# ARE LION TAMARINS (*Leontopithecus*: PRIMATES) SEXUALY DIMORPHIC IN REGARD TO BODY MEASUREMENTS?*

## *OS MICOS LEÕES (Leontopithecus: PRIMATES) SÃO SEXUALMENTE DIMORFICOS A PESAR DAS MEDIDAS CORPORAIS?*

Carlos Henrique Freitas Burity[1], Alcides Pissinatti[2] and Carlos Alberto Mandarim-de-Lacerda[3]

**ABSTRACT.** Burity C.H.F., Pissinatti A. & Lacerda C.A.M. de. **Are lion tamarins (*Leontopithecus*: Primates) sexualy dimorphic in regard to body measurements?** [Os micos leões (*Leontopithecus*: Primates) são sexualmente dimorficos a pesar das medidas corporais?] *Revista Brasileira de Medicina Veterinária, 32(4):205-210, 2010.* Escola de Ciências da Saúde, Universidade do Grande Rio, Rua Professor José de Souza Herdy, 1160, Duque de Caxias, RJ 25071-200, Brasil. E-mail: cburity@unigranrio.com.br

The *Leontopithecus* genus comprises the following four recognized species: *L. rosalia*, *L. chrysomelas*, *L. chrysopygus*, and *L. caissara*, which are considered the largest genus in the Callitrichidae family. They occupy areas of the Atlantic Forest in Brazil, the former three species being critically endangered. Primates are sexually dimorphic in a range of morphological characteristics, such as body weight, fur, organs, and cranial, axial, and appendicular skeletons. This study assessed sexual dimorphism in body morphological characteristics of *Leontopithecus* kept in captivity. Body morphological variations were studied in a significant sample of the genus *Leontopithecus*. The analyses were performed aiming at testing possible sexual dimorphism. Welch's approximate *t* test was used for assessing 13 body measurements, some of which were sexually dimorphic, such as chest perimeter, and arm, thigh, and foot lengths. No sexual dimorphism was evidenced for body weight in *L. rosalia* and *L. chrysopygus*. Body weight in *L. chrysomelas*, however, was dimorphic. As a whole, our study confirmed the lack of sexual dimorphism for body weight in *Leontopithecus*. On the other hand, it emphasized the findings regarding body weight in *L. chrysomelas*, as well as the significant differences found in the appendicular skeleton and chest perimeter in the sample studied.

KEY WORDS. Lion tamarins, *Leontopithecus*, body and morphometry.

## INTRODUCTION

The *Leontopithecus* genus (Lesson 1840) comprises the following four recognized species: the golden lion tamarin *Leontopithecus rosalia* (Linnaeu 1766), the golden-headed lion tamarin *Leontopithecus chrysomelas* (Kuhl 1820), the black lion tamarin *Leontopithecus chrysopygus* (Mikan 1823), and the black-faced lion tamarin *Leontopithecus caissara* (Persson & Lorini 1990) (Coimbra-Filho 1990). These are the largest Callitrichid species occupying the isolated remnants of the Atlantic Forest in Brazil. The following three species were considered "critically endangered" by the IUCN Species Survival Commission (Rosenberger & Coimbra-Filho 1984, Rylands et al. 1993, IUCN 1996), *L. rosalia* in the state of Rio de Janeiro; *L. chrysopygus* in the state of São Paulo, and *L. chrysomelas*, restricted to the forests of the southern region of the state of Bahia.

* Received on May 7, 2010.
Accepted for publication on September 22, 2010.

[1] Biolólogo, *Dr. Biol.*, Escola de Ciências da Saúde, Universidade do Grande Rio, Rua Professor José de Souza Herdy, 1160, Duque de Caxias, RJ 25071-200, Brasil. E-mail: cburity@unigranrio.com.br

[2] Médico-veterinário, *Dr. Biol. Ani.*, Centro de Primatologia do Rio de Janeiro, FEEMA. Guapimirim, RJ.

[3] Biólogo, *Dr. D'etat Biol. Hum.*, Departamento de Anatomia, Instituto de Biologia, Universidade Estadual do Rio de Janeiro, Maracanã, Rio de Janeiro, RJ.

