Soini, P. 1982. Ecology and population dynamics of the pygmy marmoset, *Cebuella pygmaea*. *Folia Primatol.* 39:1-21.

Soini, P. 1988. The pygmy marmoset, genus *Cebuella*. In: *Ecology and Behavior of Neotropical Primates, Vol. 2*, R. A. Mittermeier, A. B. Rylands, A. F. Coimbra-Filho and G. A. B. da Fonseca (eds.), pp.79-129. World Wildlife Fund, Washington, D.C.

Spix, J. de. 1823. Simiarum et Vespertilionum Brasiliensium species novae ou Histoire Naturelle des Espèces Nouvelles de Singes et de Chauves-souris observées et recueillies pendant le voyage dans l'intérieur du Brésil. *Typis Francisci Seraphici Hubschmanni, Monachii.*

Thomas, O. 1922. On the systematic arrangement of the marmosets. *Ann. Mag. Nat. Hist.* (9)9: 196-199.

Hybridization in Free-Ranging *Callithrix flaviceps* and The Taxonomy of The Atlantic Forest Marmosets

Marmosets of the genus *Callithrix* are usually placed in two species groups on the basis of their morphology and distribution: The *Callithrix argentata* and the *Callithrix jacchus* groups. The tufted-ear marmosets, *Callithrix jacchus* group, are found in central and eastern Brazil, represented by the following distinct parapatric forms: *C. jacchus, C. aurita, C. flaviceps, C. geoffroyi, C. penicillata and C. kuhli*: the taxonomy of which has been the subject of some discussion (Hershkovitz, 1977; Mittermeier and Coimbra-Filho, 1981; Vivo, 1988; Rylands *et al.*, 1993).

The presence or absence of natural hybrids has been a moot point for the discussion of the taxonomy of the *Callithrix jacchus* group (Coimbra-Filho and Mittermeier, 1973; Hershkovitz, 1977; Coimbra-Filho *et al.*, 1993; Marroig, 1995). Unfortunately, much of the debate has been based on museum specimens or captive animals which, in the majority of cases, are not representative of contact zone populations.

In an interesting article discussing the controversy about whether the Atlantic forest and central Brazilian marmosets are species or subspecies, Marroig (1995) proposed that the debate be postponed until new data on hybrid zones arise. He stated that there are few localities where hybrids exist between the species of eastern Brazil, and that records of hybrid zones are absent, beyond that of *C. jacchus* and *C. penicillata* reported by Alonso *et al.* (1987).

Contrary to Marroig's assertions, my field data have indicated that there has always been hybridization in contact zones between species of the *Callithrix* jacchus group (see also Coimbra-Filho *et al.*, 1993). In fact, the only contact zone where I failed to find evidence of natural hybridization was between *C. aurita* and *C. penicillata* in the state of São Paulo. I believe, however, that further fieldwork will probably uncover a hybrid zone there as well.

The buffy-headed marmoset, *C. flaviceps*, inhabits the highlands of the Atlantic Forest of Espírito Santo and eastern Minas Gerais, south of the Rio Doce, and has the smallest geographical range among the forms of *C. jacchus* group (Hershkovitz, 1977; Coimbra-Filho *et al.*, 1981; Ferrari and Mendes, 1991; Mendes, 1993). It is listed as endangered by the World Conservation Union (IUCN) and as threatened in the Brazilian national list (see Bernardes *et al.*, 1990). As in other marmosets, habitat destruction is the major threat, although recent studies have shown that these monkeys are relatively tolerant of habitat disturbance and fragmentation (Ferrari and Mendes, 1991; Diego *et al.*, 1993).

