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Morphological data of pygmy lorises (*Nycticebus pygmaeus*)

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Summary

The identification of the pygmy lorises *Nycticebus pygmaeus* appears to be still problematic. Sympatric occurrence and overlapping body mass ranges in obese or underweight individuals suggests that body mass data alone do not allow for species identification. Fur coloration has been found to be subject to seasonal changes and thus can also be misinterpreted. The paper looks into body measurements, potential sexual dimorphism of these measurements and their suitability for species identification.

Pygmy lorises can be best identified by taking a set of body measurements. Head-body length, taken from the top of the head to the base of the tail, of *Nycticebus pygmaeus* measures between 195 and 230 mm in adult animals. The average ear length for the pygmy loris is 23 mm and the average tail length is 18 mm. Ear length and tail length are not species specific and can only be assessed relative to the head-body length. Foot length should always be measured, since it is very consistent for the species and on average is 45 mm. Foot span, hand span and hand length should also be included.

Một số kết quả nghiên cứu hình thái của loài Culi nhỏ (*Nycticebus pygmaeus*)

Tóm tắt

Việc nhận dạng loài culi nhỏ *Nycticebus pygmaeus* vẫn là một vấn đề khó khăn và cần được nghiên cứu. Do loài culi nhỏ có một số khu vực phân bố trùng lặp với loài culi lớn, đồng thời trọng lượng của những cá thể riêng biệt của 2 loài có thể bằng nhau phụ thuộc vào thể trạng và từng giai đoạn phát triển của chúng. Do đó không thể chỉ dùng yếu tố trọng lượng để nhận dạng loài. Mặt khác, màu sắc lông của loài cũng thay đổi theo mùa dẫn đến những nhầm lẫn khi nhận dạng. Nghiên cứu này tìm hiểu về những số đo đặc trưng trên cơ thể loài culi, sự khác nhau do giới tính và khả năng dùng để nhận dạng loài.

Đối với loài culi nhỏ, phương pháp dùng các số đo này có thể là phương pháp tốt nhất. Chiều dài thân được đo từ đỉnh đầu đến gốc đuôi. Số đo chuẩn của cá thể trưởng thành từ 195 mm đến 230 mm. Trung bình chiều dài tai là 23 mm và dài đuôi là 18 mm. Tuy chiều dài tai và đuôi không phải là chỉ số đặc trưng của loài tuy nhiên có thể xem xét trong tương quan với chiều dài thân. Chiều dài của chi sau rất đặc trưng cho loài với kích thước trung bình là 45 mm. Độ rộng của chi sau, chi trước và chiều dài của chi trước cũng cần được xác định.

Introduction

As the name suggests the pygmy loris *Nycticebus pygmaeus* is distinguished from other Southeast Asian loris species mainly by its small size. The type specimen is described as weighing 377 g with a head-body length of 286 mm (Bonhote, 1907).

However, identification of the species can be problematic, as throughout its range east of the Mekong River in Vietnam, eastern Cambodia, Laos, and southernmost China (Streicher, 2004) the pygmy loris occurs sympatrically with the Bengal slow loris (*Nycticebus bengalensis*).

There is still uncertainty how to differentiate the two species, which is further complicated by the claimed existence of a third loris species *Nycticebus intermedius* (Dao Van Tien, 1960). But the latter species appears to be based on a misidentified *Nycticebus pygmaeus* (Groves, 1971; 1998; 2001; Streicher, 2004).

Discussions about the size of lorises are often primarily based on body mass and not actually on size, especially for live animals. Size and body mass usually are related with larger animals also having higher body masses. In the field it is obviously easier to estimate the body mass than the head-body length of the animals. Consequently, reports often use body mass as the characteristic to distinguish the pygmy loris from other loris' species.

Average body mass values for pygmy lorises are currently given as 420 g for males and 428 g for females (Streicher, 2005), whereas body mass values of Bengal slow lorises range between 1,100 and 1,400 g (Nekaris *et al*., 2006) and can in exceptions be as high as 2,000 g (Pro Wildlife unpubl., 2006).

Lorises of this size are unlikely to be mistaken for individuals of *Nycticebus pygmaeus*. The bodyweight values of the pygmy lorises in such cases differ to a degree, which allows easy species identification. But in the majority of cases distinction is less straightforward.

