

= Giant mouse lemur =

The giant mouse lemurs (members of the genus *Mirza*) are a genus of strepsirrhine primates . Two species have been formally described ; the northern giant mouse lemur (*Mirza zaza*) and Coquerel 's giant mouse lemur (*Mirza coquereli*) . Like all other lemurs , they are native to Madagascar , where they are found in the western dry deciduous forests and further to the north in the Sambirano valley and Sahamalaza Peninsula . First described in 1867 as a single species , they were grouped with mouse lemurs and dwarf lemurs . In 1870 , British zoologist John Edward Gray assigned them to their own genus , *Mirza* . The classification was not widely accepted until the 1990s , which followed the revival of the genus by American paleoanthropologist Ian Tattersall in 1982 . In 2005 , the northern population was declared a new species , and in 2010 , the World Wide Fund for Nature announced that a southwestern population might also be a new species .

Giant mouse lemurs are about three times larger than mouse lemurs , weighing approximately 300 g (11 oz) , and have a long , bushy tail . They are most closely related to mouse lemurs within Cheirogaleidae , a family of small , nocturnal lemurs . Giant mouse lemurs sleep in nests during the day and forage alone at night for fruit , tree gum , insects , and small vertebrates . Unlike many other cheirogaleids , they do not enter a state of torpor during the dry season . The northern species is generally more social than the southern species , particularly when nesting , though males and females may form pair bonds . The northern species also has the largest testicle size relative to its body size among all primates and is atypical among lemurs for breeding year @-@ round instead of seasonally . Home ranges often overlap , with related females living closely together while males disperse . Giant mouse lemurs are vocal , although they also scent mark using saliva , urine , and secretions from the anogenital scent gland .

Predators of giant mouse lemurs include the Madagascar buzzard , Madagascar owl , fossa , and the narrow @-@ striped mongoose . Giant mouse lemurs reproduce once a year , with two offspring born after a 90 @-@ day gestation . Babies are initially left in the nest while the mother forages , but are later carried by mouth and parked in vegetation while she forages nearby . In captivity , giant mouse lemurs will breed year @-@ round . Their lifespan in the wild is thought to be five to six years . Both species are listed as endangered due to habitat destruction and hunting . Like all lemurs , they are protected under CITES Appendix I , which prohibits commercial trade . Despite breeding easily , they are rarely kept in captivity . The Duke Lemur Center coordinated the captive breeding of an imported collection of the northern species , which rose from six individuals in 1982 to 62 individuals by 1989 , but the population fell to six by 2009 and was no longer considered a breeding population .

= = Taxonomy = =

The first species of giant mouse lemur was described by the French naturalist Alfred Grandidier in 1867 based on seven individuals he had collected near Morondava in southwestern Madagascar . Of these seven specimens , the lectotype was selected in 1939 as MNHN 1867 ? 603 , an adult skull and skin . Naming the species after the French entomologist Charles Coquerel , Grandidier placed Coquerel 's giant mouse lemur (*M. coquereli*) with the dwarf lemurs in the genus *Cheirogaleus* (which he spelled *Cheirogalus*) as *C. coquereli* . He selected this generic assignment based on similarities with fork @-@ marked lemurs (*Phaner*) , which he considered to also be members of *Cheirogaleus* . The following year , the German naturalist Hermann Schlegel and Dutch naturalist François Pollen independently described the same species and coincidentally gave it the same specific name , *coquereli* , basing theirs on an individual from around the Bay of Ampasindava in northern Madagascar . Unlike Grandidier , they placed their specimen in the genus *Microcebus* (mouse lemurs) ; however , these authors also listed all *Cheirogaleus* under *Microcebus* and based the classification of their species on similarities with the greater dwarf lemur (*M. typicus* , now *C. major*) .