As was pointed out by Rylands *et al.* (1993), the occurrence of typical *C. flaviceps* in the north of the state of Rio de Janeiro is unlikely. I found *C. aurita* as far north as Natividade, and in the extreme north of this state there is probably a hybrid zone between *C. aurita and C. flaviceps* (Mendes, 1993). Recent attempts to obtain new information on the geographic distribution of these marmosets have revealed contact zones of *C. flaviceps* with *C. geoffroyi* in the state of Espírito Santo, and with *C. aurita* in the state of Minas Gerais. Hybrids were found in three sites in Espírito Santo in the contact zone between *C. flaviceps* and *C. geoffroyi*, in the municipalities of Santa Teresa and Santa Leopoldina, and in three sites in Minas Gerais, in the contact zone between *C. flaviceps* and *C. aurita*, in the municipality of Carangola and Ipanema (Mendes, 1993).

In the two sites in Santa Teresa, there were mixed groups containing hybrids as well as apparently typical *C. flaviceps* and *C. geoffroyi*. At one of these sites, the Santa Lúcia Biological Station, I saw a group composed only of *C. geoffroyi* about 500 m from the mixed groups. Groups consisting only of hybrids were not observed. In Santa Leopoldina, groups of *C. flaviceps* were found at altitudes between 500 and 650 m asl, while a group of hybrids was seen at 500 m asl. It was not possible, however, to determine whether the latter contained animals other than hybrids. A group consisting only of *C. geoffroyi* was observed at a site approximately 1 km to the southeast of this area.

In many ways, the coloration of the head and ear tufts of the *C. flaviceps* x *C. geoffroyi* hybrids is similar to that of hybrids of *C. flaviceps* x *C. jacchus* and *C. aurita* x *C. kuhli* described by Coimbra-Filho *et al.* (1993). The similarity of these hybrids with *C. penicillata* would account for Ávila-Pires' (1969) identification of a specimen from Santa Teresa as *C. penicillata*, which Hershkovitz (1977) considered to be a *C. flaviceps* x *C. geoffroyi* hybrid. Groups composed of individuals appearing to be *C. flaviceps* x *C. aurita* hybrids were observed at two localities in forest fragments near Carangola. Some of the individuals were similar in coloration to either *C. flaviceps* or *C. aurita*, while the majority exhibited intermediate patterns. A group with similar intermediate color patterns

was observed in Ipanema, about 10 km from the Estação Biológica de Caratinga, where *C. flaviceps* has been studied by Ferrari and Diego (1992).

The formation of reproductive mixed groups and the production of hybrids between *C. geoffroyi* and *C. flaviceps* indicates that reproductive isolation is incomplete. Nonetheless, the presence of apparently non-hybrid groups next to the hybrids suggest that genetic interchange is reduced, indicating a degree of reproductive isolation consistent with the view of these two forms as distinct species. This is reinforced by the aberrant color patterns of the *C. flaviceps* x *C. geoffroyi* hybrids, which possibly resemble an ancestral phenotype. The existence of reproductive groups apparently composed entirely of hybrids of *C. flaviceps* with *C. aurita* with intermediate color patterns suggests that reproductive barriers between these two forms are less well defined than those between *C. flaviceps* and *C. geoffroyi*. The closer phylogenetic proximity between *C. flaviceps* and *C. aurita* in relation to other *C. jacchus* group forms has been pointed out by Hershkovitz (1977) and Natori (1986), supporting Coimbra-Filho's (1990) position that they are forms of the same species and the suggestion of Rylands *et al.* (1993) for a new grouping: the "Aurita group" (*C. aurita* and *C. flaviceps*) and "Jacchus group" (*C. penicillata*, *C. jacchus*, *C. kuhli*, and *C. geoffroyi*). My analyses of the vocalizations of the traditional *C. jacchus* group are consistent with this grouping, but stronger evidence may be required to justify treating the "Aurita group" as a single species and the new "Jacchus group" as four species.

I agree with Marroig (1995) that natural hybridization in itself does not justify classifying the *Callithrix* forms as subspecies. However, the present data demonstrate that there are different degrees of reproductive isolation among neighboring forms of the *C. jacchus* group and across different hybrid zones. Genetic studies on hybrids and neighboring populations are needed. Unfortunately, habitat destruction in eastern Brazil has been a serious problem for the native marmoset population and makes these kinds of studies sometimes extremely difficult to conduct.