Primates are sexually dimorphic in a range of morphological characteristics, such as coat, body weight, organs, and cranial, axial, and appendicular skeletons (Leutenegger & Cheverud 1985). There are two major theories explaining the causes of sexual dimorphism. The most traditional one is the "sexual selection" (Darwin 1871), based on competition among males for mating. The other theory considers the intraspecific competition of males and females for environmental resources, especially food (Selander 1972). Several corollaries to these basic theories have also been proposed (Clutton-Brock & Harvey 1977, Leutenegger & Cheverud 1985).

In regard to morphological characteristics, the number of publications about New World primates is even smaller than that about Old World primates. These studies on New World primates are usually aimed at helping in the assessment of little known species (Rosenberger & Coimbra-Filho 1984, Lemos de Sá & Glander 1993, Bicca-Marques et al. 1997, Garber & Leigh 1997), or of recently described species (Lorini & Pearson 1990, Ferrari & Lopes 1992, Mittermeier et al. 1992, Queiroz 1992, Roosmalen et al. 1998).

An approach frequently associated with mophometrics aspects is sexual dimorphism, markedly variations in size (Leutenegger & Larson 1985, Leigh & Shea 1995, Taylor 1995, Walvath & Glantz 1996, Lockwood 1999, Holden & Mace 1999). However, this should be analyzed carefully, because some aspects can influence in the results, as occurred with *Ateles*. Peres (1994) reported that *Ateles* had reverse sexual dimorphism (i.e., females were larger than males), a fact that was then refuted by Smith (1996), who justified that Peres' affirmation (1994) was based on a compilation of data obtained in a study by Ford & Davis (1992) and on wrong implementation of statistical calculations.

The present study aimed at analyzing sexual dimorphism in body morphological characteristics in *Leontopithecus* kept in captivity.

## MATERIALS AND METHODS

Sixty-six lion tamarins from the Center of Primatology of Rio de Janeiro (CPRJ-FEEMA) were studied. The facility is located 100 km northeast of the city of Rio de Janeiro, in a protected forest area of the Serra dos Órgãos mountain range. At this facility, the animals were housed in groups and the enclosures were located outdoors, being, thus, exposed to the Atlantic Forest conditions such as sounds, temperature, and rainfall. The enclosures measured 6.0 x 3.0 x 2.5 meters. The south wall of each was made of concrete, and the other three walls were made of wire mesh. Food and fresh water were provided twice a day. The diet consisted of bread, bananas, eggs, raisins, meat, various commercially prepared protein supplements, and invertebrate larvae (Coimbra-Filho et al. 1981).

Many of the body measurements adopted in this study had already been widely used by other authors in morphometric studies (Schultz 1929, Hershkovitz 1977, Rosenberger & Coimbra-Filho 1984). In our study, 13 measurements were taken (Table 1) in the sample consisting of the following adult animals from the CPRJ-FEEMA museum collection: 21 *L. rosalia* (11 females); 21 *L. chrysomelas* (11 females); and 21 *L. chrysopygus* (10 females). The sex and age of the animals born in captivity or in the wild, but monitored in their natural environment, were known. According to Kleiman

Table 1. Measurements taken with measuring closes, digital calipers, and digital scale, according to other studies (Schultz 1929, Hershkovitz 1977, Rosenberger & Coimbra-Filho 1984).