First of all, bodyweight has been found to be very variable in pygmy lorises and appears to be subject to a significant seasonal change, as in certain times of the year pygmy lorises might weigh up to 700 g (Streicher, 2004). On the other hand, trade confiscated individuals of the larger loris' species might be considerably emaciated, and weigh as little as 500-700 g (Streicher, pers. observ.).

Due to this variability bodyweight cannot serve as a reliable source of information for the taxonomic identification of the animals (Streicher, 2004).

To determine phenotypic characteristics suitable to distinguish the pygmy loris from other loris' taxa, a study on the fur colouration of pygmy lorises was conducted at the EPRC between 1999 and 2002. This study showed that the fur colouration also undergoes seasonal changes and thus cannot serve as a readily identifiable trait for the species' identification (Streicher, 2003).

So neither bodyweight nor fur colouration alone are sufficiently distinctive characteristics for species identification and field researchers often either misidentify species or indicate uncertainty about the actual loris species encountered (Vu Ngoc Thanh, pers. com). And until now, field researchers indicate uncertainty about the actual loris species encountered, and there is still widespread confusion on the identification of lorises in the field (Vu Ngoc Thanh, pers. com).

Exact species identification is essential for taxonomic classification as well as conservation efforts. Lack of accurate data makes it impossible to assess the conservation status of the species correctly.

It has been suggested that standard measuring methods should be followed (Streicher *et al*., in print, Streicher, 2004, Nekaris, 2006) to allow comparison between the gathered data and thus clarify the taxonomy of the species.

Until recently only few data were available on pygmy lorises actual body size (Groves, in litt.; Corbet & Hill, 1992; Bonhote, 1907) and these data were surprisingly variable and partly overlapping with size ranges for other loris species, in particular the sympatric Bengal slow loris. Also sexual dimorphism has been suggested for bodyweight and size (Groves, 2004; Kappeler, 1991; Nekaris *et al*., 2006).

The following data represent the first comprehensive overview about the body measurements of the pygmy lorises and provide standard values to facilitate further species identification.

Materials and Methods

27 adult pygmy lorises have been measured of which 15 were female and 12 were male. Lorises usually reach the bodyweight of an adult individual within less than a year, but under unfavourable conditions might not develop full body size for a considerably longer time (Ratajszczak, 1998). Therefore animals were only measured once they were at least two years of age. Pygmy lorises are strictly seasonal and all infants are born in February and March (Streicher, 2004) which facilitates age estimates.

The measurements were taken under anaesthesia. Ketamine has been used at an average

dosage of 27 mg/kg bodyweight. After intramuscular injection an anaesthetic effect is achieved after about 5 minutes, and anaesthesia lasts on average about 32 minutes (Streicher, 2004).

The measurements were taken as suggested by Streicher *et al.* (in print): Head-body length, upper arm length, forearm length, thigh length, knee height, hand length, hand span, foot length, foot span, tail length, maximum head length and ear length.

Head-body length was measured from the top of the head to the base of the tail.

Females and males were compared for each of the measurements, and statistical comparisons involved the use of both nonparametric and parametric analyses. These include Student's t and Mann-Whitney U tests, both analysed at P=0.05. Based on personal observations, it was hypothesised that there are no significant differences between the sexes, however all tests were two-tailed. Similarly, parametric analyses do not assume equal variances between the sexes. Nonparametric tests were performed because a general lack of morphometric data for *N. pygmaeus* cautions against assuming a normal distribution in measurement variables. Descriptive and comparative statistics were analysed with SPSS 11.0.

Results

A descriptive statistical summary for all variables measured is presented in Table 1. A few selective variables, which are supposed to be of importance in species identification are further explored and illustrated in the figures below.

Table 1. Student's *t*-test and Mann-Whitney U summary for thigh length of pygmy lorises.
The comparisons use P=0.05. Student's *t*-tests present degree of freedom, t_{crit} = critical values, and t_{obt} = obtained values. Values for t_{crit} are directional or one-tailed, and degrees of freedom do not assume equal variances. Mann-Whitney U tests present N_1 and N_2, the Z critical value for one-tailed tests and the obtained Z values.

