# The Primate Ear Bone Collection of the University of Turin: Revision and Improvement

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## Introduction

In 1878, Alban H.G. Doran (1849-1927) first published the most comprehensive study on comparative anatomy of the auditory ossicles in Mammals, including Primates. This author illustrated the features of those *ossicula*, with the purpose of demonstrating if and how far the ear bones can retrace the systematic of this class.
Since the '60s, in addition to the monographic work on the comparative anatomy of middle and inner ear of Werner (1960), Masali (1964, 1971) and Masali and Chiarelli (1965a,b) conduced morphometric studies on human and non-human Primate ear bones, confirming their taxonomic and systematic utility. Further researches have focused on the possibility of characterizing ancient human populations with the help of such cranial structures (Siori *et al.*, 1995; Masali and Micheletti Cremasco, 2006). Ear ossicles have also been important sources of palaeobiological information about the evolutionary history of Primates and Man, when analyzed together with the other auditory structures and their biomechanical functions (Arensburg and Nathan, 1972; Rak and Clarke, 1979; Masali *et al.*, 1992; De Ruiter *et al.*, 2002; Moggi-Cecchi *et al.*, 2002). It is evident, therefore, the importance of such cranial elements and their unfortunately scarce collections.
The main contribution of this work is the improvement of the collection of Primate ear bones stored in the University of Turin. To this end, the existing material has been reorganized, revised and supplemented with new specimens and *taxa*. Today, the overall picture of the diagnostic features, at generic and/or specific level, as well as the data-base of metric characters are more complete. The rearrangement of the collection has also offered the possibility of identifying some pathological ossicles that are currently under study.

## Materials and Methods

The primatological ear bone series has been collected since the '60s at the Institute of Anthropology of the University of Turin, and now is kept in the Life Sciences and Systems Biology Department of the same University. Unfortunately, during these 50 years, several specimens have been lost or broken and this has led to a discrepancy between the current size of the collection and the morphometric data collected.
Given the small size and the fragility of the sample, we have used a stereoscopic microscope equipped with a *camera lucida* for the observation and the reproduction of the ossicles.
The measurements were obtained following the methodology described by Masali (1964), and Quam and Rak (2008) (Fig. 1). For the nomenclature and systematics of the Primates refer to Gippoliti e Visalberghi (2001).