| Measurements | Description |
|---|---|
| MI Body Weight (g) | Obtained from the CPRJ-FEEMA museum files, containing data accurately measured with a 1g scale. |
| MII Head Length (mm) | Maximum antero-posterior diameter; from glabella to the most distant point on the occiput in the midsagittal plane. |
| MIII Head Breadth (mm) | Maximum lateral diameter; greatest breadth of the brain-part of the head over the parietal or temporal bone, perpendicular to the midsagittal plane. |
| MIV Horizontal Head Circumference (mm) | Greatest horizontal circumference of head through the glabella, i. e., in the same plane as the head length MII). |
| MV Sitting Height (mm) | From vertex to the most caudal point on buttocks over the ischial tuberosities, taken parallel to the body axis. |
| MVI Trunk Height (mm) | Anterior trunk height, formerly called thoraco-abdominal height; from suprasternale to symphysion, parallel to the body axis. |
| MVII Chest Circumference (mm) | Circumference of chest in the plane determined by the nipples. |
| MVIII Hand Length (mm) | From carpale to chirodactylion II ou IV, parallel to the longitudinal axis of the hand, and with the forearm, palm and fingers in one direction. |
| MIX Upper Arm Length (mm) | From acromion to radiale. Since the upper end point of this measurement is not situated on the humerus it is important to hold the upper arm always in the same position, namely, close to the side of the chest. |
| MX Forearm Length (mm) | From radiale to stylion. It will be found most practicable to take this measurement with the hand in a position of supination so that the two landmarks are on the same side of the forearm. |
| MXI Foot Length (mm) | From pterion to pododactylion II or IV, parallel to foot axis and with the toes perfectly straight. |
| MXII Leg Length (mm) | From tibiale to sphyrion, parallel to the long axis of the tibia. |
| MXIII Thigh Length (mm) | From trochanterion summum to femorale, parallel to the long axis of the femur. |

(1981), lion tamarins become sexually mature (adult) at approximately 18 months of age.

Although no animal was sacrificed for this study, some died from different natural causes and underwent necropsy.

Measurements were taken with measuring tapes, digital calipers, and digital scale, with respective accuracies of 1 cm, 0.01 mm, and 0.01 g.

Descriptive statistics were calculated for each measurement in all species of *Leontopithecus*. In order to analyze univariate differences between sexes, the means were initially compared using the Student *t* test. This two sample *t* test assumes that both samples come at random from a normal population with equal variances. When this assumption is not valid, we can perform a procedure known as Welch's approximate *t* test (Zar 1984, Burity et al. 1997a). As in this study some variances were statistically different, invalidating the *t* test assumptions, Welch's approximate *t* test was used. This test consisted of an approximate *t* value, for which the critical value was calculated as a weighted average of the critical t values based on the corresponding degrees of freedom of the two samples (Sokal & Rohlf 1995).

## RESULTS

The results of the univariate analyses of body measurements of *Leontopithecus* are shown in Tables 2 to 4 and Figure 1.

Comparing males and females using Welch's approximate t test, significant differences in some body measurements were found ($p<0.05$; sexual dimorphism). However, chest perimeter (M.VII) and foot length (M.XI) were the only dimorphic measurements in two of the three species of *Leontopithecus* (Figure 1) studied. Other measurements were dimorphic in isolation (Tables 2 to 4).

Considering the 13 body measurements studied, *L. chrysomelas* was the most sexually dimorphic species (4/13= 31%), followed by *L. rosalia* (3/13=23%), and *L. chrysopygus* (2/13=15%). In these sexually dimorphic measurements, males always had greater values than females did (Tables 2 to 4).

## DISCUSSION

In the scientific literature, studies on morphology or morphometry of *Leontopithecus*, independently from the descriptions of holotypes, are scarce. Most publica-

Table 2. Values of mean and standard error of mean (SEM) for each outer body measurement in both sexes of *Leontopithecus rosalia*, and results of comparison between sexes.