Measurement Variable	Statistical comparison				
	Student's t-test summary				
				P-value	
	Degrees of Freedom	t_{crit}	t_{obt}	One-tail	Two-tail
Thigh length	25	1.71	2.55	0.03	0.05
	Mann-Whitney U summary				
	N1	N2	$Z_{crit.}$	$Z_{obt.}$	
Thigh length	15	12	1.65	2.22	

Table 2. Descriptive statistics for body measurements in *Nycticebus pygmaeus*.
All measures reported in mm, and sex is not differentiated.

Measurement variable	N of cases	Mean	Median	Standard Deviation	Coefficient of Variation
Head-body length	26	217	220	9.2	23.5
Upper arm length	27	61.2	62	4.6	13.3
Foream length	27	63.5	63	3.7	17.2
Thigh length	27	65.0	65	3.8	16.9
Knee height	27	74.9	75	4.7	16.0
Hand length	27	36.9	36	3.3	11.2
Hand span	27	53.1	53	3.5	15.1
Foot length	27	45.1	44	5.4	8.4
Foot span	27	64.7	65	3.5	18.3
Ear length	26	23.1	23	3.2	7.2
Maximum head length	25	50.6	50	4.3	11.8
Tail length	26	18.0	18	2.7	6.8

Head-body length

The average head-body length for adult female and male pygmy lorises is 216.3 and 217.9 mm, respectively. The standard deviation for females is 9.9 mm and for males 8.5 mm. The value range for females is between 195 and 230mm and for males between 200 and 230 mm. There is no significant difference between the sexes, and the mean head-body length for all animals averages 217.0 mm with a standard deviation of only 9.2 mm (Fig. 1 and 2).

Ear length

The average ear length for adult pygmy lorises is 23.8 mm in females and 22.2 mm in males. There is no significant difference between the sexes and the mean for all sexes is 23.1 mm with a standard deviation of 3.2 mm. Ear length varies from 14-32 mm in this sample (Fig. 3).

Fig. 1. Head-body length bar graph for the total *N. pygmaeus* samples, illustrating the frequency of occurrence based on set bin lengths. X-axis shows the highest value in the bin, with a set length of 5 mm. Each individual measure within the 5mm bin range contributes to the frequency of the Y-axis.

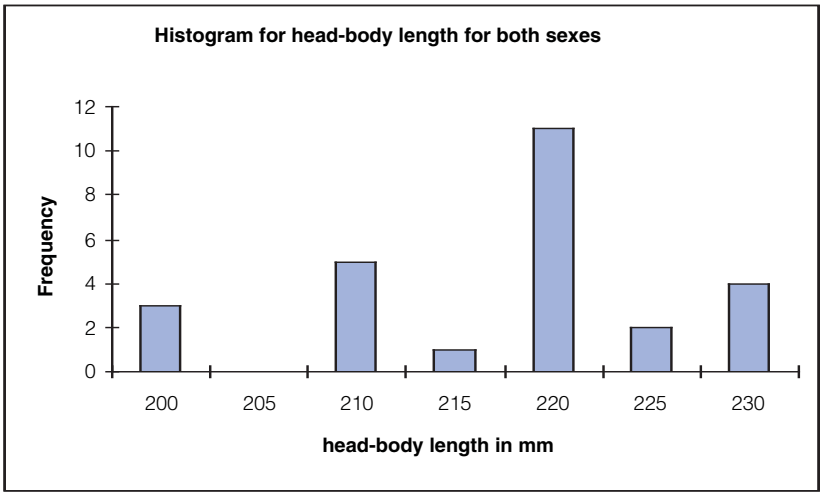
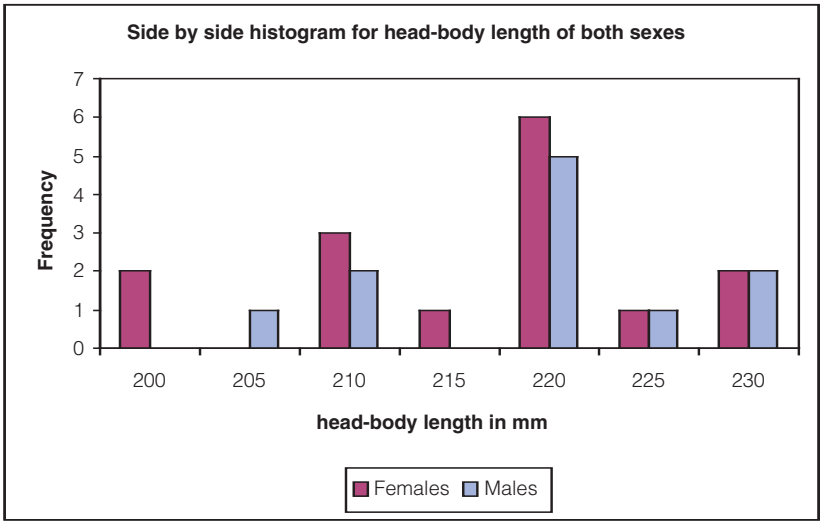


