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SHORT COMMUNICATION

Morphological Variations of the Cranium Within the Genus *Leontopithecus*

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ABSTRACT. Multivariate analysis methods were applied to the cranial measurements of *Leontopithecus*. In *Leontopithecus chrysomelas*, the face is generally narrow and the cranial shape is relatively unique. Especially, the male has extremely narrow face and quite unique cranial shape among *Leontopithecus*. *Leontopithecus rosalia* has the broad face compared with the other species. The cranial size of *L. rosalia* is as large as that of *L. chrysomelas*. Male of *Leontopithecus chrysopygus* is the largest in overall size of the cranium, and has the widest braincase.

Key Words: *Leontopithecus*; Cranial measurements; Multivariate analysis.

INTRODUCTION

Leontopithecus is confined to dwindling patches of the tropical rain forest that once covered the coast of southeastern Brazil. This animal is among the most dangerous and least known New World monkeys.

The genus *Leontopithecus* has the three distinct species: *Leontopithecus chrysomelas*, *Leontopithecus rosalia*, and *Leontopithecus chrysopygus* (ROSENBERGER & COIMBRA-FILHO, 1984). Few skeletal materials of the three species, especially *L. chrysomelas* and *L. chrysopygus*, are available in museum collections around the world (e.g., NAPIER, 1976; ALBRECHT, 1982). As far as the cranial measurements are concerned, we find no mention of the comparisons among these species except for a paper by ROSENBERGER and COIMBRA-FILHO (1984) whose analysis was performed by using univariate analysis methods. Thus multivariate analysis methods have not been employed to examine the cranial variations among the species of *Leontopithecus* although these are one of the best methods for analyzing morphological variations. In the present study, we aim to clarify the variations of the cranium within the genus *Leontopithecus* applying the multivariate analysis methods to its cranial measurements.

MATERIALS AND METHODS

For the classification and nomenclature of *Leontopithecus*, we follow ROSENBERGER and COIMBRA-FILHO (1984). The materials used in the present study were housed in the Centro de Primatologia de Rio de Janeiro (Rio de Janeiro, Brazil; CPRJ-FEEMA), the Museu Nacional de Rio de Janeiro (Universidade Federal, Rio de Janeiro, Brazil; MNRJ), and the U.S. National Museum of Natural History (Washington, D.C., U.S.A.).

The sample sizes of the three species of *Leontopithecus* were small, and especially materials

Table 1. Samples used in the present study.

	Male	Female
Leontopithecus chrysomelas	3	5
L. rosalia	10	15
L. chrysopygus	5	0

of female of *L. chrysopygus* were not obtained (Table 1), because there are few skeletal materials in museum collection. It is assumed, therefore, that the specimens used here can be representative of each population of *Leontopithecus*.

The following items were measured: (1) nasion to prosthion; (2) left frontomalare orbitale to right frontomalare orbitale; (3) nasion to left frontomalare orbitale; (4) greatest breadth across outer margins of orbits; (5) left zygion to right zygion; (6) nasion to opisthocranion; (7) prosthion to opisthocranion; (8) greatest breadth between buccal surfaces of upper canines; (9) bi-condylar breadth; (10) greatest breadth of the braincase; and (11) minimum breadth of postorbital constriction.

Penrose's size and shape coefficients were used for distance analyses. Quantification theory model IV was applied to the distance matrices to reduce multiple dimensions to a simple dimension with a minimum loss of total information. In addition, principal component analysis was used for detailed analysis.

RESULTS AND DISCUSSION

First of all, the Penrose's size and shape distances were calculated from the cranial measurements (Table 2). On the basis of the distances, affinities among the five populations can be illustrated in one-dimensional space. Figure 1 and Figure 2 were made by using coordinates resulting from analyses based on the quantification theory model 1V. In Figure 1, the populations are simply arranged in the order of cranial size. The size of *L. chrysomelas* is almost equal to that of *L. rosalia*. Male of *L. chrysopygus* is very much larger than the other populations. In the Penrose's shape distance, male of *L. chrysomelas* is quite different from the other populations (Fig. 2).

Table 2. The Penrose's size and shape distances calculated from the cranial measurements.*

	m-cm	f-cm	m-ro	f-ro	m-cp
m-cm	—	0.5934	0.0129	0.8487	1.9056
f-cm	1.1043	—	0.7812	0.0228	4.6256
m-ro	1.7542	0.7107	—	1.0708	1.6050
f-ro	1.9845	0.7455	0.4141	—	5.2977
m-cp	1.3149	0.2440	0.4066	0.3811	—

*Size distances in the upper triangular section and shape distances in the lower triangular section. m-ro: Male of *L. rosalia*; f-ro: female of *L. rosalia*; m-cm: Male of *L. chrysomelas*; f-cm: female of *L. chrysomelas*; m-cp: male of *L. chrysopygus*.