In 1870 , the British zoologist John Edward Gray placed Coquerel 's giant mouse lemur into its own genus , *Mirza* . This classification was widely ignored and later rejected in the early 1930s by

zoologists Ernst Schwarz , Guillaume Grandidier , and others , who felt that its longer fur and bushy tail did not merit a separate genus and instead placed it in *Microcebus* . British anatomist William Charles Osman Hill also favored this view in 1953 , noting that despite its larger size (comparable to *Cheirogaleus*) , its first upper premolar was proportionally small as in *Microcebus* . In 1977 , French zoologist Jean @-@ Jacques Petter also favored the *Microcebus* classification , despite the threefold size difference between Coquerel 's giant mouse lemur and the other members of the genus .

The genus *Mirza* was resurrected in 1982 by American paleoanthropologist Ian Tattersall to represent an intermediate branch between *Microcebus* and *Cheirogaleus* , citing the Coquerel 's giant mouse lemur 's significantly larger size than the largest *Microcebus* and locomotor behavior more closely aligned with *Cheirogaleus* . Adoption of *Mirza* was slow , though in 1994 it was used in the first edition of *Lemurs of Madagascar* by Conservation International . In 1993 , primatologist Colin Groves initially favored the *Microcebus* classification in the second edition of *Mammal Species of the World* , but began supporting the resurrection of *Mirza* in 2001 . In 1991 , prior to adopting *Mirza* , Groves was the first to use the common name " giant mouse lemur " . Prior to that , they were popularly referred to as " Coquerel 's mouse lemur " .

In 2005 , Peter M. Kappeler and Christian Roos described a new species of giant mouse lemur , the northern giant mouse lemur (*M. zaza*) . Their studies compared the morphology , behavioral ecology , and mitochondrial cytochrome b sequences of specimens from both Kirindy Forest in central @-@ western Madagascar and around Ambato in northwestern Madagascar , part of the Sambirano valley . Their study demonstrated distinct differences in size , sociality , and breeding , as well as sufficient genetic distance to merit specific distinction between the northern and central @-@ western populations . Because Grandidier 's description was based on a southern specimen , they named the northern population as a new species .

The World Wide Fund for Nature (WWF) announced in 2010 that a biodiversity study from 2009 in the gallery forest of Ranobe near Toliara in southwestern Madagascar revealed a population of giant mouse lemurs previously unknown to science , and possibly a new species . They noted a significant difference in coloration between the two known species and the specimen they observed . However , further testing was required to confirm the discovery .

== Etymology ==

The etymology of *Mirza* puzzled researchers for many years . Gray often created mysterious and unexplained taxonomic names ? a trend not only continued with his description of *Mirza* in 1870 , but also with the genera *Phaner* (fork @-@ marked lemurs) and *Azema* (for *M. rufus* , now a synonym for *Microcebus*) , both of which were described in the same publication . In 1904 , American zoologist Theodore Sherman Palmer attempted to document the etymologies of all mammalian taxa , but could not definitively explain these three genera . For *Mirza* , Palmer only noted that it derived from the Persian title *mîrzâ* (" prince ") , a view tentatively supported by Alex Dunkel , Jelle Zijlstra , and Groves in 2012 . However , because the reference to Persian princes might have come from *Arabian Nights* , a popular piece of literature at the time , Dunkel et al. also searched the general literature published around 1870 . The origin of all three names was found in a British comedy *The Palace of Truth* by W. S. Gilbert , which premiered in London on 19 November 1870 , nearly one and a half weeks prior to the date written on the preface of Gray 's manuscript (also published in London) . The comedy featured characters bearing all three names : King Phanor (sic) , *Mirza* , and *Azema* . The authors concluded that Gray had seen the comedy and then based the names of three lemur genera on its characters .

== Evolution ==

Based on studies using morphology , immunology , repetitive DNA , SINE analysis , multilocus phylogenetic tests , and mitochondrial genes (mtDNA) , giant mouse lemurs are most closely related to mouse lemurs within the family *Cheirogaleidae* , and together they form a clade with the

hairy @-@ eared dwarf lemur (*Allocebus*) . Both dwarf lemurs and fork @-@ marked lemurs are more distantly related , with fork @-@ marked lemurs being either a sister group of all cheirogaleids , or more closely related to sportive lemurs (*Lepilemur*) .

