

# Rhesus macaque

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The **rhesus macaque** (*Macaca mulatta*), is one of the best-known species of Old World monkeys. It is listed as Least Concern in the IUCN Red List of Threatened Species in view of its wide distribution, presumed large population, and its tolerance of a broad range of habitats. Native to South, Central and Southeast Asia, troops of *Macaca mulatta* inhabit a great variety of habitats from grasslands to arid and forested areas, but also close to human settlements.<sup>[2]</sup>

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## Characteristics

The rhesus macaque is brown or grey in color and has a pink face, which is bereft of fur. Its tail is of medium length and averages between 20.7 and 22.9 cm (8.1 and 9.0 in). Adult males measure approximately 53 cm (21 in) on average and weigh about 7.7 kg (17 lb). Females are smaller, averaging 47 cm (19 in) in length and 5.3 kg (12 lb) in weight. Rhesus macaques have on average 50 vertebrae. Their intermembral index (ratio of arm length to leg length) is 89%. They have dorsal scapulae and a wide rib cage.

The rhesus macaque has 32 teeth with a dental formula of 2.1.2.3/2.1.2.3 and bilophodont molars. The upper molars have four cusps: paracone, metacone, protocone and hypocone. The lower molars also have four cusps: metaconid, protoconid, hypoconid and entoconid.

### Rhesus macaque<sup>[1]</sup>



#### Conservation status



Least Concern (IUCN 3.1)<sup>[2]</sup>

#### Scientific classification

Kingdom:    Animalia

Phylum:   Chordata

Class:       Mammalia

Order:       Primates

Family:      Cercopithecidae

Genus:       *Macaca*

Species:     ***M. mulatta***

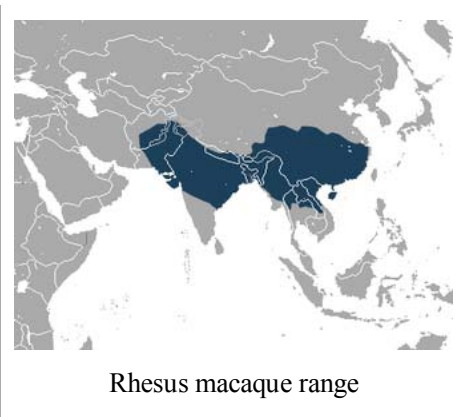
#### Binomial name

***Macaca mulatta***

(Zimmermann, 1780)

## Distribution and habitat

Rhesus macaques are native to northern India, Bangladesh, Pakistan, Nepal, Burma, Thailand, Afghanistan, Vietnam, southern China, and some neighboring areas. They have the widest geographic ranges of any nonhuman primate, occupying a great diversity of altitudes throughout Central, South and Southeast Asia. Inhabiting arid, open areas, rhesus macaques may be found in grasslands, woodlands and in mountainous regions up to 2,500 m (8,200 ft) in elevation. They are regular swimmers. Babies as young as a few days old can swim, and adults are known to swim over a half mile between islands, but are often found drowned in small groups where their drinking waters lie. Rhesus macaques are noted for their tendency to move from rural to urban areas, coming to rely on handouts or refuse from humans.<sup>[3]</sup>



Rhesus macaque range

The southern and the northern distributional limits for rhesus and bonnet macaques, respectively, currently run parallel to each other in the western part of India, are separated by a large gap in the center, and converge on the eastern coast of the peninsula to form a distribution overlap zone. This overlap region is characterized by the presence of mixed-species troops, with pure troops of both species sometimes occurring even in close proximity to one another. The range extension of rhesus macaque – a natural process in some areas and a direct consequence of introduction by humans in other regions – poses grave implications for the endemic and declining populations of bonnet macaques in southern India.<sup>[4]</sup>

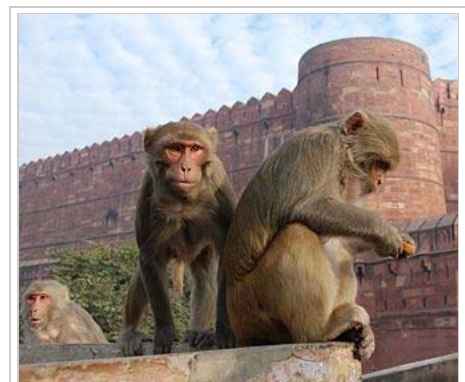
## Distribution of subspecies and populations

The name "rhesus" is reminiscent of the Greek mythological king Rhesus. However, the French naturalist Jean-Baptiste Audebert, who applied the name to the species, stated: "it has no meaning".<sup>[5]</sup>

According to Zimmermann's first description of 1780, the rhesus macaque is distributed in eastern Afghanistan, Bangladesh, Bhutan, as far east as the Brahmaputra Valley in peninsular India, Nepal and northern Pakistan. Today, this is known as the Indian rhesus macaque *M. m. mulatta*, which includes the morphologically similar *M. rhesus villosus* described by True in 1894 from Kashmir and *M. m. mcmahoni* described by Pocock in 1932 from Kootai, Pakistan. Several Chinese subspecies of rhesus macaques have been described between 1867 and 1917. The molecular differences identified among populations, however, are alone not consistent enough to conclusively define any subspecies.<sup>[6]</sup>

