.120	23.410	22.750	23.780	19.350	16.360	20.970	16.840	30.490	24.530
Ex9	380.500	505.020	428.740	395.800	416.770	585.890	633.030	547.370	519.290	567.100
Ex10	409.180	507.250	479.040	485.310	467.100	655.420	651.380	522.110	557.930	581.530
Ex11	76.000	111.000	104.500	98.900	100.600	92.900	82.500	90.500	86.700	86.700
Ex12	-1.320	-40.540	-41.150	-32.360	-23.860	-95.800	-90.910	-80.660	-47.290	-43.830
Ex13	6.560	2.700	-2.870	0.0	0.0	-47.360	-30.300	-34.250	-10.380	-3.460
Ex14	42.110	2.700	2.870	12.130	7.950	-15.070	0.0	-5.520	0.0	9.230
Ex15	56.580	25.230	41.150	58.650	48.710	3.230	0.0	0.0	6.920	28.840
Ex16	44.740	43.240	55.500	54.600	54.670	20.450	12.120	25.410	44.980	0.0
Ex17	81.580	92.730	91.870	85.950	85.490	81.810	84.850	82.870	89.570	88.810
Ex18	13.160	17.120	14.350	14.160	14.910	15.070	13.330	13.260	24.220	20.760
Ex19	100.000	97.300	114.830	103.130	104.370	95.800	98.180	102.760	115.340	103.810
Ex20	25.000	26.130	26.790	29.320	28.630	18.300	19.390	22.100	29.990	32.300
Ex21	107.990	112.6[illegible]	119.620	102.120	106.360	103.340	109.090	110.500	116.490	115.340
Ex22	23.630	31.530	28.710	30.330	28.830	22.600	24.240	27.620	32.300	26.840
Ex23	111.840	124.320	117.700	106.170	109.340	107.640	115.150	116.020	119.950	126.970
Ex24	27.630	31.530	33.490	29.320	27.830	26.910	27.880	27.620	32.200	32.300
Ex25	126.320	142.340	138.760	131.450	129.220	135.630	149.090	152.490	151.100	134.950
Ex26	35.470	38.740	41.150	42.470	39.760	30.140	30.300	37.570	41.520	40.370
Ex27	2.060	1.830	1.800	2.230	2.280	1.270	1.150	1.160	1.510	2.020
Ex28	10.200	12.500	11.400	11.000	11.200	10.100	9.900	10.100	9.100	9.500
Ex29	180.390	170.400	170.180	162.640	169.640	163.170	177.780	187.130	167.030	155.790
Ex30	107.840	112.800	119.300	110.000	108.930	111.880	121.210	108.910	114.290	115.790
Ex31	118.630	143.200	135.090	122.730	125.890	131.680	135.350	133.660	121.980	131.580
Ex32	59.200	51.800	53.000	55.400	56.400	53.800	48.300	40.000	68.400	74.700
Ex33	33.000	27.000	23.500	28.800	32.500	25.400	28.700	43.600	27.200	23.300

