

= Plesiorcyteropus =

Plesiorcyteropus , also known as the bibymalagasy or Malagasy aardvark , is a recently extinct eutherian mammalian genus from Madagascar . Upon its description in 1895 , it was classified with the aardvark , but more recent studies have found little evidence to link it to aardvarks or any other order of mammals . Therefore , it is now placed in its own order , Bibymalagasia , which may be part of Afrotheria . Molecular evidence suggests that it is related to the tenrecs . Two species are currently recognized , the larger *P. madagascariensis* and the smaller *P. germainepetterae* . They probably overlapped in distribution , as subfossil remains of both species have been found in the same site .

Knowledge of the skeletal anatomy is limited , as only limb and partial pelvis and skull bones have been recovered to date . Plesiorcyteropus was probably a digging animal that fed on insects such as termites and ants . It also shows adaptations for climbing and sitting . Estimates of its mass range from 6 to 18 kilograms (13 to 40 lb) . When and why it became extinct remains unknown . One bone has been radiocarbon dated to 200 BCE ; forest destruction by humans may have contributed to its extinction .

= = Taxonomy = =

= = = Identification and species = = =

French naturalist Henri Filhol first described *Plesiorcyteropus madagascariensis* in 1895 on the basis of a partial skull found at the cave of Belo . His description was vague even by 19th @-@ century standards , but he placed the animal close to the aardvark (*Orycteropus*) . The generic name combines Ancient Greek *plesio-* " near " with *Orycteropus* , the genus of the aardvark , and the specific name refers to Madagascar . Charles Lamberton , who had access to a larger sample for his 1946 review of the genus , noted substantial variation , but did not attempt to differentiate multiple species . In 1994 , Ross MacPhee again reviewed *Plesiorcyteropus* and was able to separate two species , the larger *P. madagascariensis* and a new , smaller species that he named *Plesiorcyteropus germainepetterae* after scientist Germaine Petter . The two species differ in a number of morphological characters in addition to size .

Remains of *Plesiorcyteropus* have been misidentified as rodents and primates . Charles Immanuel Forsyth Major described *Myoryctes rapeto* in 1908 as a " giant subfossil rat " on the basis of two innominate bones (pelvic bones) . The generic name was replaced by *Majoria* in 1915 , because *Myoryctes* was preoccupied by the name of a nematode worm . However , according to MacPhee , innominates of *Majoria* are identical to those assigned to *Plesiorcyteropus* . Guillaume Grandidier assigned a well @-@ preserved femur (upper leg bone) to a gigantic relative of the living *votso* (*Hypogeomys antimena*) , a large rodent , which he described as *Hypogeomys boulei* . Lamberton identified this femur as *Plesiorcyteropus* and MacPhee concurred . Remains of both *Majoria rapeto* and *Hypogeomys boulei* fall at the upper end of the size range of the genus , indicating that they are referable to *P. madagascariensis* . Another *Plesiorcyteropus* innominate was mistakenly assigned to *Daubentonia robusta* , the extinct giant aye @-@ aye , and other material has been misidentified as of a dwarf lemur (*Cheirogaleus*) .

= = = Relationships = = =

Filhol had classified *Plesiorcyteropus* as close to the aardvark on the basis of morphological similarities . In his 1946 review , Charles Lamberton was unable to provide a definitive allocation , confused by the various similarities he saw with aardvarks , pangolins , armadillos , and anteaters . He believed it was most likely a primitive , isolated member of " Edentata " , a group in which he included aardvarks , pangolins , and *Xenarthra* (sloths , armadillos , and anteaters) . He rejected some alternatives , such as a close affinity to aardvarks or the possibility that the material assigned

to Plesiorcyteropus did not in fact represent a single animal . Bryan Patterson , who revised tubulidentates (the order of which the aardvark is the only living representative) in the 1970s , accepted Plesiorcyteropus as a member of the group , dismissing many similarities with pangolins and other animals as convergent . However , he placed it as the only member of its own subfamily Plesiorcyteropodinae in view of its differences from other tubulidentates (subfamily Orycteropodinae) , and hypothesized that it arrived on Madagascar in the Eocene , at the same time as the lemurs . Johannes Thewissen , who critiqued some aspects of Patterson 's classification in 1985 , also accepted Plesiorcyteropus as a tubulidentate without comment .