The Chinese subspecies can be divided in:

- *M. m. mulatta* is found in western and central China, in the south of Yunnan and southwest of Guangxi;<sup>[7]</sup>
- *M. m. lasiota* (Gray, 1868), the west Chinese rhesus macaque, is distributed in the west of Sichuan, northwest of Yunnan, and southeast of Qinghai;<sup>[7]</sup> it is possibly synonymous with *M. m. sanctijohannis* (Swinhoe, 1867), if not with *M. m. mulatta*.<sup>[6]</sup>
- *M. m. tcheliensis* (Milne-Edwards, 1870), the north Chinese rhesus macaque, lives in the north of Henan, south of Shanxi and near Beijing. Some consider it as the most endangered subspecies.<sup>[8]</sup> Others consider it possibly



Rhesus macaques in the Red Fort of Agra in India



Rhesus macaque in Kinnerasani Wildlife Sanctuary, Andhra Pradesh, India

synonymous with *M. m. sanctijohannis*, if not with *M. m. mulatta*.<sup>[6]</sup>

- *M. m. vestita* (Milne-Edwards, 1892), the Tibetan rhesus macaque, lives in the southeast of Tibet, northwest of Yunnan (Deqing), and perhaps including Yushu;<sup>[7]</sup> it is possibly synonymous with *M. m. sanctijohannis*, if not with *M. m. mulatta*.<sup>[6]</sup>
- *M. m. littoralis* (Elliot, 1909), the south Chinese rhesus macaque, lives in Fujian, Zhejiang, Anhui, Jiangxi, Hunan, Hubei, Guizhou, northwest of Guangdong, north of Guangxi, northeast of Yunnan, east of Sichuan and south of Shaanxi;<sup>[7]</sup> it is possibly synonymous with *M. m. sanctijohannis*, if not with *M. m. mulatta*.<sup>[6]</sup>
- *M. m. brevicaudus*, also referred to as *Pithecus brevicaudus* (Elliot, 1913), lives on the Hainan Island and Wanshan Islands in Guangdong, and the islands near Hong Kong;<sup>[7]</sup> it may be synonymous with *M. m. mulatta*.<sup>[6]</sup>
- *M. m. siamica* (Kloss, 1917), the Indochinese rhesus macaque, is distributed in Myanmar, in the north of Thailand and Vietnam, in Laos and in the Chinese provinces of Anhui, northwest Guangxi, Guizhou, Hubei, Hunan, central and eastern Sichuan, and western and south-central Yunnan; possibly synonymous with *M. m. sanctijohannis*, if not with *M. m. mulatta*.<sup>[6]</sup>

## Feral colonies in the United States

Around the spring of 1938, a colony of rhesus macaques called "the Nazuri's" was released in around Silver Springs in Florida by a tour boat operator known locally as "Colonel Tooey" to enhance his "Jungle Cruise". A traditional story that the monkeys were released for scenery enhancement in the Tarzan movies that were filmed at that location is false, as the only Tarzan movie filmed in the area, 1939's *Tarzan Finds a Son!* does not contain rhesus macaques.<sup>[9]</sup> In addition, various colonies of rhesus and other monkey species are speculated to be the result of zoos and wildlife parks destroyed in hurricanes, most notably Hurricane Andrew.<sup>[10]</sup>

A notable colony of rhesus macaques on Morgan Island, one of the Sea Islands in the South Carolina Lowcountry, was imported in the 1970s for use in local labs and are by all accounts thriving.<sup>[11]</sup>

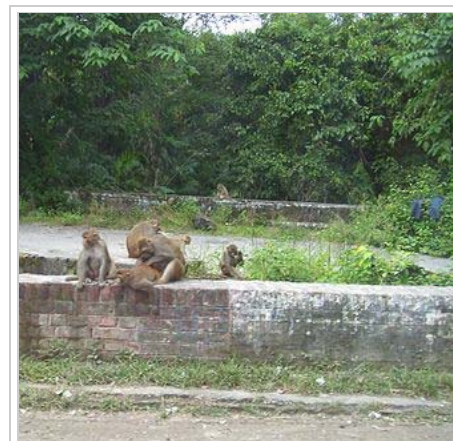
## Ecology and behavior

Rhesus macaques are diurnal animals, and both arboreal and terrestrial. They are quadrupedal and, when on the ground, they walk digitigrade and plantigrade. They are mostly herbivorous, feeding mainly on fruit, but also eating seeds, roots, buds, bark, and cereals. They are estimated to consume around 99 different plant species in 46 families. During the monsoon season, they get much of their water from ripe and succulent fruit. Macaques living far from water sources lick dewdrops from leaves and drink rainwater accumulated in tree hollows.<sup>[12]</sup> They have also been observed eating termites, grasshoppers, ants and beetles.<sup>[13]</sup> When food is abundant, they are distributed in patches and forage throughout the day in their home ranges. They drink water when foraging and gather around streams and rivers.<sup>[14]</sup> Rhesus macaques have specialized pouch-like cheeks, allowing them to temporarily hoard their food.