Fig. 2. Head-body length bar graph for both sexes, illustrating the frequency of occurrence based on set bin lengths. X-axis shows the highest value in the bin, with a set length of 5 mm. Each individual measure within the 5 mm bin range contributes to the frequency of the Y-axis.



Tail length

The mean values for tail length in female pygmy lorises are 18.0 mm and 17.4 mm in males. There is no significant difference between sexes and the mean for all sexes is 18.0 mm with a standard deviation of 2.7 mm. The tail length varies between 14 and 26 mm (Fig. 4).

Intermembral index

The intermembral index for the pygmy loris does not differ significantly between males and females, and is 89.3 for both sexes with a standard deviation of 5.0. The lowest value is only 76.0 and the highest value 99.2. The intermembral index was calculated with knee height, thigh length, forearm and upper arm length. The average is comparable to other members of Lorisidae, which general show little difference in intermembral index.

Fig. 3. Ear length bar graph for the total *N. pygmaeus* samples, illustrating the frequency of occurrence based on set bin lengths. X-axis shows the highest value in the bin, with a set length of 2 mm. Each individual measure within the 2 mm bin range contributes to the frequency of the Y-axis.

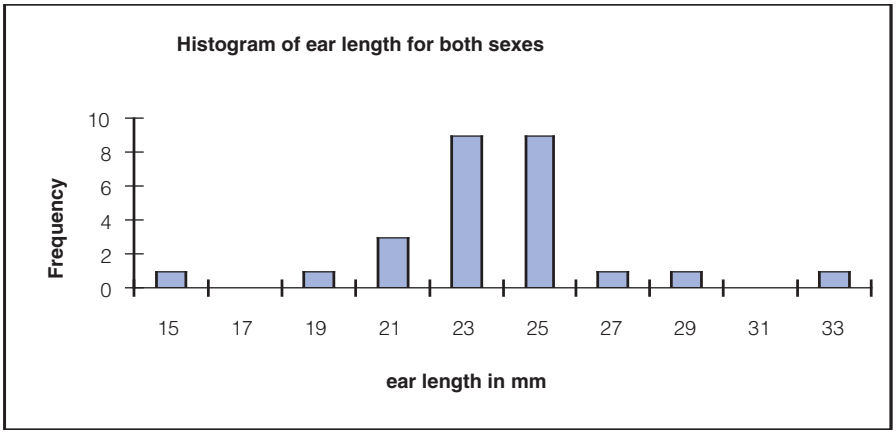


Fig. 4. Tail length bar graph of histogram for the total *N. pygmaeus* sample, illustrating the frequency of occurrence based on set bin lengths. X-axis shows the highest value in the bin, with a set length of 2 mm. Each individual measure within the 2 mm bin range contributes to the frequency of the Y-axis.

Comparative statistics

Significant differences were not anticipated between the sexes. And indeed statistical analyses, both parametric and nonparametric, reveal that all of the measurement variables were statistically insignificant in comparison, with the exception of thigh length. Females were found to have significantly longer thigh length than males using Student's t-test and Mann-Whitney U. The obtained t-value of 2.55 at 25 degrees of freedom, and z-value of 2.22, exceed the critical values for significance at P=0.05. However, this does not affect the intermembral index values between the sexes, which cautions against the significance of this difference. For females, thigh length averaged 66.2 mm with a standard deviation of 4.1 mm. In males the mean thigh length was 63.4 mm with a standard deviation of 2.9 mm. The difference is created by a few high outliers in the female data set, which suggests rather a measuring mistake than a valid difference. In general females and males do not differ significantly in this study.