Appendix III D,1/8

CARDINALINAE FEMALES

	1-SPIZ A	2-PHEU C	3-PHEU A	4-PHEU L	5-PHEU M	6-CARD C	7-CARD P	8-CARD S	9-CARY C	10CARY H
Ex34	0.0	1.000	1.000	0.0	1.000	0.0	0.0	0.0	0.0	0.0
Ex35	0.0	1.000	1.000	0.0	0.0	0.0	0.0	0.0	0.0	1.000
Ex36	0.0	1.000	0.0	0.0	1.000	0.0	0.0	0.0	0.0	0.0
Ex37	0.0	1.000	1.000	1.000	1.000	0.0	0.0	0.0	0.0	0.0
Ex38	0.0	1.000	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex39	0.0	1.000	1.000	1.000	1.000	0.0	0.0	0.0	0.0	0.0
Ex40	1.000	1.000	1.000	0.0	1.000	1.000	0.0	1.000	1.000	1.000
Ex41	1.000	0.0	0.0	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Ex42	1.000	0.0	0.0	1.000	1.000	1.000	1.000	0.0	1.000	1.000
Ex43	0.0	0.0	0.0	0.0	0.0	0.0	1.000	0.0	0.0	0.0
Ex44	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex45	0.0	0.0	0.0	0.0	0.0	1.000	1.000	0.0	0.0	0.0
Ex46	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.000
Ex47	0.0	0.0	0.500	0.0	0.0	0.0	1.000	0.0	0.0	0.0
Ex48	1.000	0.0	0.0	0.0	0.0	0.0	0.0	1.000	1.000	0.0
Ex49	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.000	0.0	0.0
Ex50	1.000	0.0	0.0	1.000	0.0	0.0	0.0	0.0	0.0	0.0
Ex51	1.000	1.000	0.0	1.000	1.000	0.0	0.0	0.0	0.0	0.0
Ex52	1.000	0.300	1.000	1.000	1.000	0.0	0.0	0.0	0.0	0.0
Ex53	1.000	1.000	1.000	1.000	1.000	0.0	0.0	0.0	0.0	0.0
Ex54	1.000	0.0	1.000	0.0	1.000	0.0	0.0	0.0	0.0	0.0
Ex55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex56	0.0	0.0	0.0	0.0	0.0	1.000	1.000	1.000	0.0	0.0
Ex57	1.000	1.000	0.0	1.000	1.000	1.000	1.000	1.000	0.0	0.0
Ex58	1.000	0.0	1.000	0.0	0.0	0.0	0.0	0.0	0.0	1.000
Ex59	1.000	0.0	0.0	1.000	1.000	0.0	0.0	0.0	0.0	0.0
Ex60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex61	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.000
Ex62	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex63	1.000	1.000	0.0	1.000	1.000	0.0	0.0	0.0	0.0	0.0
Ex64	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex65	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex66	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Appendix III D,2/8

CARCINALINAE FEMALES

	11RHOD C	12PEFI E	13PITY G	14S ATRI	15S MAXI	16S ATRI	17S SIMI	18S CCFR	19S OPEN	20S MAXI
Ex1	91.700	86.700	82.100	114.500	84.000	91.300	93.000	97.800	80.500	94.030
Ex2	-21.810	-57.670	-54.610	-65.500	-47.620	-76.670	-31.180	-36.910	-37.270	-21.280
Ex3	-2.190	-5.770	-35.320	-34.930	-27.390	-32.860	-19.350	-16.360	-12.420	-19.150
Ex4	-30.530	-11.530	-26.800	-34.930	-19.050	-27.280	-15.050	-16.260	-9.940	-15.960
Ex5	-8.720	-17.300	-3.650	-26.200	-1.190	-16.430	-8.600	-3.070	-3.730	0.0
Ex6	-6.540	-26.530	-7.310	-8.730	4.760	10.950	-5.380	11.250	12.420	0.0
Ex7	143.950	132.640	158.340	139.740	140.480	136.910	131.180	154.400	142.860	141.490
Ex8	25.080	29.990	31.670	33.190	33.330	27.380	21.510	32.720	26.570	21.290
Ex9	547.070	565.170	442.140	615.720	525.000	525.740	525.810	468.300	518.010	542.550
Ex10	630.320	596.310	504.260	672.490	582.140	596.930	582.800	505.110	514.290	521.290
Ex11	101.500	98.800	93.800	119.500	93.600	103.800	100.400	106.200	91.200	99.500
Ex12	-61.770	-65.790	-72.490	-87.870	-72.630	-63.230	-99.600	-84.670	-73.460	-105.530
Ex13	-39.410	-13.160	-25.590	-33.470	-30.980	-41.830	-39.840	-35.750	-29.610	-50.250
Ex14	-7.680	-3.040	-4.260	-4.180	-5.340	-2.920	-4.980	-9.410	0.0	-5.030
Ex15	4.930	23.230	14.930	2.510	5.340	0.970	3.980	3.760	3.290	3.020
Ex16	30.540	40.490	39.450	12.550	18.160	24.320	20.920	16.930	19.740	20.100
Ex17	60.700	30.970	86.350	87.870	85.470	60.740	86.650	87.490	85.530	90.450
Ex18	16.750	16.190	12.790	16.740	13.830	14.590	14.940	13.170	15.350	15.080
Ex19	95.550	101.210	104.480	107.110	96.150	95.330	105.580	104.420	101.970	95.480
Ex20	20.690	26.320	22.390	27.620	19.230	19.460	20.920	20.700	23.030	15.080
Ex21	106.400	105.260	113.010	108.790	108.970	107.980	113.550	119.470	109.650	105.530
Ex22	24.660	30.360	26.650	27.620	25.640	24.320	24.900	27.280	25.220	13.070
Ex23	112.320	104.250	116.200	117.150	112.180	111.870	119.520	121.350	116.230	120.600
Ex24	24.630	30.360	27.720	31.600	27.780	24.320	25.900	27.280	25.220	23.120
Ex25	135.960	146.760	154.580	167.360	146.370	148.830	151.390	156.160	144.740	150.750
Ex26	33.500	43.520	40.510	48.540	36.320	41.830	39.840	40.450	35.090	35.180
Ex27	1.420	2.020	1.820	0.920	1.290	1.290	1.330	1.170	1.450	1.360
Ex28	10.200	9.600	10.000	13.800	11.300	11.500	11.100	12.300	11.000	11.300
Ex29	175.490	154.170	162.000	170.290	166.370	178.260	181.080	172.360	164.550	176.990
Ex30	114.710	112.500	118.000	108.700	107.080	120.000	113.510	114.630	105.450	123.890
Ex31	135.290	131.250	127.000	126.810	121.240	128.700	128.830	130.060	123.640	146.020
Ex32	63.200	66.300	66.800	73.000	73.000	64.000	67.600	67.000	65.800	-9.930
Ex33	20.300	25.700	26.000	-9.900	19.500	21.000	26.500	23.700	29.000	-9.900