Perhaps the controversy about *Callithrix* will persist despite our efforts to understand the phylogeny and taxonomy of these primates. I believe that the debate is, in fact, very useful in that it has stimulated new research in comparative morphology, biogeography, genetics, behavior and ecology, and has been a driving force in the development of our knowledge of these marmosets.

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References

Alonso, C., Faria, D. S. de, Langguth, A., and Santee, D. F. 1987. Variação da pelagem na área de intergradação entre *Callithrix jacchus* e *Callithrix penicillata*. *Rev. Brasil. Biol.* 47(4):465-478.

Ávila-Pires, F. D. 1969. Taxonomia e zoogeografia do gênero *Callithrix* Erxleben, 1777 (Primates, Callitrichidae). *Rev. Brasil. Biol.* 29(1):46.

Bernardes, A. T., Machado, A. B. M., and Rylands, A. B. 1990. *Fauna Brasileira Ameaçada de Extinção*. Fundação Biodiversitas, Belo Horizonte.

Coimbra-Filho, A. F. 1990. Sistemática, distribuição geográfica e situação atual dos símios brasileiros (Platyrrhini, Primates). *Rev. Brasil. Biol.* 50:1063-1079.

Coimbra-Filho, A. F., and Mittermeier, R. A. 1973. New data on the taxonomy of the Brazilian marmosets of the genus *Callithrix* Erxleben, 1777. *Folia Primatol.* 20:241-264.

Coimbra-Filho, A. F., Mittermeier, R. A. and Constable, I. D. 1981. *Callithrix flaviceps* (Thomas, 1903) recorded from Minas Gerais, Brazil (Callitrichidae, Primates). *Rev. Brasil. Biol.* 41(1):141-147.

Coimbra-Filho, A. F., Pissinatti, A., and Rylands, A. B. 1993. Experimental multiple hybridism and natural hybrids among *Callithrix* species from eastern Brazil. In: *Marmosets and Tamarins; Systematics, Behaviour, and Ecology*, A. B. Rylands (ed.), pp.95-120. Oxford University Press, Oxford.

Diego, V. H., Ferrari, S. F. and Mendes, F. D. C. 1993. Conservação do sagüi-da-serra (*Callithrix flaviceps*). O papel de matas particulares. In: *A Primatologia no Brasil - 4*. M. E. Yamamoto and M. B. C. de Sousa (eds.), pp.129-137. Editora Universitária, Universidade Federal do Rio Grande do Norte, Natal.

Ferrari, S. F. and Diego, V. H. 1992. Long-term changes in a wild marmoset group. *Folia Primatol.* 58:215-218.

Ferrari, S. F. and Mendes, S. L. 1991. Buffy-headed marmosets 10 years on. *Oryx* 25:105-109.

Hershkovitz, P. 1977. *Living New World Monkeys (Platyrrhini), With an Introduction to Primates, Vol. I.* Chicago University Press, Chicago.

Marroig, G. 1995. Espécies ou subespécies em *Callithrix*. *Neotropical Primates* 3(1):10-13.

Mendes, S. L. 1993. Distribuição geográfica e estado de conservação de *Callithrix flaviceps* (Primates: Callitrichidae). In: *A Primatologia no Brasil - 4*. M. E. Yamamoto and M. B. C. de Sousa (eds.), pp.139-154. Editora Universitária, Universidade Federal do Rio Grande do Norte, Natal.

Mittermeier, R. A. and Coimbra-Filho, A. F. 1981. Systematics: Species and subspecies. In: *Ecology and Behavior of Neotropical Primates, Vol. 1*, A. F. Coimbra-Filho and R. A. Mittermeier (eds.), pp.29-111. Academia Brasileira de Ciências, Rio de Janeiro.

Natori, M. 1986. Interspecific relationships of *Callithrix* based on the dental characters. *Primates* 27(3):321-336.

Rylands, A. B., Coimbra-Filho, A. F and Mittermeier, R. A. 1993. Systematics, geographic distribution, and some

notes on the conservation status of the Callitrichidae. In: *Marmosets and Tamarins: Systematics, Behaviour, and Ecology*, A. B. Rylands (ed.), pp.11-77. Oxford University Press, Oxford.