In psychological research, rhesus macaques have demonstrated a variety of complex cognitive abilities, including the ability to make same-different judgments, understand simple rules, and monitor their own mental states.<sup>[15][16]</sup> They have even been shown to demonstrate self-agency,<sup>[17]</sup> an important type of self-awareness. In 2014, onlookers at a train station in Kanpur, India, documented (<http://time.com/3643900/monkey-electrocution-india/>) a Rhesus monkey, knocked unconscious by overhead power lines, that is revived by another Rhesus that systematically administers a series of resuscitative actions.

## Group structure

Like other macaques, rhesus troops comprise a mixture of 20–200 males and females.<sup>[18]</sup> Females may outnumber the males by a ratio of 4:1. Males and females both have separate hierarchies. Female philopatry, common among social mammals, has been extensively studied in Rhesus macaques. Females tend not to leave the social group and have highly stable matrilineal hierarchies in which a female's rank is dependent on the rank of her mother. In addition, a single group may have multiple matrilineal lines existing in a hierarchy, and a female outranks any unrelated females that rank lower than her mother.<sup>[19]</sup> Rhesus macaques are unusual in that the youngest females tend to outrank their older sisters.<sup>[20]</sup> This is likely because young females are more fit and fertile. Mothers seem to prevent the older daughters from forming coalitions against her. The youngest daughter is the most dependent on the mother, and would have nothing to gain from helping her siblings in overthrowing their mother. Since each daughter had a high rank in her early years, rebelling against her mother is discouraged.<sup>[21]</sup> Juvenile male macaques also exist in matrilineal lines, but once they reach four to five years of age, they are driven out of their natal groups by the dominant male. Thus, adult males gain dominance by age and experience.<sup>[14]</sup>



A roadside band of rhesus macaque in Rishikesh, Uttarakhand, India:

Although they are infamous as urban pests, which are quick to steal not only food, but also household items, it is not certain if the pair of jeans draped over the wall on the right is their handiwork.

In the group, macaques position themselves based on rank. The "central male subgroup" contains the two or three oldest and most dominant males which are codominant, along with females, their infants and juveniles. This subgroup occupies the center of the group and determines the movements, foraging and other routines.<sup>[14]</sup> The females of this subgroup are also the most dominant of the entire group. The farther to the periphery a subgroup is, the less dominant it is. Subgroups on the periphery of the central group are run by one dominant male which ranks lower than the central males, and maintains order in the group and communicates messages between the central and peripheral males. A subgroup of subordinate, often subadult males occupy the very edge of the groups and have the responsibility of communicating with other macaque groups and making alarm calls.<sup>[22]</sup> Rhesus social behaviour has been described as despotic in that high-ranking individuals show little tolerance and frequent and often severe aggression towards non-kin.<sup>[23]</sup>

## Communication

Rhesus macaques interact using a variety of facial expressive, vocalizations and body postures, and gestures. Perhaps the most common facial expression the macaque makes is the "silent bared teeth" face.<sup>[24]</sup> This is made between individuals of different social ranks with the lower ranking one giving the expression to its superior. A less dominant individual will also make a "fear grimace" accompanied by a scream to appease or redirect aggression.<sup>[25]</sup> Another submissive behavior is the "present rump", where an individual raises its tail and exposes its genitals to the dominant one.<sup>[24]</sup> A dominant individual will threaten another individual standing quadrupedally making a silent "open mouth stare" accompanied by the tail sticking straight.<sup>[26]</sup> During movements, macaques will make "coos" and "grunts". These are also made during affiliative interactions and approaches before grooming.<sup>[27]</sup> When they find rare food of high quality, macaques will emit "warbles," "harmonic arches", or "chirps." When in threatening situations, macaques will emit a single loud, high-pitched sound called a "shrill bark".<sup>[28]</sup> "Screeches," "screams", "squeaks", "pant-threats", "growls", and "barks" are used during aggressive interactions.<sup>[28]</sup> Infants "gecker" to attract their mother's attention.<sup>[29]</sup>

## Reproduction

Adult male macaques try to maximize their reproductive success by entering into sex with females, both in and outside the breeding period. Females prefer to mate with males that will increase the survival of their young. Thus, a consort male provides resources for his female and protects her from predators. Larger, more dominant males are more likely to provide for the females. The breeding period can last up to 11 days, and a female usually mates with four males during that time. Male rhesus macaques have not been observed to fight for access to sexually receptive females, although they suffer more wounds during the mating season.<sup>[30]</sup> Female macaques first breed when they are four years old, and reach menopause at around 25 years of age.<sup>[31]</sup> When mating, a male rhesus monkey usually ejaculates less than 15 seconds after sexual penetration.<sup>[32]</sup> Male macaques generally play no role in raising the young, but do have peaceful relationships with the offspring of their consort pairs.<sup>[14]</sup>



Rhesus macaque with two babies near the Jakhu temple of Shimla, Himachal Pradesh

Mothers with one or more immature daughters in addition to their infants are in contact with their infants less than those with no older immature daughters, because the mothers may pass the parenting responsibilities to her daughters. High-ranking mothers with older immature daughters also reject their infants significantly more than those without older daughters, and tend to begin mating earlier in the mating season than expected based on their dates of parturition the preceding birth season.<sup>[33]</sup> Infants farther from the center of the groups are more vulnerable to infanticide from outside groups.<sup>[14]</sup> Some mothers abuse their infants, which is believed to be the result of controlling parenting styles.<sup>[34]</sup>