| Measurements | Female (n=11) | | Male (n=10) | | Welch's t | Prob. |
|---|---|---|---|---|---|---|
| | Mean | SEM | Mean | SEM | | |
| MI)-Body Weight (g) | 463.00 | 31.21 | 528.70 | 40.45 | 1.29 | NS |
| MII)-Head Length (mm) | 49.71 | 0.30 | 50.80 | 0.59 | 1.65 | NS |
| MIII)-Head Breadth (mm) | 31.10 | 0.58 | 31.03 | 0.60 | -0.08 | NS |
| MIV)-Horizontal Head Circumference(mm) | 150.82 | 1.58 | 146.30 | 2.55 | -1.51 | NS |
| MV)-Sitting Height(mm) | 241.18 | 2.56 | 245.50 | 2.83 | 1.13 | NS |
| MVI)-Trunk Height(mm) | 160.96 | 3.02 | 165.92 | 1.83 | 1.40 | NS |
| MVII)-Chest Circumference(mm) | 151.27 | 2.20 | 147.40 | 3.01 | -1.04 | NS |
| MVIII)-Hand Length(mm) | 58.53 | 1.04 | 60.67 | 0.77 | 1.65 | NS |
| MIX)-Upper Arm Length(mm) | 67.72 | 0.87 | 70.95 | 0.94 | 2.52 | 0.01 |
| MX)-Forearm Length(mm) | 68.13 | 0.84 | 68.15 | 1.18 | 0.01 | NS |
| MXI)-Foot Length(mm) | 75.38 | 0.80 | 77.95 | 1.18 | 1.80 | 0.04 |
| MXII)-Leg Length(mm) | 85.35 | 0.99 | 89.69 | 0.82 | 2.60 | 0.008 |
| MXIII)-Thigh Length(mm) | 75.34 | 1.10 | 74.97 | 0.66 | -0.29 | NS |

n = Sample size;
SEM = Standard error of the mean;
Prob. = Probability of being different from zero;
Welch's t = Welch's approximate t test;
NS = Not significant ($p>0.05$)

Table 3. Values of mean and standard error of mean (SEM) for each outer body measurement in both sexes of *Leontopithecus chrysomelas*, and results of comparison between sexes.

| Measurements | Female (n=11) | | Male (n=10) | | Welch's t | Prob. |
|---|---|---|---|---|---|---|
| | Mean | SEM | Mean | SEM | | |
| MI)-Body Weight(g) | 531.82 | 20.97 | 591.00 | 14.64 | 2.31 | 0.02 |
| MII)-Head Length(mm) | 49.05 | 0.52 | 50.97 | 0.50 | 2.66 | 0.007 |
| MIII)-Head Breadth(mm) | 30.56 | 0.49 | 31.27 | 0.60 | 0.92 | NS |
| MIV)-Horizontal Head Circumference(mm) | 148.00 | 1.46 | 152.80 | 2.09 | 1.88 | 0.04 |
| MV)-Sitting Height(mm) | 245.45 | 2.49 | 241.00 | 2.56 | -1.25 | NS |
| MVI)-Trunk Height(mm) | 150.80 | 4.34 | 148.24 | 4.19 | -0.42 | NS |
| MVII)-Chest Circumference(mm) | 142.57 | 5.84 | 161.50 | 3.92 | 2.69 | 0.007 |
| MVIII)-Hand Length(mm) | 64.81 | 1.01 | 62.92 | 1.32 | -1.14 | NS |
| MIX)-Upper Arm Length(mm) | 68.96 | 0.78 | 68.43 | 0.62 | -0.53 | NS |
| MX)-Forearm Length(mm) | 69.90 | 1.14 | 70.06 | 0.90 | 0.11 | NS |
| MXI)-Foot Length(mm) | 80.35 | 0.74 | 82.14 | 0.94 | 1.50 | NS |
| MXII)-Leg Length(mm) | 87.47 | 1.26 | 88.79 | 1.35 | 0.71 | NS |
| MXIII)-Thigh Length(mm) | 74.57 | 0.66 | 73.85 | 1.24 | -0.51 | NS |

n = Sample size;
SEM = Standard error of the mean;
Prob. = Probability of being different from zero;
Welch's t = Welch's approximate t test;
NS = Not significant ($p>0.05$)

Table 4. Values of mean and standard error of mean (SEM) for each outer body measurement in both sexes of *Leontopithecus chrysopygus*, and results of comparison between sexes.