Although *Mirza* , *Microcebus* , and *Allocebus* form a clade within Cheirogaleidae , the three lineages are thought to have diverged during a narrow window of time , so the relationships within this clade are difficult to determine and may change with further research . All three are thought to have diverged at least 20 mya (million years ago) , although another estimate using mtDNA places the divergence between *Mirza* and *Microcebus* at 24 @.@ 2 mya . Divergence between the two recognized species of giant mouse lemur is estimated at 2 @.@ 1 mya .

= = Description = =

Though giant mouse lemurs are relatively small cheirogaleids , they are more than three times larger than the smallest members of the family , the mouse lemurs . Their body weight averages 300 g (11 oz) . At around 300 mm (12 in) , their bushy and long tail is longer than their head @-@ body length , which averages 233 mm (9 @.@ 2 in) . Their forelimbs are shorter than the hind limbs (with an intermembral index of 70) , a trait shared with mouse lemurs . The skull is similar to that of dwarf and mouse lemurs , and the auditory bullae are small .

Like other cheirogaleids , the dental formula for giant mouse lemurs is $2 @.@ 1 @.@ 3 @.@ 3 @.@ 1 @.@ 3 @.@ 3 \times 2 = 36$; on each side of the mouth , top and bottom , there are two incisors , one canine , three premolars , and three molars ? a total of 36 teeth . Their upper teeth converge towards the front of the mouth , but are straighter than those in mouse lemurs . The first upper premolar (P2) is relatively small , but nearly as tall as the next premolar (P3) . Unlike mouse lemurs and more like dwarf lemurs , giant mouse lemurs have a prominent anterior lower premolar (P2) . Also more aligned with dwarf lemurs , the first two upper molars (M1 ? 2) have a more anterior hypocone that sits opposite the metacone , compared to the mouse lemurs ' more posterior hypocone , which is presumably a symplesiomorphic (ancestral) trait . Also on M1 and M2 , the cingulum (a crest or ridge on the tongue side) comprises two small cuspules . In all other dental characteristics , giant mouse lemurs are noticeably similar to both dwarf and mouse lemurs .

Giant mouse lemurs have two pairs of mammae , one on the chest (pectoral) and one on the abdomen (abdominal) . Their fur is typically grayish @-@ brown on the dorsal (back) side and more gray in color on the ventral (front) side . The tail is typically black @-@ tipped . The new population found by WWF in 2010 has an overall lighter color , along with reddish or rusty patches near the hands and feet on the dorsal side of the arms and legs . This population also has a red tail , which darkens at the end . Vibrissae are found above the eyes (superciliary) , above the mouth (buccal) , under the lower jaw (genal) , near the top of the jaw (interramal) , and on the wrist (carpal) . Like mouse lemurs , the ears are large and membranous .

Ear size is one differentiating factor between the northern giant mouse lemur and Coquerel 's giant mouse lemur , with the former having shorter , rounded ears , while the latter has relatively large ears . The northern giant mouse lemur is generally larger and also has a shorter tail and shorter canine teeth . This species also has the largest testicles relative to body size of any living primate , with an average volume of 15 @.@ 48 cm³ (0 @.@ 945 cu in) , corresponding to 5 @.@ 5 % of its body weight . If human males had comparably sized testes , they would weigh 4 kg (8 @.@ 8 lb) and be the size of a grapefruit .

= = Distribution and habitat = =

Coquerel 's giant mouse lemur has a spotty distribution across western Madagascar 's dry deciduous forests due to the forest fragmentation throughout the region . The dry forests in this lowland region vary in elevation from sea level to 700 m (2 @.@ 300 ft) . The range of this species is divided into northern and southern subpopulations , which are separated by several hundred kilometers . Both historical and current populations between these ranges are uncertain . The southern region is bound by the Onilahy River in the south and the Tsiribihina River in the north ,

while the northern population is found in the northwestern corner of the island at Tsingy de Namoroka National Park . They are most commonly found in forests near rivers and ponds .