## Self-awareness

In several experiments giving mirrors to rhesus monkeys they looked into the mirrors and groomed themselves. This behaviour indicates that they recognised and were aware of themselves.<sup>[35]</sup>

## In science

The rhesus macaque is well known to science. Due to its relatively easy upkeep in captivity, wide availability and closeness to humans anatomically and physiologically, it has been used extensively in medical and biological research on human and animal health-related topics. It has given its name to the rhesus factor, one of the elements of a person's blood group, by the discoverers of the factor, Karl Landsteiner and Alexander Wiener. The rhesus macaque was also used in the well-known experiments on maternal deprivation carried out in the 1950s by controversial comparative psychologist Harry Harlow. Other medical breakthroughs facilitated by the use of the rhesus macaque include:

- development of the rabies, smallpox, and polio vaccines
- creation of drugs to manage HIV/AIDS
- understanding of the female reproductive cycle and development of the embryo and the propagation of embryonic stem cells.<sup>[36]</sup>



Project Mercury rocket Little Joe 1B, launched in 1960, carried *Miss Sam* to 9.3 mi (15.0 km) in altitude.

The U.S. Army, the U.S. Air Force, and NASA launched rhesus macaques into outer space during the 1950s and 1960s, and the Soviet/Russian space program launched them

into space as recently as 1997 on the Bion missions. One of these primates ("Able"), which was launched on a suborbital spaceflight in 1959, was among the first living beings (along with "Miss Baker" on the same mission) to travel in space and return alive.<sup>[37]</sup>

On October 25, 1994, the rhesus macaque became the first cloned primate with the birth of Tetra. January 2001 saw the birth of ANDi, the first transgenic primate; ANDi carries foreign genes originally from a jellyfish.<sup>[38]</sup>

Though most studies of the rhesus macaque are from various locations in northern India, some knowledge of the natural behavior of the species comes from studies carried out on a colony established by the Caribbean Primate Research Center of the University of Puerto Rico on the island of Cayo Santiago, off Puerto Rico. There are no predators on the island, and humans are not permitted to land except as part of the research programmes. The colony is provisioned to some extent, but about half of its food comes from natural foraging.

Rhesus macaques, like many macaques, carry the Herpes B virus. This virus does not typically harm the monkey but is very dangerous to humans in the rare event that it jumps species, for example in the 1997 death of Yerkes National Primate Research Center researcher Elizabeth Griffin.<sup>[39][40][41]</sup>

## Sequencing the genome

Work on the genome of the rhesus macaque was completed in 2007, making the species the second nonhuman primate to have its genome sequenced.<sup>[42]</sup> Humans and macaques apparently share about 93% of their DNA sequence and shared a common ancestor roughly 25 million years ago.<sup>[43]</sup> The rhesus macaque has 21 pairs of chromosomes.<sup>[44]</sup>

Comparison of rhesus macaques, chimpanzees and humans revealed the structure of ancestral primate genomes, positive selection pressure and lineage-specific expansions and contractions of gene families.

### Genomic information

<b>NCBI genome ID</b>	215 ( <a href="http://www.ncbi.nlm.nih.gov/genome/215">http://www.ncbi.nlm.nih.gov/genome/215</a> )
<b>Ploidy</b>	diploid
<b>Genome size</b>	3,097.37 Mb
<b>Number of chromosomes</b>	21 pairs
<b>Year of completion</b>	2007

"The goal is to reconstruct the history of every gene in the human genome," said Evan Eichler, University of Washington, Seattle. DNA from different branches of the primate tree will allow us "to trace back the evolutionary changes that occurred at various time points, leading from the common ancestors of the primate clade to *Homo sapiens*," said Bruce Lahn, University of Chicago.<sup>[45]</sup>

After the human and chimpanzee genomes were sequenced and compared, it was usually impossible to tell whether differences were the result of the human or chimpanzee gene changing from the common ancestor. After the rhesus macaque genome was sequenced, three genes could be compared. If two genes were the same, they are presumed to be the original gene.<sup>[46]</sup>

The chimpanzee and human genome diverged 6 million years ago. They have 98% identity and many conserved regulatory regions. Comparing the macaque and human genomes, which diverged 25 million years ago and had 93% identity, further identified evolutionary pressure and gene function.

Like the chimpanzee, changes were on the level of gene rearrangements rather than single mutations. There were frequent insertions, deletions, changes in the order and number of genes, and segmental duplications near gaps, centromeres and telomeres. So macaque, chimpanzee, and human chromosomes are mosaics of each other.

Surprisingly, some normal gene sequences in healthy macaques and chimpanzees cause profound disease in

humans. For example, the normal sequence of phenylalanine hydroxylase in macaques and chimpanzees is the mutated sequence responsible for phenylketonuria in humans. So humans must have been under evolutionary pressure to adopt a different mechanism.

Some gene families are conserved or under evolutionary pressure and expansion in all three primate species, while some are under expansion uniquely in human, chimpanzee or macaque.