Appendix III D,3/8

CARCINALINAE FEMALES

	11RHOD C	12PERI E	13PITY G	14S ATRI	15S MAXI	16S ATRI	17S SIMI	18S COER	19S OPEN	20S MAXI
Ex34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex35	0.0	0.0	0.0	1.000	1.000	1.000	0.0	0.0	1.000	0.0
Ex36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex39	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex40	1.000	1.000	0.0	1.000	1.000	0.0	0.0	1.000	1.000	1.000
Ex41	0.0	0.0	0.0	1.000	1.000	0.0	1.000	1.000	0.0	1.000
Ex42	0.0	0.0	0.0	0.0	0.0	1.000	0.0	0.0	0.0	0.0
Ex43	0.0	0.0	0.0	0.0	0.0	1.000	0.0	0.0	0.0	0.0
Ex44	0.0	1.000	0.0	1.000	0.0	0.0	1.000	0.0	0.0	0.0
Ex45	1.000	0.0	0.0	0.0	0.0	1.000	1.000	0.0	0.0	0.0
Ex46	0.0	0.0	0.0	0.0	0.0	0.0	1.000	0.0	0.0	0.0
Ex47	0.0	0.0	0.0	1.000	1.000	0.0	0.0	0.0	0.0	0.0
Ex48	0.0	1.000	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex49	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex50	1.000	0.0	0.0	0.0	0.0	0.0	1.000	0.0	0.0	0.0
Ex51	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex52	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex53	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex54	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex56	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex57	1.000	1.000	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex58	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex59	0.0	0.0	0.0	1.000	1.000	1.000	1.000	1.000	0.0	1.000
Ex60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.000	0.0
Ex61	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex62	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex64	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.000	0.0
Ex65	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex66	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Appendix III D,4/8