The northern giant mouse lemur is found in isolated forest patches along the northwest coast in both the more humid Sambirano valley and Sahamalaza Peninsula , as well as the Ampasindava Peninsula . Its range extends from the Maevarano River in the south to the Mahavavy River in the north . The new population reported by the WWF in 2010 is found in the gallery forests of Ranobe near Toliara in southwestern Madagascar .

= = Behavior = =

Giant mouse lemurs were first studied in the wild by Petter and colleagues in 1971 . His observations were secondary to his primary research interest , the fork @-@ marked lemurs north of Morondava . Both northern and southern populations were studied intermittently between 1978 and 1981 , and in 1993 , long @-@ term social and genetic studies began in Kirindy Forest . Behavioral studies of captive individuals have also been performed at the Duke Lemur Center (DLC) in Durham , North Carolina during the 1990s .

= = = Population density and territory = = =

Before the recognition of more than one species , differences in population density were noted between southern forests like Kirindy and northern forests near Ambanja . Later , it was recognized that Coquerel 's giant mouse lemur was found in lower densities than the northern giant mouse lemur . The former range between 30 and 210 individuals per square kilometer (250 acres) , with lower densities in open areas of the forest , while the latter has been recorded with 385 to 1 @,@ 086 individuals per km² . However , in the case of the northern giant mouse lemur , populations were found in more isolated forest fragments and it is thought that their consumption of introduced cashew and mango help sustain these higher populations .

According to studies of Coquerel 's giant mouse lemur , home ranges of both sexes vary from 1 to 4 hectares (2 to 10 acres) with frequent overlap , particularly on the periphery of their range . Individuals most heavily use and aggressively defend a smaller core area within their range . Individuals can have up to eight neighbors . Home ranges of males tend to overlap with those of both females and other males , and typically expand to four times the size during the mating season . Female home ranges show no variability in size , and can remain stable for years . At Kirindy Forest , genetic studies showed that the home ranges of related females tend to clump closely together , while unrelated males may overlap their range , suggesting male dispersal and migration is responsible for gene flow .

= = = Activity patterns = = =

Both species are strictly nocturnal , leaving their nests around sunset to stretch and self @-@ groom for a few minutes . Both species typically forage between 5 and 10 m (16 and 33 ft) above the forest floor , though Coquerel 's giant mouse lemur has been observed on the ground . They primarily move by quadrupedal running and occasionally leaping between branches , and use the same feeding postures as mouse lemurs , such as clinging to tree trunks . When moving through the trees , giant mouse lemurs scurry rapidly like mouse lemurs , unlike dwarf lemurs , which use more deliberate movement . Slow movements are usually seen in lower , denser foliage when hunting for insects , while more rapid motion and leaping is typically seen at moderate heights of 2 ? 5 m (6 @.@ 6 ? 16 ft) . Surveillance of the home range involves slower movements in lighter foliage near the tops of large trees , while movements along the border of a home range is more rapid and occurs at a lower height . Similar movement patterns have been observed in captivity as well .

Giant mouse lemurs begin foraging moments before the sun disappears , occasionally participate in social activities during the last half of the night , and return to one of their nests prior to sunrise . Cold temperatures cause them to leave the nest later and return early , sometime during the second

half of the night . During the first half of the night , giant mouse lemurs are more likely to rest for an hour or more , usually at the expense of social activities , but not feeding time . Rest periods are longer when temperatures are low . Unlike many other cheirogaleids , they remain active all year and do not enter daily or seasonal torpor .