Reviewing Patterson 's and Thewissen 's contributions in 1994 , Ross MacPhee found little support for the classification of Plesiorcyteropus as a tubulidentate in their data . MacPhee used a cladistic analysis of eutherians to ascertain the relationships of the genus , but found that while different analytic variants supported different affinities ? with aardvarks , hyraxes , ungulates (hooved mammals) , and even lipotyphlans (shrews , moles , hedgehogs , and allies) ? there was no compelling evidence linking it to any other eutherian group . Therefore , he erected a separate order for Plesiorcyteropus , named Bibymalagasia , arguing that it would be unacceptable to leave a Recent eutherian unassigned to any order and that discovery of more material , or further analysis , was unlikely to demonstrate close affinities of Plesiorcyteropus with any other order . He considered it possible but unlikely that a few fossil taxa , such as Palaeorycteropus and Leptomanis from the Paleogene of France , would eventually be found to be bibymalagasians . Various analyses published by Robert Asher and colleagues in 2003 , 2005 , and 2007 , based on morphology combined with DNA sequence data in some analyses , produced different estimates of the relationships of Plesiorcyteropus , some placing it within Afrotheria close to aardvarks or Afrosoricida , but others supporting a relationship with the hedgehog Erinaceus . A 2004 morphological study by Inés Horowitz , focusing on extinct South American ungulates (such as Notoungulata and Litopterna) , placed Plesiorcyteropus among tubulidentates and closer to the extinct aardvark relative Myorycteropus than to Orycteropus . A 2013 study by Michael Buckley examined preserved collagen sequences in Plesiorcyteropus bones . Buckley found that the animal was closely related to the tenrecs , a group of insectivorous mammals native to Madagascar , and suggested that it should be placed in the order Tenrecoidea with the tenrecs and golden moles .

= = = Common names = = =

" Madagascar aardvark " has been used as a common name for Plesiorcyteropus , but MacPhee considered it inappropriate because the animal may not be related to aardvarks . Instead , he proposed " bibymalagasy " as a common name , a manufactured Malagasy word meaning " Malagasy animal " .

= = Description = =

Plesiorcyteropus is known from a number of subfossil bones , comparable to coverage of some of the poorly known subfossil lemurs , such as Daubentonia robusta . The material includes several skulls , all of which are missing the facial bones , complete long bones such as the femur and humerus (upper arm bone) , and other bones , but some elements are still unknown , including most of the skeleton of the hand and foot . There is little reason to assume it was similar in general form to the aardvark . No teeth or jaws referable to Plesiorcyteropus have been found , and it is generally assumed that the animal was toothless .

Based on the area of a femur cross @-@ section , MacPhee calculated estimates of body mass . The lowest estimate , based on comparative data from armadillos and pangolins , was 6 kilograms (13 lb) for the smallest femur he had (referable to P. germainepetterae) and the highest estimate , based on comparative data from caviomorph rodents , was 18 kilograms (40 lb) for the largest available femur (P. madagascariensis) ; estimates from primates fell between those extremes . MacPhee favored the lower estimates , because those were based on armadillos , which have femora similar to those of Plesiorcyteropus . On the other hand , the caviomorph model produced a

better estimate of brain size in *Plesiorycteropus* .

== Skull ==

There are four known skulls (three of *P. madagascariensis* and one of *P. germainepetterae*) , each of which is damaged . All are missing the front (rostral) part , and three are broken at about the same place (at the paranasal cavities , at the front of the braincase) , suggesting that the front part of the skull was thinner and more fragile than the back part , which consists of thick bones . MacPhee estimated maximum skull length in *P. madagascariensis* at 101 millimetres (4 @. @ 0 in) . The length of the frontal bone averages 35 @. @ 4 millimetres (1 @. @ 39 in) in *P. madagascariensis* and is 29 @. @ 4 millimetres (1 @. @ 16 in) in *P. germainepetterae* .

The robust nasal bones , preserved in a single specimen , are widest at the front , a feature unusual among placentals that is also seen in armadillos , and are also unusually flat . The ethmoid labyrinth , in the nasal cavity , was large , suggesting that *Plesiorycteropus* had a good sense of smell . A much larger part of the nasal septum , which separates the left and right nasal cavities , is ossified than usual in other mammals ; MacPhee could find a similar condition only in sloths , which have a very short nose . The lacrimal bone is relatively large . At it is a single lacrimal canal , which opens near the suture between the frontal and lacrimal bones , like in lipotyphlans . There is a small tubercle (absent in armadillos) near this opening . The orbital cavity , which houses the eyes , is relatively short , similar to the situation in pangolins and armadillos . A distinct tubercle is present on the suture between the frontal and parietal bones in *P. germainepetterae* , but not *P. madagascariensis* . *P. madagascariensis* has a more expansive braincase and a less pronounced narrowing between the orbits . The foramen rotundum , an opening in the bone of the orbit , is present . The optic canal , which houses the nerves leading to the eyes , is narrow , suggesting that the eyes were small , similar to many other tenrecoids . As in pangolins and xenarthrans , little of the squamosal bone can be seen from above . The temporal lines on the braincase , which anchor muscles , are located lower in *P. germainepetterae* . Like in armadillos , the parietals are relatively large . An interparietal bone is present . Unlike in anteaters and pangolins , the occiput (the back of the skull) is flat and vertical . *Plesiorycteropus* lacks notches above the foramen magnum (the opening that connects the brain to the spinal cord) , which are present in armadillos . The nuchal crest , a projection on the occiput , is straight in *P. madagascariensis* , but in *P. germainepetterae* it is interrupted in the middle , similar to the situation in armadillos and hyraxes .