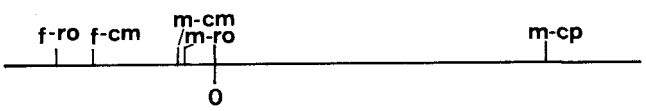

Fig. 1. One-dimensional expression based on the Penrose's size distance. Abbreviations are explained in Table 2.

Fig. 2. One-dimensional expression based on the Penrose's shape distance. Abbreviations are explained in Table 2.

The principal component analysis was applied to the cranial measurements for the purpose of a detailed analysis of the variations. As shown in Table 3, the first three principal components have eigenvalues greater than 1.0, and their cumulative proportion of total variance is 0.8117.

The component loadings for the first component show positive values which are almost similar among one another, so that this component appears to relate to overall size of the cranium (Table 4). In the second component, the loadings to exhibit breadth of the facial region have positive values, ranging from 0.3108 to 0.5577, and the other loadings show negative values (Table 4). Therefore, this component is related to relative size of the facial breadth. The third component represents width of the braincase because the loadings for greatest width of braincase and minimum breadth of postorbital constriction show quite large values (Table 4).

Table 3. First three eigenvalues and cumulative proportion of total variance.

Order of eigenvalue	Eigenvalue	Cumulative proportion of total variance
1	5.7129	0.5194
2	2.0193	0.7029
3	1.1966	0.8117

Table 4. Component loadings for the first three principal components.

No. of measurement items	PC1	PC2	PC3
1	0.8384	−0.2521	0.0496
2	0.7793	0.5075	−0.0390
3	0.7826	0.3937	−0.0315
4	0.7846	0.5202	−0.0737
5	0.8820	−0.0781	−0.2977
6	0.7173	−0.4952	0.0324
7	0.8897	−0.3103	0.0985
8	0.7417	0.3108	−0.1274
9	0.5925	−0.5287	−0.1351
10	0.4093	−0.4875	0.7024
11	0.1471	0.5577	0.7476

Table 5. Mean scores.

	PC1	PC2	PC3
L. chrysomelas			
Male	0.976	−2.138	−0.528
Female	−0.950	−0.345	−0.256
L. rosalia			
Male	0.862	0.416	−0.234
Female	−1.774	0.312	0.202
L. chrysopygus			
Male	4.197	0.028	0.756

Table 5 shows mean values of the principal component scores in each population. In the overall size, the difference between *L. chrysomelas* and *L. rosalia* is not clear. Male of *L. chrysopygus* is very much larger than the other populations. The facial breadth of *L. chrysomelas* is generally narrow compared with the other species, but its male has especially narrow face. In *L. rosalia*, the face is the broadest of *Leontopithecus*. The braincase of male in *L. chrysopygus* is the widest of the five populations. These results are compatible with those of the distance analyses.

ROSENBERGER and COIMBRA-FILHO (1984) characterized the cranium of the three species of *Leontopithecus* as follows: *L. chrysomelas* has comparatively unique cranial shape and its face is very narrow; *L. rosalia* is the smallest and most gracile with a highly abbreviated premaxilla; *L. chrysopygus* is the quite largest in the cranial size. The present study almost supports their conclusions, but there are a few discrepancies between them. In the present study, *L. rosalia* has the broadest face among *Leontopithecus* and its cranium is as large as that of *L. chrysomelas*, so that it is quite difficult to consider the cranium of *L. rosalia* to be the smallest and most gracile. In *L. chrysomelas*, face of the male is extremely narrow and its general cranial shape is very much unique compared with the female. Accordingly, *L. chrysomelas* has probably quite large sexual difference in the breadth of the face and general cranial shape although ROSENBERGER and COIMBRA-FILHO (1984) used mixed-sex sample for the analysis of its cranial measurements.

It was said that the Callitrichidae did not show sexual dimorphism in cranial and dental characters. Recently, however, sexual dimorphism is recognized in dentition of *Leontopithecus* (ROSENBERGER & COIMBRA-FILHO, 1984) and *Saguinus* (HANIHARA & NATORI, 1988). In the present study, we can also suggest the sexual difference in cranial measurements of *L. chrysomelas*. It is necessary, therefore, to re-examine sexual dimorphism in cranical and dental characters of the Callitrichidae in detail.

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