Vivo, M. de. 1991. *Taxonomia de* Callithrix *Erxleben, 1777 (Callithrichidae, Primates)*. Fundação Biodiversitas, Belo Horizonte.

Terrestrial Travel in Muriquis (*Brachyteles arachnoides*) Across a Forest Clearing at the Estação Biológica de Caratinga, Minas Gerais, Brazil

Muriqui monkeys (*Brachyteles arachnoides*) have been the subjects of systematic studies at the Estação Biológica de Caratinga (EBC) in Minas Gerais, Brazil, since 1983 (Fonseca, 1983; Strier, 1986, 1992; Mendes, 1990, 1995; Odalia Rímoli, 1992; Rímoli, 1994; Nogueira, 1996). As in many other populations, the EBC muriquis are confined to a protected tract of forest isolated from other forest patches by pasture and fields (Strier and Fonseca, in press). Over the years, researchers have occasionally observed members of the main study group descend to the ground to cross gaps in the canopy or to drink or feed within the forest (Valle *et al.*, 1984). Observations of quadrupedal terrestrial travel have increased over the years as the group has become more habituated to the presence of researchers in remote parts of the forest (Strier, 1992). Nevertheless, it is still rare for muriquis to travel more than a few meters on the ground before climbing back into the canopy, where they spend most of their time and where, until recently, all of their long distance travel occurred.

On 18 November 1996, a subgroup of 41 individuals belonging to the 59 member main study group was monitored as it crossed an open clearing in the forest measuring 20 meters in width. Researchers had been accompanying the muriquis in a part of the forest they seldom use. After a long rest period, the muriquis started to travel until they reached the edge of the open clearing. They stopped suddenly at the forest edge, and began to embrace one another while vocalizing in a prolonged display. Their display was typical of their response during tense situations, such as intergroup encounters (Valle *et al.*, 1984; Strier, 1992) or the proximity of potential predators (Printes *et al.*, 1996). Adults of both sexes participated in the display, which persisted for 39 minutes without pause.

At 1220 h, AR, the only adult female in the subgroup without an infant, was identified at the other side of the clearing although she had not been observed to cross it. She emitted a series of long neighs, which were answered by other members of the group from the far side of the clearing. At 1259 h, CL, one of the oldest adult males present, descended to the ground and walked (quadrupedally) across the 20 m clearing. The rest of the subgroup followed after him in a single line. The sequence of the progression following him was: nine other adult males, then the other 12 adult females with their infants and juveniles, and the last two adult males in the subgroup at the rear. Once the muriquis reached the trees on the far side of the clearing, they resumed traveling in the direction they had originally been heading.

Such a progression is not exceptional, for muriquis at the EBC commonly travel in a single file through the canopy when they are moving rapidly from one part of the forest to another, or when they descend to the ground between adjacent trees. It is also common for older adult females or males to take the lead in group movements, as they did when they crossed the clearing.

Adults are usually active participants during displays toward potential threats. They may have displayed at the clearing in the same way they respond to other threats because they were surprised to discover such an extensive gap in the forest, or because they perceived their vulnerability to predators if they were to cross such an open expanse. Despite their obvious tension, the fact that they ultimately crossed the clearing instead of returning by safer arboreal routes to where they had previously been suggests that foraging needs may have outweighed these other concerns.

The risk of attack from terrestrial predators may be high for muriquis traveling long distances on the ground, particularly in rural areas where semi-feral dogs frequently hunt. The only other report of long distance terrestrial travel we know of for muriquis involved a solitary female from the Rio Casca population, whose only dispersal option from her natal group required her unsuccessful attempt at crossing a pasture to reach a different forest tract (Lemos de Sá, 1988).

Although the EBC muriquis were evidently disturbed when they reached the forest clearing, the fact that this large social unit traversed an expanse of ground may be indicative of their potential to move between forest patches to increase the area of forest available to them. As protected populations such as that at the EBC expand in size (Strier, 1996), such terrestrial movements may permit them to colonize new forests.

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