CARDINALINAE FEMALES

	21S AURA	22S CINC	23S ATRI	24S RUFI	25S ALBI	26P GLAU	27P CYAN	8P PRIS	29P PARE	30P CAER
Ex1	89.000	106.000	88.300	95.000	-9.900	61.800	61.300	72.000	48.600	63.500
Ex2	-31.460	-150.940	-71.350	-52.630	-9.900	-53.400	-50.570	-36.110	-26.750	-23.620
Ex3	-4.490	-66.040	-26.050	0.0	-9.900	-17.600	-29.360	-18.060	-4.120	-4.720
Ex4	-2.250	-28.300	-30.580	5.260	-9.900	-15.420	-13.050	-11.110	-2.060	-12.600
Ex5	2.250	-47.170	-5.660	-5.260	-9.900	-6.470	-8.160	-5.560	-6.170	-3.150
Ex6	4.430	37.740	-11.330	0.0	-9.900	0.0	0.0	6.540	6.170	3.150
Ex7	123.210	64.910	124.580	126.320	-9.900	137.540	169.660	133.330	154.320	148.030
Ex8	20.220	23.580	22.650	15.790	-9.900	24.270	39.150	25.000	32.920	22.050
Ex9	468.760	613.210	571.910	536.840	-9.900	422.330	533.440	480.560	413.580	401.570
Ex10	530.340	594.340	540.200	536.840	-9.900	524.270	564.440	513.890	471.190	444.030
Ex11	94.300	102.000	98.000	117.000	99.000	68.900	76.600	76.000	65.000	63.490
Ex12	-74.230	-68.630	-64.770	-95.470	-80.810	-74.020	-73.110	-82.590	-91.540	-29.940
Ex13	-27.570	-39.220	-25.000	-34.190	-20.200	-23.220	-31.330	-36.840	-30.770	-1.230
Ex14	-5.300	-9.800	3.410	0.0	-5.050	2.900	-5.220	-11.840	-3.080	7.190
Ex15	8.480	29.410	2.270	0.0	10.100	30.480	6.530	7.890	9.230	50.360
Ex16	24.390	39.220	11.360	25.640	20.200	33.380	27.420	13.160	35.380	59.750
Ex17	81.650	88.240	94.320	76.920	101.010	92.890	96.610	92.110	93.850	86.330
Ex18	11.660	9.800	17.050	8.550	20.200	15.970	14.360	15.790	16.920	11.990
Ex19	102.850	117.650	110.230	94.020	111.110	113.210	112.270	107.890	113.850	105.520
Ex20	21.210	24.510	26.140	17.090	20.200	24.670	23.500	23.680	26.150	23.980
Ex21	103.920	127.450	117.050	102.560	121.210	120.460	125.330	118.420	120.000	116.310
Ex22	22.270	29.410	34.090	25.640	30.300	29.030	27.420	27.630	27.690	28.790
Ex23	109.230	117.650	121.590	94.020	121.210	123.370	125.330	119.740	123.080	119.900
Ex24	26.510	29.410	34.090	17.090	30.300	29.030	30.030	26.320	27.690	26.380
Ex25	143.160	68.630	162.500	136.750	151.520	145.140	159.270	150.000	153.850	135.490
Ex26	31.810	29.410	42.050	34.190	40.400	34.830	41.780	38.160	36.920	37.170
Ex27	1.290	2.450	0.940	-0.850	1.520	1.540	1.170	1.030	1.250	2.230
Ex28	10.500	11.000	12.300	12.000	-9.900	8.200	9.400	8.300	8.100	9.400
Ex29	184.760	209.090	176.420	191.670	100.000	165.850	162.770	161.930	165.430	164.040
Ex30	114.290	118.180	105.690	108.330	100.000	104.880	104.260	110.840	102.470	114.890
Ex31	139.050	154.550	115.450	125.000	100.000	126.830	122.340	124.100	122.220	134.040
Ex32	69.000	66.000	81.700	-9.900	-9.900	52.300	54.500	51.700	58.000	53.300
Ex33	23.200	25.000	14.000	-9.900	-9.900	40.300	30.700	30.000	31.000	34.200

Appendix III D,5/8

CARDINALINAE FEMALES

	21S AURA	22S CINC	23S ATRI	24S RUFI	25S ALBI	26P GLAU	27P CYAN	28P BRIS	29P PARE	30P CAER
Ex34	0.0	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.000
Ex35	0.0	0.0	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex39	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex40	0.0	1.000	1.000	0.0	0.0	0.0	0.0	0.0	0.0	1.000
Ex41	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.000
Ex42	0.0	1.000	1.000	0.0	1.000	0.0	0.0	0.0	0.0	0.0
Ex43	0.0	0.0	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex44	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex46	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex47	0.0	0.0	0.0	1.000	1.000	1.000	0.0	0.0	0.0	1.000
Ex48	0.0	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex49	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex50	0.0	0.0	0.0	0.0	1.000	0.0	0.0	0.0	0.0	1.000
Ex51	0.0	0.0	1.000	0.0	0.0	0.0	0.0	0.0	0.0	1.000
Ex52	0.0	0.0	0.0	0.0	1.000	0.0	0.0	0.0	0.0	1.000
Ex53	0.0	0.0	0.0	0.0	1.000	0.0	0.0	0.0	0.0	1.000
Ex54	0.0	0.0	0.0	1.000	0.0	1.000	0.0	0.0	0.0	0.0
Ex55	0.0	0.0	0.0	0.0	1.000	0.0	0.0	0.0	0.0	0.0
Ex56	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex57	1.000	-9.900	0.0	0.0	0.0	1.000	1.000	1.000	1.000	1.000
Ex58	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex59	1.000	0.0	0.0	1.000	1.000	0.0	0.0	0.0	0.0	0.0
Ex60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex61	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex62	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex63	0.0	0.0	1.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex64	0.0	1.000	0.0	0.0	1.000	0.0	0.0	0.0	0.0	0.0
Ex65	0.0	1.000	0.0	0.0	1.000	0.0	0.0	0.0	0.0	0.0
Ex66	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