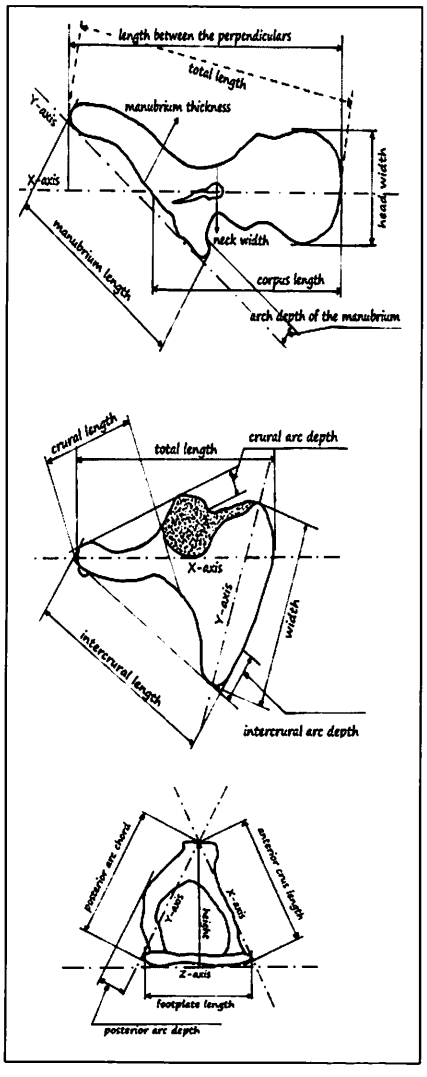


Fig. 1. *Measurements according to Masali (1964), modified.*

| FAMILY | SPECIES | MALLEUS | | INCUS | | STIRRUP | |
|---|---|---|---|---|---|---|---|
| | | right | left | right | left | right | left |
| **Lemuridae** Gray, 1821 | *Eulemur fulvus* | | 1 | | | | 1b |
| | *Lemur catta* | 1b | 3 | | 3 | | 1b |
| **Galagonidae** Gray, 1825 | *Galago sp.* | 1+1b | 2 | 2 | 2 | | 1 |
| **Callithricidae** Thomas, 1903 | *Callimico goeldi* | 1 | | 1pat | 1 | | |
| | *Callithrix jacchus* | 2 | | 1 | | | |
| | *Callithrix sp.* | 1 | 1 | 1pat | 1pat | | |
| | *Leontopithecus rosalia* | 1 | | 1 | | | |
| | *Leontopithecus sp.* | | 1 | | 1 | | |
| **Cebidae** Bonaparte, 1831 | *Alouatta caraya* | 1b | | 1 | 1 | | |
| | *Alouatta seniculus* | 3 | 1 | 1 | 1 | | |
| | *Alouatta palliata* | 1+1b | 1 | 3 | 2+1b | | |
| | *Alouatta sp.* | 1 | 1 | 1 | 2 | 1b | |
| | *Aotus trivirgatus* | 2 | 2 | 2 | 2 | 2b | 1b |
| | *Ateles hybridus* | 1 | 1+1b | 1+1b | 4 | 1 | |
| | *Ateles paniscus* | | | 1 | 1b | | |
| | *Ateles mona* | 1 | | 1 | | | |
| | *Ateles sp.* | 1 | | 1 | 1b | | 1 |
| | *Lagothrix sp.* | | 2 | | 2 | | |
| | *Callicebus donacophilus* | 1 | | 1 | 1 | | |
| | *Callicebus sp.* | | 1 | | | 1b | |
| | *Cebus albifrons* | 4 | 3 | 4 | 5 | 2+2b | 1 |
| | *Cebus capucinus* | 1+1b | 1 | 2 | 2 | | |
| | *Cebus apella* | | 1 | 1+1b | | 1 | |
| | *Cebus sp.* | 2+1b | 2 | 2 | 2 | | 1 |
| | *Saimiri sciureus* | 1 | 1 | 1 | 1 | | |
| | *Saimiri sp.* | 1r | | 1 | | | |
| **Cercopithecidae** Gray, 1821 | *Cercocebus atys* | 1 | 1 | 1 | 1 | | |
| | *Cercopithecus mona* | 1 | | 2 | | 1 | |
| | *Cercopithecus sp.* | 1 | 1 | | 1 | | 1 |
| | *Chlorocebus aethiops* | 1 | 1 | 1 | 1 | | 1b |
| | *Chlorocebus pygerythrus* | 1pat | 1pat | | | | |
| | *Chlorocebus sabaeus* | | | 1+1b | | 1 | |
| | *Macaca fascicularis* | 2+2b | 2+2b | 2+1b | 3 | | |
| | *Macaca mulatta* | 3 | 3 | 1 | 2 | | |
| | *Macaca nemestrina* | 4+1b | 4 | 1 | 1 | | |
| | *Macaca sylvanus* | 3 | 1 | 3 | 1 | | |
| | *Macaca ochreata* | 1 | 1 | 1 | 1 | | |
| | *Macaca sinica* | 2 | 2 | 1 | 2 | | |

| FAMILY | SPECIES | MALLEUS | | INCUS | | STIRRUP | |
|---|---|---|---|---|---|---|---|
| | | right | left | right | left | right | left |
| | *Macaca sp.* | 4 | 3 | 2 | 2 | 2 | 1 |
| | *Mandrillus leucophaeus* | 1 | | | | | |
| | *Papio sp.* | 3 | 6 | 4+1pat | 5 | | |
| | *Colobus guereza* | 2 | 1 | | 1 | | |
| | *Colobus polykomos* | | 1 | | | 1 | |
| | *Nasalis larvatus* | 1 | 1b | 1 | | | |
| | *Procolobus badius* | 1b | 1 | 1 | 1 | | |
| | *Semnopithecus entellus* | 2 | 2 | 2pat | 2pat | 1 | |
| | *Semnopithecus sp.* | | 1 | | | | |
| | *Trachypithecus obscurus* | | 1b | | 1 | | |
| **Hylobathidae** Gray, 1871 | *Hylobates moloch* | 2 | 1 | 1b | 1 | | |
| | *Hylobates syndactylus* | 2 | 1 | 2 | 1 | | 1 |
| | *Hylobates sp.* | 1 | | | 1 | | |
| **Hominidae** Gray, 1825 | *Gorilla gorilla* | 1 | | | | | |
| | *Pan troglodytes* | 1 | | | | | |
| **Cercopithecidae/Hylobatidae N.D.** | | 20+1b | 14+1b | 16 | 10+1pat | 2 | 2 |
| | | 97 | 79 | 78 | 75 | 18 | 13 |
| | **Total for each bone** | **176** | | **153** | | **31** | |

Tab. 1. *The consistency of the Primate ear bone collection (pat=pathological; b=broken).*

## Results

1) *The consistency of the collection.* The consistency of the ear bone collection is shown in Tab. 1. The total number has been recorded for each ossicle. The ear bones belong to 52 species of 28 genera, including *Lemuridae* (2), *Galagonidae* (1), *Callithricidae* (5), *Cebidae* (17), *Cercopithecidae* (21), *Hylobatidae* (3) and *Hominidae* (3). The ossicles that in the historical collection were generically referred as "*Scimmia*" are still subject to revision, and therefore counted separately.
2) *Criticalities of the methodologies and additional measurements.* The most common morphometric techniques show criticalities when applied to the Primate ear bones, particularly of Platyrrhines and Prosimians. Specifically, the *length of the manubrium* and *corpus length* of the malleus required a slight effort of interpretation both because of the lack of the short apophysis and the particular alignment of the head and body. Similarly, due to the noteworthy morphological variability of the articular surface of the incus, it was difficult to identify the landmarks to trace the *y-axis* and thus measure the *incus width*. Some measurements carried out on human bones were considered useful also for non-human Primates: *manubrium mediolateral thickness* and *neck width* of the malleus; *articular facet height* of the incus; *total height* of the stapes and *depth* of its footplate. These new measurements are shown in Fig. 1.
3) *Diagnostic and taxonomy.* An important result of this work relates to the diagnostic capabilities of the auditory ossicles to various ranks of the taxonomy. Unlike what was stated in the literature, the malleus and the incus were indeed useful in the distinction of Primates not only at the level of infraorder but also of genus. The detailed description of the diagnostic characters will be subject to further future studies.

## Future developments

Future developments of this research could be: redefinition of some measurements for the application of metrical method to Prosimians and Platyrrhines; definition, description and statistical analyses of morphometric data for taxonomic utility; study and pathological evaluations of injuries and/or alterations in shape and size.

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