| Measurements | Female (n=10) | | Male (n=11) | | Welch's t | Prob. |
|---|---|---|---|---|---|---|
| | Mean | SEM | Mean | SEM | | |
| MI)-Body Weight (g) | 597.50 | 22.28 | 624.55 | 22.21 | 0.86 | NS |
| MII)-Head Length (mm) | 51.62 | 0.52 | 50.82 | 0.52 | -1.09 | NS |
| MIII)-Head Breadth (mm) | 31.01 | 0.63 | 32.00 | 0.33 | 1.39 | NS |
| MIV)-Horizontal Head Circumference (mm) | 163.00 | 9.14 | 158.64 | 2.08 | -0.47 | NS |
| MV)-Sitting Height (mm) | 249.00 | 5.19 | 248.00 | 2.67 | -0.17 | NS |
| MVI)-Trunk Height (mm) | 171.74 | 2.74 | 174.75 | 3.83 | 0.64 | NS |
| MVII)-Chest Circumference (mm) | 144.70 | 3.35 | 153.82 | 2.31 | 2.24 | 0.02 |
| MVIII)-Hand Length (mm) | 66.48 | 0.54 | 67.14 | 0.73 | 0.73 | NS |
| MIX)-Upper Arm Length (mm) | 71.68 | 2.25 | 74.15 | 0.84 | 1.03 | NS |
| MX)-Forearm Length (mm) | 70.73 | 2.04 | 72.05 | 1.23 | 0.55 | NS |
| MXI)-Foot Length (mm) | 81.02 | 1.39 | 84.20 | 0.84 | 1.96 | 0.03 |
| MXII)-Leg Length (mm) | 86.92 | 2.04 | 90.16 | 1.46 | 1.29 | NS |
| MXIII)-Thigh Length (mm) | 75.49 | 3.03 | 78.96 | 1.10 | 1.08 | NS |

n = Sample size;
SEM = Standard error of the mean;
Prob. = Probability of being different from zero;
Welch's t = Welch's approximate t test;
NS = Not significant (p>0.05)

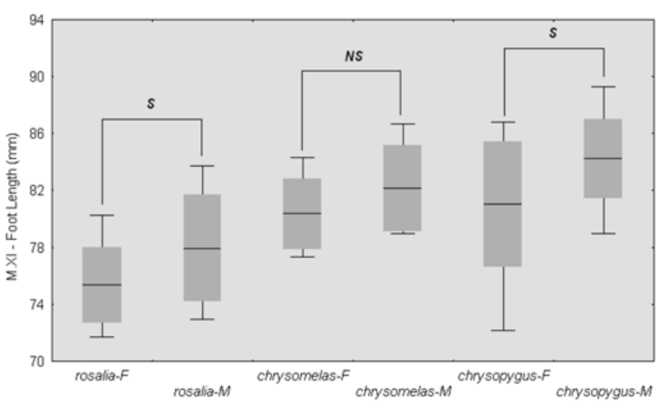


Figure 1. Box-Whisker plot for M.XI - Foot Length (mm) showing sexual dimorphism among species of *Leontopithecus*. Whisker, min and max; Box, standard deviation; Line, mean; S, significant; NS, non significant.

tions are limited to analyzing body weight and compiling data from older studies based on 1 or 2 wild and/or captive individuals, mainly *L. rosalia*.

Two studies about the morphometric features of body proportions were found in the literature. Ashton et al. (1975) reported body indices for 24 *Leontocebus* (=*Leontopithecus*) based on data from Schultz (1956), despite not referring to the species studied, most likely *L. rosalia*. In addition, the data obtained were presented as indices, making the comparison with our data difficult. In a second study, Oxnard (1983), also based on Schultz (*op. cit.*), performed univariate and multivariate analyses in several genera, *Leontocebus* (=*Leontopithecus*) included. Oxnard (1983), studying these body proportions, found no sexual dimorphism in *Leontocebus* (=*Leontopithecus*, probably *L. rosalia*). However, in univariate analysis, measurements related to the limbs, such as forearm, legs, and foot lengths, were significantly dimorphic for *L. rosalia*.

In regard to body weight, a larger number of publications may be found in the scientific literature. However, these are still insufficient, as well as much too focused on *L. rosalia*.