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CARDINALINAE FEMALES

	31P CYAN	32P AMOE	33P VERI	34P CIRI	35P ROSI	36P LECL	37P CAER
Ex1	48.300	51.900	49.500	50.800	48.300	48.300	52.500
Ex2	-13.630	-7.710	-22.220	-21.650	-10.350	-20.700	-38.100
Ex3	0.0	-1.930	-16.160	-5.910	0.0	-6.210	-5.710
Ex4	2.070	1.930	-2.020	0.0	0.0	0.0	-9.520
Ex5	2.070	1.930	0.0	1.970	0.0	-6.210	0.0
Ex6	20.700	17.340	8.080	9.840	16.560	20.700	9.520
Ex7	139.720	140.660	161.620	147.640	151.140	138.720	152.380
Ex8	18.630	19.270	26.260	19.690	26.920	24.840	24.760
Ex9	378.880	394.990	444.440	391.730	445.130	532.090	542.860
Ex10	494.470	475.920	474.750	421.260	434.780	496.890	476.190
Ex11	64.800	67.300	62.300	67.300	68.700	64.000	60.500
Ex12	-30.860	-35.660	-69.020	-50.520	-66.410	-78.130	-38.020
Ex13	0.0	-1.490	-12.840	-1.490	-14.560	-15.630	-4.960
Ex14	3.090	2.970	1.610	0.0	0.0	0.0	0.0
Ex15	50.930	41.600	22.470	34.180	11.640	7.810	24.790
Ex16	50.930	57.950	36.520	28.630	33.480	20.310	33.060
Ex17	91.050	80.240	96.310	86.160	91.700	98.440	104.130
Ex18	15.430	13.370	20.870	14.860	17.470	19.750	21.490
Ex19	108.020	101.040	109.150	104.010	97.530	112.500	132.230
Ex20	24.690	26.750	32.100	25.260	21.830	26.560	33.060
Ex21	112.650	108.470	117.170	106.980	106.260	114.060	132.230
Ex22	26.230	28.230	30.500	26.750	29.110	31.250	38.020
Ex23	109.570	108.470	117.170	108.470	112.080	120.310	132.230
Ex24	27.780	26.750	32.100	28.230	29.110	31.250	33.060
Ex25	121.910	129.270	149.280	136.700	126.640	135.940	140.500
Ex26	32.410	31.200	40.130	38.630	32.020	30.060	29.750
Ex27	1.850	2.070	1.520	1.800	1.310	1.140	0.910
Ex28	7.500	7.800	7.500	8.300	8.200	6.700	7.000
Ex29	173.330	171.790	166.670	167.470	154.880	176.120	175.710
Ex30	112.000	101.290	104.000	98.800	106.100	111.940	114.290
Ex31	125.330	119.230	121.330	118.070	113.410	123.880	111.430
Ex32	56.300	56.300	61.000	58.700	60.700	58.000	58.000
Ex33	32.500	32.000	30.000	-9.900	29.000	-9.900	28.000

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CARDINALINAE FEMALES

	31P CYAN	32P AMOE	33P VERI	34P CIRI	35P FUSI	36P LECL	37P CAER
Ex34	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex35	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex36	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex37	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex38	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex39	0.0	1.000	0.0	0.0	0.0	0.0	0.0
Ex40	0.0	1.000	0.0	0.0	0.0	0.0	0.0
Ex41	1.000	0.0	0.0	0.0	0.0	1.000	0.0
Ex42	0.0	0.0	0.0	0.0	0.0	1.000	1.000
Ex43	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex44	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex45	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex46	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex47	0.0	0.0	0.0	0.0	1.000	0.0	0.0
Ex48	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex49	0.0	0.0	0.0	1.000	1.000	1.000	0.0
Ex50	1.000	0.0	0.0	0.0	0.0	1.000	1.000
Ex51	1.000	0.0	0.0	0.0	0.0	0.0	1.000
Ex52	1.000	0.0	0.0	0.0	0.0	0.0	1.000
Ex53	1.000	0.0	0.0	0.0	0.0	0.0	1.000
Ex54	0.0	1.000	0.0	0.0	0.0	0.0	0.0
Ex55	0.0	0.0	0.0	0.0	1.000	0.0	0.0
Ex56	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex57	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Ex58	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex59	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex60	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex61	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex62	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex63	1.000	0.0	0.0	0.0	0.0	0.0	1.000
Ex64	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex65	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ex66	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Appendix III D,8/8