For example, cholesterol pathways are conserved in all three species (and other primate species). In all three species, immune response genes are under positive selection, and genes of T cell-mediated immunity, signal transduction, cell adhesion, and membrane proteins generally. Genes for keratin, which produce hair shafts, were rapidly evolving in all three species, possibly because of climate change or mate selection. The X chromosome has three times more rearrangements than other chromosomes. The macaque gained 1,358 genes by duplication.

Triangulation of human, chimpanzee and macaque sequences showed expansion of gene families in each species.

The *PKFP* gene, important in sugar (fructose) metabolism, is expanded in macaques, possibly because of their high-fruit diet. So are genes for the olfactory receptor, cytochrome P450 (which degrades toxins), and CCL3L1-CCL4 (associated in humans with HIV susceptibility).

Immune genes are expanded in macaques, relative to all four great ape species. The macaque genome has 33 major histocompatibility genes, three times that of human. This has clinical significance because the macaque is used as an experimental model of the human immune system.

In humans, the preferentially expressed antigen of melanoma (PRAME) gene family is expanded. It is actively expressed in cancers, but normally is testis-specific, possibly involved in spermatogenesis. The PRAME family has 26 members on human chromosome 1. In the macaque, it has eight, and has been very simple and stable for millions of years. The PRAME family arose in translocations in the common mouse-primate ancestor 85 million years ago, and is expanded on mouse chromosome 4.

DNA microarrays are used in macaque research. For example, Michael Katze of University of Washington, Seattle, infected macaques with 1918 and modern influenzas. The DNA microarray showed the macaque genomic response to human influenza on a cellular level in each tissue. Both viruses stimulated innate immune system inflammation, but the 1918 flu stimulated stronger and more persistent inflammation, causing extensive tissue damage, and it did not stimulate the interferon-1 pathway. The DNA response showed a transition from innate to adaptive immune response over seven days.<sup>[47][48]</sup>

The full sequence and annotation of the Macaque genome ([http://www.ensembl.org/Macaca\\_mulatta/Info/Index/](http://www.ensembl.org/Macaca_mulatta/Info/Index/)) is available on the Ensembl genome browser.

## See also

- Girneys

## References

- Groves, C. P. (2005). Wilson, D. E.; Reeder, D. M, eds. *Mammal Species of the World* (<http://www.bucknell.edu/mw3/browse.asp?id=12100551>) (3rd ed.). Baltimore: Johns Hopkins University Press. p. 163. OCLC 62265494 (<https://www.worldcat.org/oclc/62265494>). ISBN 0-801-88221-4.
- Timmins, R. J., Richardson, M., Chhangani, A., Yongcheng, L. (2008). "Macaca mulatta"