The first studies on compared anatomy, in which data on the species here studied may be found, reported mean values for body weight, total length (here called sitting height), and foot length that do not statistically differ from those obtained in this study. Hill (1957) reported values for the parameters above cited only in *Leontocebus rosalia* (=*Leontopithecus rosalia*) based only on three samples (2 males and 1 female). Hershkovitz (1977) reported data on *L. rosalia*, *L. chrysomelas*, and *L. chrysopygus*, which, although originating from reduced samples by other authors, also do not differ from our data.

It is worth noting that body weight is a very difficult variable to analyze, mainly due to, environmentally induced or not, physiological variations and to captivity conditions (our case). Dietz et al. (1994) reported that, in nature, the weight of *L. rosalia* males and females varied according to the dry or rainy season, or even as a result of social interactions, such as reproduction and competition. This also suggests the absence of sexual dimorphism in body weight in that *L. rosalia* population. We confirmed the absence of sexual dimorphism in body weight only in *L. rosalia* and *L. chrysopygus*. However, it is worth emphasizing that other measurements in isolation proved to be dimorphic in the species here analyzed using Welch's *t* test, especially foot length, which was sexually dimorphic in *L. rosalia* and *L. chrysopygus*. It is also worth emphasizing that for all sexually dimorphic measurements, males always had greater mean values than females did.

In their study, Dietz et al. (1994) reported that, although *L. rosalia* was not dimorphic, adult males were 4% larger than females were, differently from that which is here shown. The males of the three species here studied were, on average, 9% larger than females were, probably due to their captivity origin.

Ford & Davis (1992), in an extensive study on body size of New World primates, reported that the *Leontopithecus* genus was monomorphic for body weight (*i.e*., no marked sexual dimorphism). In general, our study confirmed the lack of sexual dimorphism for body weight in *Leontopithecus*. However, it is worth emphasizing that the sample of *L. chrysomelas* studied was dimorphic according to Welch's *t* test. Other similar studies also confirmed the monomorphism of *L. rosalia* in regard to body weight (Leigh 1992, Garber & Leigh 1997).

More recently, only the study by Rosenberger & Coimbra-Filho (1984) reported biometric data for the *Leontopithecus* species that could be compared with those in our study, due to the deficiency in morphometric data for these callitrichids in the scientific literature. Rosenberger & Coimbra-Filho (1984) reported only four body variables (among which, craniodental variables). Of those four, three were also part of our study: weight, body length, and foot length. The mean values of these variables were very similar to those found in our study, except for *L. chrysopygus*; the authors, however, used only two females, with no report on weight.

Rosenberger & Coimbra-Filho (1984) were the first to quantitatively recognize sexual dimorphism for dental characteristics in *L. rosalia*. Those authors considered that in the other two species studied, the sample available was much too small to allow further considerations on sexual dimorphism. Pissinatti et al. (1992) reported sexual dimorphism in the pelvis of *Leontopithecus* using the t test and an ischiopubic index. Based on this index, those authors identified *L. chrysopygus* as the most dimorphic. Due to restrictions on the sample size for using the *t* test, Pissinatti et al. (1992) analyzed only *L. rosalia*, which proved to be sexually dimorphic in regard to pelvic measurements.

In previous studies analyzing craniometric variables, Burity et al. (1997a, 1997b, 1999) reported a large number of sexually dimorphic variables. Therefore, craniometric variables are stronger evidence of sexual dimorphism for the sample studied than body parameters are, the latter showing that dimorphism more discretely.

In general, our study confirmed the lack of sexual dimorphism for body weight in *Leontopithecus*. However, the findings regarding body weight in *L. chrysomelas* are noteworthy, as are the significant differences found in regard to the appendicular skeleton and chest perimeter in the sample studied.

**Acknowledgments.** This study was supported by a grant from FAPERJ (c.h.f.b. 170-873/00, 170.286/07 and a.p. 171-573/00).

## REFERENCES


Ashton E.H., Flinn R.M. & Oxnard C.E. The taxonomic and functional significance of overall body proportions in primates. *J. Zool*., 175:73-105, 1975.