== Nesting ==

Both species sleep in round nests up to 50 cm (20 in) across made of interlaced lianas , branches , leaves , and twigs gathered from nearby trees and woven using the mouth and hands . Nests are typically between 2 and 10 m (6 @. 6 and 33 ft) above the ground in the fork of large tree branches or surrounded by dense lianas . Trees covered in thick lianas as well as trees with year @-@ round leaf cover (e.g. Euphorbiaceae) are favored for nest construction , though large bare trees may be used by building the nest higher . In addition to nesting in dense lianas , individual giant mouse lemurs will rotate between 10 and 12 nests every few days to avoid predators . Only females have been observed building nests in the wild , though males , females , and young have been observed building nests in captivity . Multiple nests are sometimes built in the same tree or in nearby trees and are shared by neighboring giant mouse lemurs , fork @-@ marked lemurs , and the introduced black rat (*Rattus rattus*) . Unlike most other nocturnal lemurs , giant mouse lemurs do not appear to sleep in tree holes .

== Social structure ==

Both species usually are solitary foragers , although the northern giant mouse lemur tends to be the most social , possibly due to its higher population density . Up to eight (typically four) adult males , adult females , and juveniles may be found in a northern giant mouse lemur nest , whereas Coquerel 's giant mouse lemurs do not nest communally , except when females share their nest with their offspring . Males do groom and call to females when they come into contact , and according to radio @-@ tracking and direct observations at Analabe near Kirindy , they form pair bonds , sometimes briefly traveling together during the dry season . However , most interactions between adults are infrequent and typically occur later at night and particularly during the dry season in overlapping core areas , often involving chases and other agonistic behavior , and only rarely social grooming . During the mating season , males act aggressively towards one another , pulling out fur around the head and shoulders and biting the head .

Giant mouse lemurs use at least eight vocalizations , the most common of which are contact calls , which sound like " hum " or a " hein " and are used when moving and when meeting familiar individuals . A " mother @-@ infant meeting call " used at dawn before returning to the nest consists of short , modulated whistles . Both males and females have distinct single note calls used in territorial behavior ; the female call sounds like " pfiau " and the male call is a short , loud whistle . Both sexes use an alarm call , which sounds like a " croak " , and an agonistic call , which consists of repeated " tisk @-@ tisk @-@ tisk " sounds . Females exhibit a " waking call sequence " , sometimes referred to as " loud calls " , which start when foraging commences and then switch to quieter " hon " calls possibly to indicate their position to their neighbors . A long " sexual call sequence " consisting of soft whistle and several modulated , hoarse " brroak " calls is used by both sexes during estrus . Studies of captive individuals have found other vocalizations , but their purpose has not been determined . The northern giant mouse lemur appears to be the most vocal of the two species . Although vocalizations are the primary form of social communication , they also scent mark using saliva , urine , and secretions from the anogenital scent gland on small branches and other objects .

== Reproduction ==

Reproduction starts in November for Coquerel 's giant mouse lemur at Kirindy Forest ; the estrous cycle runs approximately 22 days , while estrus lasts only a day or less . The mating season in this

southern population is limited to a few weeks , whereas the northern giant mouse lemur is thought to breed throughout the year , a trend seen in only two other species of lemur : the aye aye (*Daubentonia madagascariensis*) and the red bellied lemur (*Eulemur rubriventer*) . The northern giant mouse lemur had been observed breeding year round in captivity if their litter did not survive or was removed , but at the time this population was thought to be Coquerel 's giant mouse lemur .

One to three offspring (typically two) are born after 90 days of gestation , weighing approximately 12 g (0.42 oz) . Because they are poorly developed , they initially remain in their mother 's nest for up to three weeks , being transported by mouth between nests . Once they have grown sufficiently , typically after three weeks , the mother will park her offspring in vegetation while she forages nearby . After a month , the young begin to participate in social play and grooming with their mother , and between the first and second month , young males begin to exhibit early sexual behaviors (including mounting , neck biting , and pelvic thrusting) . By the third month , the young forage independently , though they maintain vocal contact with their mother and use a small part of her range .