- (<http://www.iucnredlist.org/details/12554>). *IUCN Red List of Threatened Species. Version 2010.4*. International Union for Conservation of Nature.
- Ciani, A. C. (1986). *Intertroop Agonistic Behavior of a Feral Rhesus Macaque Troop in Ranging in Town and Forest Areas in India* ([http://www.esploratore.com/files/resourcesmodule/@random44be4ac49f856/1153323855\\_Intertroop\\_Agonistic\\_Behavior\\_of\\_a\\_Feral\\_rhesus\\_Macaque\\_Troop\\_Ranging\\_in\\_Town\\_and\\_Areas\\_in\\_India.pdf](http://www.esploratore.com/files/resourcesmodule/@random44be4ac49f856/1153323855_Intertroop_Agonistic_Behavior_of_a_Feral_rhesus_Macaque_Troop_Ranging_in_Town_and_Areas_in_India.pdf)) (PDF). *Aggressive Behavior* 12: 433–439.
  - Kumar, R. Radhakrishna; Sinha, A. (2011). "Of Least Concern? Range Extension by Rhesus Macaques (*Macaca mulatta*) Threatens Long-Term Survival of Bonnet Macaques (*M. radiata*) in Peninsular India" ([http://nias.academia.edu/RishiKumar/Papers/538383/Of\\_least\\_concern\\_Range\\_Extension\\_by\\_Rhesus\\_Macaques\\_Macaca\\_mulatta\\_Threatens\\_Long-Term\\_Survival\\_of\\_Bonnet\\_Macaques\\_M.\\_radiata\\_in\\_Peninsular\\_India](http://nias.academia.edu/RishiKumar/Papers/538383/Of_least_concern_Range_Extension_by_Rhesus_Macaques_Macaca_mulatta_Threatens_Long-Term_Survival_of_Bonnet_Macaques_M._radiata_in_Peninsular_India)). *International Journal of Primatology* **32** (4): 945–959. doi:10.1007/s10764-011-9514-y (<https://dx.doi.org/10.1007%2Fs10764-011-9514-y>).
  - Jaeger, E. 1972. *A source-book of biological names and terms*. Springfield, Illinois: Charles C. Thomas.
  - Brandon-Jones, D., Eudey, A. A., Geissmann, T., Groves, C. P., Melnick, D. J., Morales, J. C., Shekelle, M., Stewart, C.-B. (February 2004). *Asian Primate Classification* ([http://www.gibbons.de/main/papers/pdf\\_files/2004asianprimates.pdf](http://www.gibbons.de/main/papers/pdf_files/2004asianprimates.pdf)) (PDF). 25, No. 1. *International Journal of Primatology*. pp. 97–164.
  - Shilai, JXWYM 1991. *Taxonomic revision and distribution of subspecies of Rhesus Monkey (*Macaca mulatta*) in China*. *Zoological Research*, 1991-03 Abstract ([http://en.cnki.com.cn/Article\\_en/CJFDTOTAL-DWXY199103002.htm](http://en.cnki.com.cn/Article_en/CJFDTOTAL-DWXY199103002.htm))
  - Zhang, Y., Shi, L. 1993. *Phylogeny of rhesus monkeys (*Macaca mulatta*) as revealed by mitochondrial DNA restriction enzyme analysis*. *International Journal of Primatology*, Volume 14, Number 4: 587-605. doi:10.1007/BF02215449 (<https://dx.doi.org/10.1007%2FBF02215449>)
  - Wolfe, Linda, Cambridge University Press (2002). "Primates Face to Face". p. 320. ISBN 0-521-79109-X. Excerpts available (<http://books.google.com/books?id=zYg3eOqjq4UC&lpq=PP1&dq=Primates%20Face%20to%20Face&pg=PA320#v=onepage&q=tarzan&f=false>) at Google Books.
  - Bilger, B. (April 20, 2009). "The Natural World, Swamp Things" ([http://www.newyorker.com/reporting/2009/04/20/090420fa\\_fact\\_bilger](http://www.newyorker.com/reporting/2009/04/20/090420fa_fact_bilger)). *The New Yorker*. p. 80. Retrieved 24 November 2010.
  - Taub, D.M., Mehlman, P.T. (1989). "Development of the Morgan Island rhesus monkey colony" ([http://www.ncbi.nlm.nih.gov/sites/entrez?cmd=Retrieve&db=PubMed&list\\_uids=2780958&dopt=AbstractPlus](http://www.ncbi.nlm.nih.gov/sites/entrez?cmd=Retrieve&db=PubMed&list_uids=2780958&dopt=AbstractPlus)). *Puerto Rico Health Sciences Journal* 1989 April 8 (1): 159-69.
  - Makwana, S (1979). "Field Ecology and Behavior of the rhesus macaque. Food, Feeding and Drinking in Dehra Dun Forests". *Indian Journal of Forestry* **2** (3): 242–253.
  - Lindburg, D.G. (1971) *The rhesus monkeys in north India: an ecological and behavioural study*. In: Rosenblum, LA (ed.) *Primate Behaviour: Developments in the field and laboratory research*. Academic Press, New York, vol.1, pp. 83–104.
  - Southwick, C., Beg, M., and R. Siddiqi (1965) "Rhesus Monkeys in North India." *Primate Behavior: Field Studies of monkeys and apes*. DeVore, I. San Francisco: Holt, Rinehart and Winston
  - Couchman, J. J. et al. (2010). "Beyond Stimulus Cues and Reinforcement Signals: A New Approach to Animal Metacognition" (<http://www.apa.org/pubs/journals/features/com-124-4-356.pdf>) (PDF). *Journal of Comparative Psychology* **124** (4): 356–368. doi:10.1037/a0020129 (<https://dx.doi.org/10.1037%2Fa0020129>). PMC 2991470 (<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2991470>). PMID 20836592 (<https://www.ncbi.nlm.nih.gov/pubmed/20836592>).
  - Blanchard, Tommy C.; Wolfe, Lauren S.; Vlaev, Ivo; Winston, Joel S.; Hayden, Benjamin Y. Hayden. "Biases in preferences for sequences of outcomes in monkeys" (<http://www.sciencedirect.com/science/article>