Bicca-Marques J.C., Calegaro-Marques C., Pereira de Farias E.M., Azevedo M.A.O., Santos F.G.A. 1997. Medidas morfométricas de *Saguinus imperator imperator* e *Saguinus fuscicollis weddeli* (Callitrichidae, Primates) em ambiente natural, p.257-268. In: Souza M.B.C. & Menezes A.L.L. (Eds), *A Primatologia no Brasil* 6. UFRN e SBPr, Natal.

Burity C.H.F., Mandarim-de-Lacerda C.A. & Pissinatti A. Craniometric sexual dimorphism in *Leontopithecus* Lesson, 1840 (Callitrichidae, Primates). *Primates*, 38:101-108, 1997a.

Burity C.H.F, Mandarim-de-Lacerda C.A. & Pissinatti A. Sexual dimorphism in *Leontopithecus* Lesson, 1840 (Callitrichidae, Primates); multivariate analysis of cranial measurements. *Rev. Bras. Biol*., 57:231-237, 1997b.

Burity C.H.F., Mandarim-de-Lacerda C.A. & Pissinatti A. Cranial and mandibular morphometry in *Leontopithecus* Lesson, 1840 (Callitrichidae, Primates). *Am. J. Primatol.,* 48:185-196, 1999.

Clutton-Brock T.H. & Harvey P.H. 1977. Primate ecology and social organization. *J. Zool*., 183:1-39.

Coimbra-Filho A.F. Sistemática, distribuição geográfica e situação atual dos símios brasileiros (Platyrrhini-Primates). *Rev. Bras. Biol*., 50:1063-1079, 1990.

Coimbra-Filho A.F., Silva R.R. & Pissinatti A. 1981. Sobre a dieta de Callitrichidae em cativeiro (The diet of Callitrichidae in captivity). *Rev. Biot.*, 1:83-93.

Darwin C. *The descent of man and selection in relation to sex*. London, JohnMurray, 1871. (Disponible on: http://darwin-online.org.uk/EditorialIntroductions/Freeman_The Descentof Man.html)

Dietz J.M., Baker A.J. & Miglioretti D. Seasonal variation in reproduction, juvenile growth, and adult body mass in Golden Lion Tamarins (*Leontopithecus rosalia*). *Am. J. Primatol*., 34:115-132, 1994.

Ferrari S.F. & Lopes M.A. 1992. A new species of marmoset, genus *Callithrix* Erxleben, 1777 (Callitrichidae, Primates), from western Brazilian Amazonian. *Goeldiana: Zoologia*, 12:1-13.

Ford S.M. & Davis L.C. Systematics and body size: implications for feeding adaptations in New World monkeys. *Am. J. Phys. Anthropol*., 88:415-468 1992.

Garber P.A. & Leigh S.R. Ontogenetic variation in small-bodied New World primates: implications for patterns of reproduction and infant care. *Folia Primatol.*, 68:1-22, 1997.

Hershkovitz P. *Living New World Monkeys (Platyrrhini) with an introduction to Primates*. University of Chicago Press, Chicago, 1977. 1132p.

Hill W.C.O. *Primates. Comparative anatomy and taxonomy* vol. III Pithecoidea. University Press, Edinburgh, 1957. 376p.

Holden C. & MACE R. Sexual dimorphism in stature and women's work: A phylogenetic cross-cultural analysis. *Am. J. Phys. Anthropol*., 110:27-45, 1999.

IUCN. 1996. Red list of threatened animals. The World Conservation Union Gland, IUCN, Gland Switzerland. Disponible on: <http://www.redlist.org>. Acess on: May, 2010.

Kleiman D.G. *Leontopithecus rosalia*. Mamm. Spec., 148: -7, 1981.

Leigh S.R. Patterns of variation in the ontogeny of primate body size dimorphism. *J. Hum. Evol*., 23:27-50, 1992.

Leigh S.R. & Shea B.T. Ontogeny and evolution of adult body size dimorphism in apes. *Am. J. Primatol*., 36:37-60, 1995.

Lemos de Sá R.M. & Glander K.E. Capture techniques and morphometrics for the woolly spider monkey, or muriqui (*Brachyteles arachnoids*, E. Geoffroy 1806). *Am. J. Primatol*., 29:145-153, 1993.