In their descriptions of *Plesiorycteropus* , Lamberton and Patterson posited different interpretations of the location of the mandibular fossa , where the mandible (lower jaw) articulates with the cranium . MacPhee found problems with either interpretation and suggested that the true mandibular fossa was part of the area Lamberton identified as such , at the side of the braincase . The fossa is small and low , suggesting that the animal was not capable of powerful biting . At the back of this fossa is a pseudoglenoid process , which is more prominent in *P. germainepetterae* . In *P. germainepetterae* but not *P. madagascariensis* , a small opening , perhaps the vascular foramen , is present next to the foramen ovale . The petrosal bone forms a relatively large portion of the roof of the tympanic cavity , which houses the middle ear ; parts of the petrosal are more developed in *P. madagascariensis* . Endocasts (casts of the inside of the skull) indicate that the neopallium part of the brain was relatively small .

== Postcranium ==

There are 34 known vertebrae of *Plesiorycteropus* . The animal had at least seven sacral and five or six lumbar vertebrae . A find of associated caudal vertebrae from the base of the tail , which diminish in size only slowly from front to back , suggests that the tail was long . There is no evidence for the additional joints between the vertebrae that are characteristic of xenarthrans . In the seven known thoracic (chest) vertebrae , the articulations with the intervertebral disks are bean @-@ shaped and much wider from side to side than from top to bottom . In the back thoracics and all lumbar , a longitudinal transarcual canal is present in the neural arch .

A scapula (shoulder blade) , only tentatively assigned to *Plesiorhycteropus* , has the acromion , a process , present , but the structure is probably not as large as in armadillos or armadillos . Six humeri have been found ; the bone is robust and an entepicondylar foramen is present in the distal (far) end . There are three examples of the radius , a compact and massive bone in *Plesiorhycteropus* which resembles the pangolin radius . The three known ulnae show that the olecranon process at the proximal (near) end is well @-@ developed , but the distal end is narrow ; the morphology of the bone suggests that the animal was capable of producing much force with its arms .

The innominate is known from seven examples , but most are quite incomplete . It includes a narrow ilium and long ischium . The ischial tuberosity , a narrow rough piece of bone in most placentals , is broad and smooth in *Plesiorhycteropus* . With 17 specimens , the femur is the best represented long bone . It is distinctive in its long neck , similar only to the gymnure *Echinosorex* according to MacPhee . A projection known as the third trochanter is larger in *P. madagascariensis* . The tibia and fibula are extensively fused into a tibiofibula , of which eight examples are known . This bone resembles that of armadillos in the extensive fusion , the compression of the shaft of the tibia , the narrowness of the articulation surface at the distal end , and the broad space between the bones . Unlike in armadillos , the tibia and fibula are not inclined relative to each other , but about parallel . The astragalus , which is known from four examples , is wide and short and contains a uniquely large posteromedial process . Seven metapodials (middle hand or foot bones) are known , rather variable in size , but MacPhee was unable to separate metacarpals (from the hand) and metatarsals (from the foot) . All are rather short and are broad proximally and narrow distally . Among the few known phalanges , the proximal phalange is shorter than the middle one and the distal phalanges are narrow and clawlike .

= = Ecology , behavior , and extinction = =

The forelimbs of *Plesiorhycteropus* show specializations for scratch @-@ digging , in which the forefeet are placed against the substrate , the claws are entered into the substrate , and the forefeet are then drawn back against the body . Other parts of the body also show such specializations , including large hindlimbs and a broad tail . Some aspects of the vertebral column and the pelvis suggest that the animal often assumed an erect , or sitting , posture . The animal may also have been capable of climbing , perhaps in a manner similar to gymnures and shrew tenrecs , which are small @-@ eyed like *Plesiorhycteropus* . It was probably myrmecophagous , eating insects such as ants and termites , but may also have eaten other soft food , and because of its small size probably did not forage in termite mounds , as the armadillo does .

MacPhee had material of *Plesiorhycteropus* from twelve sites in central , western , and southern Madagascar . It and other recently extinct Madagascar mammals may have lived in and near wetlands . *P. madagascariensis* is known from sites throughout this range , but *P. germainepetterae* has only been definitely recorded from the center ; small bones from southern sites may also belong to it . Thus , the two species apparently had widely overlapping ranges .

Little is known about the extinction of *Plesiorhycteropus* , but MacPhee assumed it may have happened around 1000 years ago , when the extinction of the rest of the subfossil fauna of Madagascar is thought to have concluded . Nothing like it was reported by 17th @-@ century European explorers of the island , and one bone has been radiocarbon dated to around 2150 Before Present (200 BCE) . Its extinction is somewhat anomalous , as other recently extinct Madagascan animals ? such as subfossil lemurs , Malagasy hippopotamuses , the giant fossa , and elephant birds ? were generally larger and not exclusively insectivorous ; also , some species with likely more specialized diets , such as the falanouc (*Eupleres goudoti*) and aye @-@ aye (*Daubentonia madagascariensis*) , did survive . Early human colonists of Madagascar may have caused the extinction of *Plesiorhycteropus* through the destruction of the forest and other disturbances .