- /pii/S0010027713002308). *Cognition* **130** (3): 289–299. doi:10.1016/j.cognition.2013.11.012 (<https://dx.doi.org/10.1016%2Fj.cognition.2013.11.012>).
17. Couchman, J. J. (2011). "Self-agency in rhesus monkeys" (<http://rsbl.royalsocietypublishing.org/content/early/2011/06/29/rsbl.2011.0536.short?rss=1>). *Biology Letters* **8** (1): 39–41. doi:10.1098/rsbl.2011.0536 (<https://dx.doi.org/10.1098%2Frsbl.2011.0536>). PMC 3259954 (<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3259954>). PMID 21733868 (<https://www.ncbi.nlm.nih.gov/pubmed/21733868>).
  18. Teas, J., Richie, T., Taylor, H., and C. Southwick. "Population Patterns and Behavioral Ecology of Rhesus Monkeys (*Macaca Mulatta*) in Nepal." *The Macaques: Studies in ecology, behavior, and evolution*. Lindenburg, D. San Francisco: Van Nostrand Reinhold Company, 1980
  19. Judge, P. and F. Waal (1997). "Rhesus monkey behaviour under diverse population densities: coping with long-term crowding". *Animal Behavior* **54** (3): 643–662. doi:10.1006/anbe.1997.0469 (<https://dx.doi.org/10.1006%2Fanbe.1997.0469>).
  20. Waal, F. "Codevelopment of dominance relations and affiliative bonds in rhesus monkeys." *Juvenile Primates: Life History, Development, and Behavior*. Pereira, M., and L. Fairbanks. New York: Oxford University Press, 1993.
  21. Hill, D., Okayasu, N. (1996) "Determinants of dominance among female macaques: nepotism, demography and danger." *Evolution and Ecology of Macaque Societies*. Fa, J. and D. Lindburg. Cambridge: Cambridge University Press
  22. Gouzoules H., Gouzoules S., Tomaszycski M. (1998). "Agonistic screams and the classification of dominance relationships: are rhesus monkeys fuzzy logicians?". *Animal Behaviour* **55** (1): 51–60. doi:10.1006/anbe.1997.0583 (<https://dx.doi.org/10.1006%2Fanbe.1997.0583>). PMID 9480671 (<https://www.ncbi.nlm.nih.gov/pubmed/9480671>).
  23. Thierry, B (1985). "Social development in three species of macaque (*Macaca mulatta*, *M. fascicularis*, *M. tonkeana*): A preliminary report on the first ten weeks of life". *Behavioral Processes* **11**: 89–95. doi:10.1016/0376-6357(85)90105-6 (<https://dx.doi.org/10.1016%2F0376-6357%2885%2990105-6>).
  24. Maestripieri D. (1999) "Primate social organization, gestural repertoire size, and communication dynamics: a comparative study of macaque s". In: King BJ, editor. *The origins of language: what nonhuman primates can tell us*. Santa Fe (NM): School American Research Pr. p 55-77.
  25. Rowe N. (1996) *The pictorial guide to the living primates*. East Hampton (NY): Pogonias Pr.
  26. Partan SR (2002). "Single and multichannel signal composition: facial expressions and vocalizations of rhesus macaques (*Macaca mulatta*)". *Behaviour* **139** (2–3): 993–1027. doi:10.1163/15685390260337877 (<https://dx.doi.org/10.1163%2F15685390260337877>).
  27. Hauser MD (1998). "Functional referents and acoustic similarity field playback experiments with rhesus monkeys". *Anim Behav* **55** (6): 1647–58. doi:10.1006/anbe.1997.0712 (<https://dx.doi.org/10.1006%2Fanbe.1997.0712>). PMID 9642008 (<https://www.ncbi.nlm.nih.gov/pubmed/9642008>).
  28. Lindburg DG. (1971) "The rhesus monkey in north India : an ecological and behavioral study". In: Rosenblum LA, editor. *Primate behavior: developments in field and laboratory research, Volume 2*. New York : Academic Pr. p 1-106.
  29. Patel, E.R. and M.J. Owren "Acoustic and Behavioral Analyses of 'Gecker' Distress Vocalizations in Young Rhesus Macaques (*Macaca Mulata*) (Abstract) (<http://onlinelibrary.wiley.com/doi/10.1002/ajp.20027/abstract>)" *American Journal of Primatology* Vol 62, Issue Supplement 1. 11 May 2004. p. 48.
  30. Bercovitch F (1997). "Reproductive Strategies of Rhesus Macaques". *Primates* **38** (3): 247–263. doi:10.1007/BF02381613 (<https://dx.doi.org/10.1007%2FBF02381613>).
  31. Walker ML, Herndon JG (2008). "Menopause in nonhuman primates?" (<https://www.ncbi.nlm.nih.gov>