CARDINALINAE FEMALE

	1-SPIZ A	2-PHEU C	3-PHEU A	4-PHEU L	5-PHEU M	6-CARD C	7-CARD P	8-CARD S	9-CARY C	11PHED C
Col 1	579.300	576.700	581.100	579.000	582.200	579.000	577.700	575.500	574.000	0.0
Col 2	582.000	576.000	581.100	579.000	180.500	579.000	579.000	575.500	574.000	574.000
Col 3	578.000	574.000	579.900	579.000	578.000	579.000	579.000	575.500	574.000	574.000
Col 4	578.000	576.000	576.500	579.000	579.000	579.000	579.000	575.500	574.000	574.000
Col 5	579.700	576.000	581.000	576.600	579.100	578.500	577.300	578.000	574.000	0.0
Col 6	575.000	575.000	574.000	575.000	578.000	576.400	577.300	577.000	574.000	574.000
Col 7	575.000	575.000	574.000	575.000	575.000	576.400	577.000	577.000	574.000	574.000
Col 8	575.000	575.000	573.500	577.000	575.000	577.000	577.000	577.000	574.000	574.000

	12PIPI E	13PITY G	14S ATRI	15S MAXI	16S ATRI	17S SIMI	18S COER	19S OFEN	21S AURA	23S ATRI
Col 1	0.0	481.200	577.000	574.000	0.0	572.000	572.000	0.0	576.000	582.500
Col 2	573.000	523.600	574.500	574.000	574.000	572.000	572.000	0.0	575.700	583.000
Col 3	578.000	544.900	574.500	574.000	574.000	572.000	572.000	0.0	575.700	578.500
Col 4	578.000	523.800	574.500	574.000	574.000	572.000	572.000	0.0	575.700	583.000
Col 5	573.000	0.0	0.0	581.000	575.000	575.000	580.300	575.000	578.000	0.0
Col 6	577.500	576.000	0.0	577.500	575.000	577.000	575.700	574.000	578.000	579.500
Col 7	577.500	576.000	0.0	577.000	0.0	577.000	580.700	575.000	580.000	579.000
Col 8	577.500	576.800	582.000	581.000	578.500	577.000	581.300	581.300	590.500	581.500

	24S RUFI	25S ALBI	26P GLAU	27P CYAN	28P BRIS	29P PARE	30P CYER	31P CYAN	32P AMOE	33P VERI
Col 1	485.500	460.800	582.000	581.500	582.000	561.500	579.600	579.000	579.800	566.200
Col 2	485.500	531.400	582.000	581.500	582.000	581.500	579.600	579.000	579.800	566.300
Col 3	485.500	581.000	582.000	582.000	582.000	578.000	579.600	481.500	580.300	566.300
Col 4	485.500	581.300	582.000	582.000	582.000	579.000	579.600	576.000	579.000	566.300
Col 5	576.000	581.300	581.000	581.000	582.000	578.000	577.500	560.000	579.000	571.200
Col 6	574.500	581.500	582.000	582.000	582.000	577.000	575.500	580.000	578.500	575.300
Col 7	574.500	581.000	581.500	581.000	581.000	577.000	575.000	579.000	578.500	575.300
Col 8	574.500	581.000	582.000	581.000	582.000	577.000	575.000	579.000	575.000	575.300

	34P CIPE	35P ROSI	36P LECL
Col 1	579.000	569.500	581.500
Col 2	579.000	569.500	581.000
Col 3	481.500	559.500	581.000
Col 4	481.500	491.500	581.000
Col 5	580.500	576.000	577.000
Col 6	579.500	575.000	577.000
Col 7	583.000	575.000	577.000
Col 8	579.500	574.000	572.000

[1] some characters are multiples of the original measurements

Appendix III E,1/1