Females start reproducing after ten months , while males develop functional testicles by their second mating season . Testicle size in the northern giant mouse lemur does not appear to fluctuate by season , and is so large relative to the animal 's body mass that it is the highest among all primates . This emphasis on sperm production in males , as well as the use of copulatory plugs , suggests a mating system best described as polygynandrous where males use scramble competition (roaming widely to find many females) . In contrast , male Coquerel 's giant mouse lemurs appear to fight for access to females (contest competition) during their breeding season . Males disperse from their natal range , and the age at which they leave varies from two years to several . Females reproduce every year , although postpartum estrus has been observed in captivity . In the wild , the lifespan of giant mouse lemurs is thought to rarely exceed five or six years , though in captivity they can live up to 15 years .

== Ecology ==

Both species are omnivorous , eating fruit , flowers , buds , insect excretions , tree gums , large insects , spiders , frogs , chameleons , snakes , small birds , and eggs . Coquerel 's giant mouse lemur is thought to opportunistically prey on mouse lemurs after an individual was found with a half eaten gray mouse lemur (*M. murinus*) in a trap . During June and July , at the peak of the dry season , this species relies on sugary excretions from the larvae of hemipteran and cochineal insects as well as tree gums . The sugary excretions are obtained by either licking them from the back of the insect or collecting the crystallized sugars that accumulate beneath the insect colony . During this time of year , feeding on insect secretions can account for 60 % of feeding activity . In contrast , the northern giant mouse lemur relies on cashew fruits during the dry season .

Giant mouse lemurs are often sympatric with mouse lemurs , such as *M. murinus* , though they are typically found higher in the canopy and favor thicker , taller gallery forests . At the Marosalaza forest (north of Morondava) , Coquerel 's giant mouse lemur is sympatric with four other nocturnal lemurs (mouse lemurs , sportive lemurs , dwarf lemurs , and fork marked lemurs) , but manages niche differentiation by feeding at different times and specializing on insect secretions during the dry season .

Diurnal birds of prey such as the Madagascar buzzard (*Buteo brachypterus*) are their most significant predators . Other documented predators of giant mouse lemurs include the fossa (*Cryptoprocta ferox*) , Madagascar owl (*Asio madagascariensis*) , and the narrow striped mongoose (*Mungotictis decemlineata*) .

== Conservation ==

In 2012 , the International Union for Conservation of Nature (IUCN) assessed both Coquerel 's giant mouse lemur and the northern giant mouse lemur as endangered . Prior to that , both species

had been listed as vulnerable . Populations of both species are in decline due to habitat destruction , primarily for slash @-@ and @-@ burn agriculture and charcoal production . Also , they are both hunted for bushmeat . The population announced by the WWF in 2010 was found outside the limits of a nearby protected area , PK32 @-@ Ranobe , which was granted temporary protection status in December 2008 and is co @-@ managed by the WWF . Its forests were not included in the protected area due to existing concessions for mining activities .

As with all lemurs , giant mouse lemurs were first protected in 1969 when they were listed as " Class A " of the African Convention on the Conservation of Nature and Natural Resources . This prohibited hunting and capture without authorization , which would only be given for scientific purposes or the national interest . In 1973 , they were also protected under CITES Appendix I , which strictly regulates their trade and forbids commercial trade . Although enforcement is patchy , they are also protected under Malagasy law .

Giant mouse lemurs are rarely kept in captivity , though they breed easily . In 1989 , the Duke Lemur Center held more than 70 % of the captive population (45 of 62 individuals) . At the time , the DLC was coordinating a captive breeding program for Coquerel 's giant mouse lemur , and all individuals kept at American facilities were descended from six individuals imported by the DLC in 1982 from the region around Ambanja . As of 2009 , the International Species Information System (ISIS) recorded only six remaining individuals registered in the United States and Europe , all reclassified as northern giant mouse lemurs and considered a non @-@ breeding population ; and in 2015 , only a single female remained on record .