

Coppery titi monkeys (*Plecturocebus cupreus*) in Biomedical Research

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Coppery titi monkeys, *Plecturocebus cupreus*, are a South American primate in the family Pitheciidae, who are used in behavioral, bonding, communication and neuropsychologic research. California National Primate Research Center (CNPRC) is the only national primate research center that holds a colony of Coppery titi



monkeys.

Biology: There are currently 34 species of titi monkeys. Coppery titi monkeys are classified in the Family Pitheciidae. [11,12] Titi monkeys display typical platyrrhine primitive morphology. Platyrrhine, which translates to “flat nose”, refers to the flat muzzle

and lateral nares in these New World Monkeys. However, when compared to other platyrrhine species, titi monkeys have shorter canines and display no sexual dimorphism. [12] Coppery titi monkeys have coarse hair covering their elongated bodies and tails. Their hair color varies within the species of titi monkeys. Coppery titi monkeys have chestnut reddish colored hair around their face and chest. Female titi monkeys vary in length from 29-42 cm, while males are mildly longer with an average length around 30-45 cm. [6,7,9,10,23] Additionally, their tail can measure 1/3 of their overall body length. Titi monkeys vary in weight ranging from 0.9-1.5 kg, and the maximum lifespan in captivity is approximately 25 years. [10,14,15,20,27] Coppery titi monkey’s conservation status in the wild is denoted as: “Least Concern”. [20]

Habitat in the Wild: Coppery titi monkeys are native to the Amazon forest in Peru and Brazil, South America. Titi monkeys are quadrupeds; however, they enjoy leaping and have an arboreal habitat preference in the middle of the canopy. [6,7,9] Coppery titi monkeys are frugivores and primarily eat fruits in the wild as well as plant material. They are diurnal and feed throughout the day. [23] Most importantly, titi monkeys reside in tight knit family groups. [13,17,18,19]



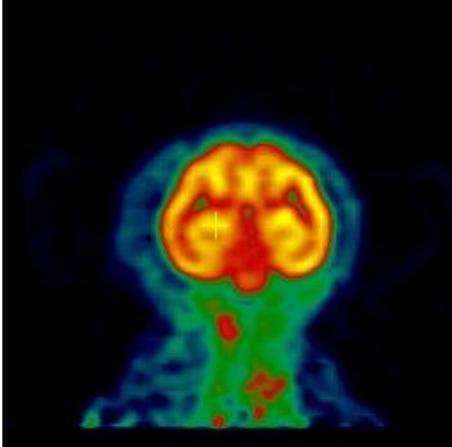
Habitat at CNPRC: Titi monkeys reside in their family groups or pair bonds in vertical enclosures with manzanita wood and enrichment devices to mimic the Amazon canopy.

Reproduction: Titi monkeys are socially monogamous in which they form pair bonds. They are noted to intertwine their tails when together, displaying their attachment. Various research studies indicate both sexes participate in leading a family group. Unlike other non-human primate species, the sire is the primary care takers of the infants. [4,5] Titi monkeys have singleton births with a gestation length approximately 128-132 days. Young adults leave the family group around 2-3 years of age. [11]

Vocalization: Titi monkeys are highly vocal with a variety of communication methods. For example, they use “chirping” calls between each other during foraging, but “bellow calls” between pairs at sunrise. Neighboring family groups are noted to respond to the “bellow” calls. In addition to their vast communication network, olfactory cues used are utilized. “Chest rubbing” is seen in males as they rub their chest on branches to mark their territory via their scent gland. [21] Their intricate communication system has been extensively studied at CNPRC.

Model for Neurobiology of Pair Bonds: These socially monogamous pairs have been used as a neural model to assess mediation of pair bonds and attachment. Both oxytocin (OT) and arginine vasopressin (AVP) are known mediators in mammalian pair bonds. [22,26,27] Oxytocin receptors (OTR) and AVP receptors (specifically AVPR1a), in titi monkeys were found to be in an area of the brain

which modulates visual and sensory stimuli.^[4,5,6] In coppery titi monkeys OTR expression was more prevalent when compared to Rhesus macaques (*Macaca mulatta*) and marmosets (*Callithrix jacchus*). Likewise, AVPR1a expression was greater in the brains of coppery titi monkeys as well.^[5]



Advanced imaging has been utilized to examine changes in cerebral glucose metabolism during the formation and maintenance of pair bonds. These include positron emission tomography (PET) scans along with structural magnetic resonance imaging (MRI). During a one-week duration of pairing there was an increase in cerebral glucose metabolism observed.^[25] The figure to the left depicts a PET scan from a titi monkey at the level of the hippocampus.

Studies involving pharmacological effects have also been performed at the CNPRC. These studies have focused on the influence of pharmacological manipulation on pair bonds. Titi monkeys display increased locomotion, vocalization and increased hormonal cortisol changes when separated from their pair mate. Titi monkeys displayed increased locomotion and an increased cortisol response following naloxone treatment, but after morphine administration, a μ -opioid, the cortisol response was reduced. Overall, “ μ opioid receptor agonists were determined to have an anxiolytic effect, while the opioid antagonist, naloxone, had anxiogenic effects.”^[5]

Autism Spectrum Disorder Research:

Oxytocin is a neurotransmitter and hormone produced by the hypothalamus that is involved in regulation of the hypothalamic-pituitary axis and has been linked in previous research to social and nonsocial behaviors.^[26,28] In human research and clinical trials, intranasally administered oxytocin has been utilized as a potential treatment for autism spectrum disorder and schizophrenia.^[1,8,22] Like humans, coppery titi monkeys form strong pair bonds, exhibit social attachment, and OT has high homology between the titi monkey and humans. This species has been studied to determine the correlation between intranasally oxytocin and changes in

social behaviors and interactions. Collectively, the attributes of this species make it an ideal model for understanding human social interactions. ^[5,6]

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