Discussion

The main focus of the paper is to give a set of standard mean values for measurements for the pygmy loris, which can facilitate identification of species. Furthermore this paper aims to identify measurements, which are relatively consistent for the species and can easily be reproduced by different observers and can therefore serve as a species specific characteristic.

Probably the most important measurement is the head-body length. It is not only the measurement most often used for taxonomic descriptions, but also the measurement, which is most readily taken. Unfortunately it is also a measurement, where there is no general agreement how it has to be taken. I have earlier described, how it was measured in the course of these data collection, but it might be assessed different by different researchers. Head-body length might be measured in a fully stretched out animal from the root of the tail to the tip of the nose. This is commonly done on museum specimen and when skins are measured. However head-body length of living specimen is often taken from the top of the head to the root of the tail. The two values differ of course considerably, in adult pygmy lorises by about 50 mm. Consequently head-body length values can not be compared as long as the measuring method is not known. Currently available measurements for pygmy lorises head-body length are given as follows. 286 +/-18 mm (Bonhote, 1907), 230-287 mm (Groves, in litt.), 210-290 mm (Corbet & Hill, 1992). The high values can easily be explained under the assumption, that these data are based predominantly on dead individuals or skins, which have been measured fully stretched out.

If a measuring standard for head-body length can be generally accepted for this taxon, this measure has a high descriptive value. However in the study head-body length has been found to be the least consistent of all measurements taken with a high coefficient of variation. But still it appears sufficiently suitable as species specific characteristic in particular in its exclusivity. Animals with a head-body length of more than 230 mm are most likely not *Nycticebus pygmaeus*. However animals measuring 230 mm head-body length or less are not necessarily *Nycticebus pygmaeus* but could also be subadult representatives of another loris species. It is important to assess the age of the animal by other ways for example by dentition or vocalization (Lorises in the first two years of their life do also often utter a chirp or chitter, when being handled. Chirping or chittering animals should not be considered adult. (Streicher, pers. observ.)

Ear length and tail length are additional measurements, which are readily noted by researchers because they are obvious, visible characters. They are both very consistent for the species and have a low coefficient of variation. But preliminary data suggest that both ear and tail length values for adult *Nycticebus bengalensis* are nearly equal in range than for pygmy lorises and can therefore not serve as species specific characteristics. Ear length and tail length can only serve for species identification in combination with head-body length.

One more measure appears remarkable. Next to the ear and tail length foot length appears to be the measurement, with the lowest coefficient of variation. Foot length is also a measurement, where there is little chance for variation by different observers and a high consistency can be expected if data are collected. Foot length should therefore been generally measured if lorises are to be identified. A foot length of 45 mm suggests that the measured animal is a pygmy loris.

Foot span, hand length and hand span are as well easily measurable values. The coefficients of variation are higher than for foot length but variation was limited to a very narrow range.

Other measures are less useful for general species identification, because they are more difficult to take and there might be considerable differences between researcher's methods. And they can not be taken from skins or museum specimen.

However all morphometric data might give insights into the species' ecology. Is there any particular meaning for example to the hand and foot span of the species? Does this reflect in any way the living environment of the pygmy lorises? Is there any correlation between these measures and the diameter of branches preferably used for locomotion? And if so how different is it from the sympatric Bengal slow loris? After all these two loris species are the only lorisids that live in sympatry. So they must occupy different ecological niches. An obvious one would be the preferred tree level for foraging. Is this reflected in their morphology?

Within the lorisidae the pygmy lorises have the highest intermembral index and are the least hindlimb dominant species. This identifies them as active quadrupeds.

Conclusions

1. Pygmy lorises can be best identified by taking a set of body measurements.
2. Head-body length, taken from the top of the head to the base of the tail, of *Nycticebus pygmaeus* measures between 195 and 230 mm in adult animals.
3. The average ear length for the pygmy loris is 23 mm and the average tail length is 18 mm. Ear length and tail length are not species specific and can only be assessed relative to the head-body length.
4. Foot length should always be measured, since it is very consistent for the species and on average is 45 mm. Foot span, hand span and hand length should also be included.

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