- /pmc/articles/PMC2553520). *Biology of Reproduction* **79** (3): 398–406. doi:10.1095/biolreprod.108.068536 (https://dx.doi.org/10.1095%2Fbiolreprod.108.068536). PMC 2553520 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2553520). PMID 18495681 (https://www.ncbi.nlm.nih.gov/pubmed/18495681).
32. *The pursuit of pleasure* (http://books.google.com/books?id=LiyEhQPmRsC&printsec=frontcover#v=onepage&q=monkey%20ejaculate%20withdraw&f=false). Transaction Publishers. 1992. ISBN 978-1-4128-3867-2. Retrieved 19 April 2013.
  33. Berman, C (1992). "Immature siblings and mother-infant relationships among free-ranging rhesus monkeys on Cayo Santiago". *Animal Behavior* **44**: 247–258. doi:10.1016/0003-3472(92)90031-4 (https://dx.doi.org/10.1016%2F0003-3472%2892%2990031-4).
  34. Maestriepieri D (1998). "Parenting Styles of Abusive Mothers in group-living Rhesus Macaques". *Animal Behaviour* **55** (1): 1–11. doi:10.1006/anbe.1997.0578 (https://dx.doi.org/10.1006%2Fanbe.1997.0578). PMID 9480666 (https://www.ncbi.nlm.nih.gov/pubmed/9480666).
  35. Rajala, A. Z., Reininger, K. R., Lancaster, K. M., & Populin, L. C. (2010). "Rhesus monkeys (*Macaca mulatta*) do recognize themselves in the mirror: implications for the evolution of self-recognition". *PLOS ONE* **5**: e12865. doi:10.1371/journal.pone.0012865 (https://dx.doi.org/10.1371%2Fjournal.pone.0012865).
  36. Mitruka, B. M. (1976) *Introduction*. In: Mitruka, B. M., Rawnsley, H. M., Vadehra, D. V., (eds.) *Animals for medical research: models for the study of human disease*. New York: Wiley & Sons. p 1–21.
  37. "Kansan among first to go to space" (http://www.kansas.com/2010/03/22/1236075/kansan-among-first-to-go-to-space.html), *Wichita Eagle and Kansas.com*, March 22, 2010.
  38. "GM monkey first" (http://news.bbc.co.uk/2/hi/science/nature/1112171.stm). *BBC News*. BBC. 11 January 2001. Retrieved 13 February 2015.
  39. [1] (http://www.egriffinresearch.org/about-elizabeth/)
  40. A Drop of Virus From a Monkey Kills a Researcher in 6 Weeks, By RICK BRAGG, New York Times, December 14, 1997 (http://www.nytimes.com/1997/12/14/us/a-drop-of-virus-from-a-monkey-kills-a-researcher-in-6-weeks.html)
  41. "Yerkes 'family' pulled together after death of young researcher from rare Herpes B infection" (http://www.emory.edu/EMORY\_REPORT/erarchive/1998/January/erjanuary.12/1\_12\_98Yerkes.html). Emory.edu. 1998-01-12. Retrieved 2015-03-09.
  42. Zahn, L. M., Jasny, B. R., Culotta, E., and Pennisi, E. (2007-04-13). "A Barrel of Monkey Genes". *Science* **316** (5822): 215. doi:10.1126/science.316.5822.215 (https://dx.doi.org/10.1126%2Fscience.316.5822.215).
  43. "DNA sequence of Rhesus macaque has evolutionary, medical implications" (http://www.bcm.edu/news/item.cfm?newsID=853) (Press release). Human Genome Sequencing Center. 13 April 2007. Retrieved 2007-04-15.
  44. P. Peticone, M. Rizzoni, F. Palitti, P. di Chiara (July 1974). "Banding patterns of the chromosomes of the Rhesus monkey (*Macaca mulatta*)" (http://www.sciencedirect.com/science/article/pii/0047248474900232). *Journal of Human Evolution* **3** (4): 291–295. doi:10.1016/0047-2484(74)90023-2 (https://dx.doi.org/10.1016%2F0047-2484%2874%2990023-2).
  45. Rhesus Macaque Genome Sequencing and Analysis Consortium (2007) *The rhesus macaque genome*. *Science*, 2007, vol. 316, no. 5822: 235-237
  46. Rhesus Macaque Genome Sequencing and Analysis Consortium (2007) *Evolutionary and biomedical insights from the rhesus macaque genome* *Science*, Vol. 316, No. 5822. (13 April 2007): 222-234
  47. Cilloniz, Cristian; Shinya, Kyoko Peng, Xinxia Korth, Marcus J. Proll, Sean C. Aicher, Lauri D. Carter, Victoria S. Chang, Jean H. Kobasa, Darwyn Feldmann, Friedericke Strong, James E. Feldmann, Heinz Kawaoka, Yoshihiro Katze, Michael G. (2009). Diamond, Michael S, ed. "Lethal Influenza Virus Infection in Macaques Is

Associated with Early Dysregulation of Inflammatory Related Genes" (<http://dx.doi.org/10.1371%2Fjournal.ppat.1000604>). *PLoS Pathogens* **5** (10): e1000604. doi:10.1371/journal.ppat.1000604 (<https://dx.doi.org/10.1371%2Fjournal.ppat.1000604>).

48. Brown, Joseph N.; Palermo, Robert E. Baskin, Carole R. Gritsenko, Marina Sabourin, Patrick J. Long, James P. Sabourin, Carol L. Bielefeldt-Ohmann, Helle García-Sastre, Adolfo Albrecht, Randy Tumpey, Terrence M. Jacobs, Jon M. Smith, Richard D. Katze, Michael G. (15 November 2010). "Macaque Proteome Response to Highly Pathogenic Avian Influenza and 1918 Reassortant Influenza Virus Infections" (<http://jvi.asm.org/content/84/22/12058.abstract>). *J Virol* **84** (22): 12058–12068. doi:10.1128/jvi.01129-10 (<https://dx.doi.org/10.1128%2Fjvi.01129-10>). Retrieved 11 March 2013.

## External links

- ARKive**: images and movies of the rhesus macaque *Macaca mulatta* ([http://www.arkive.org/species/GES/mammals/Macaca\\_mulatta/](http://www.arkive.org/species/GES/mammals/Macaca_mulatta/))
- Brain Maps and Brain Atlases of rhesus Macaque** (<http://brainmaps.org>)
- Primate Info Net: *Macaca mulatta* Factsheet** ([http://pin.primate.wisc.edu/factsheets/entry/rhesus\\_macaque](http://pin.primate.wisc.edu/factsheets/entry/rhesus_macaque))
- University of Michigan Museum of Zoology's Animal Diversity Web: *Macaca mulatta*** ([http://animaldiversity.ummz.umich.edu/site/accounts/information/Macaca\\_mulatta.html](http://animaldiversity.ummz.umich.edu/site/accounts/information/Macaca_mulatta.html))
- Macaca mulatta* Genome** (<http://www.rhesusgenome.org>)
- Rhesus Play** (<http://www.media-generation.com/DVD%20PAGES/Rhesus/Rhesus.htm>) Film analysis of agonistic play by Don Symons (UCSB) on DVD
- View the Macaque genome** ([http://www.ensembl.org/Macaca\\_mulatta/Info/Index/](http://www.ensembl.org/Macaca_mulatta/Info/Index/)) in Ensembl.



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