Leutenegger W. & Cheverud J.M. Sexual dimorphism in primates: the effects of size, p.33-50. In: Jungers W.L. (Ed.), *Size and scaling in primate biology*. Plenum Press, New York, 1985.

Leutenegger W. & Larson S. Sexual dimorphism in the postcranial skeleton of new world primates. *Folia Primatol*., 44:82-95, 1985.

Lockwood CA. Sexual dimorphism in the face of *Australopithecus africanus*. Am. J. Phys. Anthropol., 108:97-127, 1999.

Lorini M.L. & Persson V.G. Nova espécie de *Leontopithecus* Lesson, 1840, do Sul do Brasil (Primates, Callitrichidae). *Bol. Mus. Nac. N. S. Zool*., 338:1-14, 1990.

Mittermeier R.A., Schwarz M. & Ayres J.M. A new species of marmoset, genus *Callithrix* Erxleben, 1777 (Callitrichidae, Primates), from the Rio Maués Region, State of Amazonas, Central Brazilian Amazonia. *Goeldiana: Zoologia*, 14:1-17, 1992.

Oxnard C.E. Sexual dimorphism in the overall proportions of primates. *Am. J. Primatol*., 4:1-22, 1983.

Peres C.A. Which are the largest New World monkeys? *J. Hum. Evol*., 26:245-249, 1994.

Pissinatti A., Silva Jr E.C., Coimbra-Filho A.F., Bertolazzo W. & Cruz J.B. Sexual dimorphism of the pelvis in *Leontopithecus* (Lesson, 1840). *Folia Primatol*., 58:204-209, 1992.

Queiroz H.L. A new species of capuchin monkey, genus *Cebus* Erxleben, 1777 (Cebidae, Primates), from Eastern Brazilian Amazonia. *Goeldiana: Zoologia*, 15:1-13, 1992.

Roosmalen M.G.M., Van-Roosmalen T., Mittermeier R.A. & Fonseca G.A.B. A new and distinctive species of marmoset, (Callitrichidae, Primates), from the lower Rio Aripuanã, State of Amazonas, Central Brazilian Amazonia. *Goeldiana: Zoologia*, 22:1-13, 1998.

Rosenberger A.L. & Coimbra-Filho A.F. Morphology, taxonomic status and affinities of the Lion Tamarins, *Leontopithecus* (Callitrichinae, Cebidae). *Folia Primatol*., 42:149-179, 1984.

Rylands A.B., Coimbra-Filho A.F. & Mittermeier R.A. Systematics, geographic distribution, and some notes on the conservation status of the Callitrichidae, p.11-77. In: Rylands A.B. (Ed), *Marmosets and Tamarins. Systematics, Behaviour and Ecology*. Oxford University Press, Oxford, 1993.

Schultz A.H. The technique of measuring the outer body of human fetuses and of primates in general. *Contrib. Embriol*., 213-257, 1929.

Schultz AH. Post embryonic age changes. *Primatology*, 1:887-964, 1956.

Selander R.K. Sexual selection and sexual dimorphism in birds, p.180-230. In: Campbell B. (Ed), *Sexual selection of descent of man, 1871-1971*. Aldine, Chicago, 1972.

Smith RJ. Sexual dimorphism in *Ateles paniscus* body mass. *J. Hum. Evol*., 31:69-73, 1996.

Sokal R.R. & Rohlf F.J. Biometry. *The principles and practice of statistics in biological research*. New York, WH Freeman and Company, 1995. 887p.

Taylor AB. Effects of the ontogeny and sexual dimorphism on scapula morphology in the mountain gorilla (*Gorilla gorilla beringei*). *Am. J. Phys. Anthropol*., 98:431-445, 1995.

Walvath D.E. & Glantz M.M. Sexual dimorphism in the pelvic midplane and its relationship to Neandertal reproductive patterns. *Am. J. Phys. Anthropol*., 100:89-100, 1996.

Zar J.H. *Biostatistical Analysis*. Englewood, Prentice Hall, 1984. 929p.