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Microsciurus flaviventer (Rodentia: Sciuridae)

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Abstract: *Microsciurus flaviventer* (Gray, 1867) is a Neotropical tree squirrel commonly known as the Amazon dwarf squirrel. Small bodied with dark brown dorsal pelage contrasted with a gray or yellowish gray venter, and a faintly banded tail. *M. flaviventer* is 1 of 4 species in the genus *Microsciurus*. The geographic range of *M. flaviventer* extends from the Amazon basin of South America throughout western and southeastern Colombia, Ecuador, southern Peru, Brazil west of Río Negro, and Madeira. It is most commonly associated with evergreen lowland tropical rainforest. Status of *M. flaviventer* is "Data Deficient" under the International Union for Conservation of Nature and Natural Resources *Red List of Threatened Species*; however, loss of habitat is a major concern.

Key words: Amazon basin, Amazon dwarf squirrel, Bolivia, Brazil, Colombia, Ecuador, lowland rainforest, Peru

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Microsciurus Allen, 1895

Macroxus: Gray, 1867:432. Part (description of *flaviventer*); not *Macroxus* F. Cuvier (1823:120).
Sciurus Thomas, 1893:337. Type locality "La Gloria, Chanchamayo."
Microsciurus Allen, 1895:332. Type species *Sciurus* (*Microsciurus*) *alfari* Allen, 1895, by original designation.

Microsciurus flaviventer (Gray, 1867)

Amazon Dwarf Squirrel

Macroxus flaviventer Gray, 1867:432. Type locality "Brazil;" restricted to "the area of Pebas," by Cabrera (1961) based on information published by Thomas (1928).
Sciurus chrysurus: Thomas, 1893:337. Part, not *chrysurus* Pucheran (1845:337).
Sciurus peruanus Allen, 1897:115. Type locality "Guayabamba [= Cajabamba, Cajamarca province], alt. 4000 feet [1219.2 m]."
Sciurus similis Nelson, 1899:78. Type locality "Cali, Cauca Valley, Colombia (alt. 6000 ft. [1828.8 m])."

Fig. 1.—Adult *Microsciurus flaviventer* from Tiputini, Ecuador. Sex unknown. Photo by George Lamson used with permission.

Sciurus simonsi Thomas, 1900:294. Type locality "Porvenir, near Zaparal, Province of Bolivar, Ecuador. Altitude 1500 m."
Sciurus (*Microsciurus*) *peruanus napi* Thomas 1900:295. Type locality "Mouth of Coca River, upper Rio Napo."
Sciurus otinus Thomas 1901:193. Type locality "Medellin, Colombia."
Microsciurus otinus: Allen, 1914:156. Name combination.
Microsciurus simonsi: Allen, 1914:161. Name combination.
Microsciurus peruanus: Allen, 1914:161. Name combination.
Microsciurus napi: Allen, 1914:163. Name combination.
Microsciurus rubrirostris Allen, 1914:163. Type locality "Chanchamayo, central Peru; altitude 2000 m."
Microsciurus florenciae Allen, 1914:164. Type locality "Florencia (altitude 1000 feet [304.8 m]), Caquetá district, Colombia." *Microsciurus avunculus* Thomas, 1914: 574. Type locality "Oriente of Ecuador. Type from Gualaquiza; alt. 2500' [762 m]".
Microsciurus rubricollis Thomas, 1914: 574. No type locality given; incorrect subsequent spelling of *Microsciurus rubrirostris* Allen, 1914.
Microsciurus manarius Thomas, 1920:275. Type locality "Acajutuba, Rio Negro, near its mouth."
Microsciurus sabanillae Anthony, 1922:2. Type locality "Sabanilla, Prov. de Loja, Ecuador; altitude, 5700 feet [1737.36 m]."
Microsciurus flaviventer: Thomas, 1928:290. First use of current name combination.

Context and Content. Order Rodentia, suborder Sciuromorpha, superfamily Sciuroidea, family Sciuridae, subfamily Sciurinae, tribe Sciurini. Moore (1959) placed *Microsciurus* in the tribe Microsciurini.

Eight subspecies of *Microsciurus flaviventer* are currently recognized (Thorington and Hoffmann 2005):

M. f. flaviventer (Gray, 1867:432). See above; *manarius* Thomas is a synonym.
M. f. napi (Thomas, 1900:295). See above; *avunculus* Thomas and *florenciae* Allen are synonyms.
M. f. otinus (Thomas, 1901:193). See above.
M. f. peruanus (Allen, 1897:115). See above.
M. f. rubrirostris Allen, 1914:163. See above; *rubicollis* Thomas is a synonym.
M. f. sabanillae Anthony, 1922:2. See above.
M. f. similis (Nelson, 1899:78). See above.
M. f. simonsi (Thomas, 1900: 294). See above.

Nomenclatural Notes. The Spanish common name for *Microsicurus flaviventer* is la ardilla enana amazónica (Buitron-Jurado and Tobar 2007). Ecuadorian common names for *M. flaviventer* are ardilla chica, ardilla chiquita, and ardillita (Tirira 2004). The Oriente names for *M. flaviventer* are ardilla negra, ardilla negrita, ardilla de bolsillo, ardilla de la pequeña, ardilla matapalera, ardilla matapalo, and ardilla voladora (Tirira 2004). The Achuar-shuar name for *M. flaviventer* is wíchi*n*k and kunamp-rush (Tirira 2004). The Cofán name for *M. flaviventer* is tiriri (Tirira 2004). The Huaorani name for *M. flaviventer* is kemo (Tirira 2004). The Quichua del oriente name for *M. flaviventer* is shitipu (Tirira 2004). The Shiwiar name for *M. flaviventer* is konam and wíching (Tirira 2004). The Siona-se-coyas name for *M. flaviventer* is kʷiri sisi (Tirira 2004). The Matses name for *M. flaviventer* is kapa kudu (Fleck and Voss 2006). The Andoke name for *M. flaviventer* is I'x'siko (Vasco-Palacios et al. 2008). The Muinane name for *M. flaviventer* is Tyityio (Vasco-Palacios et al. 2008). The Uitoto name for *M. flaviventer* is Nopi (Vasco-Palacios et al. 2008).

Recent evidence suggests that *Microsciurus* is polyphyletic (Mercer and Roth 2003; Steppan et al. 2004; Pečnerová and Martínková 2012) as *M. flaviventer* and *M. alfari* occurred on separate nodes (Pečnerová and Martínková 2012). There is no consensus on the location of *M. flaviventer* within the phylogenetic tree and support for positions is weak, perhaps due to markers used in analyses, *mtcyb*, *irbp*, *12S* ribosomal, *16S* ribosomal, and *c-myc* exon 3, which are better predictors of deep nodes than recent nodes (Mercer and Roth 2003; Steppan et al. 2004; Pečnerová and Martínková 2012). Additionally, the congener *M. alfari* is positioned more distant from *M. flaviventer* than expected (Pečnerová and Martínková 2012). Further work is required to elaborate on the phylogenetic relationship of *Microsciurus* and sister taxa (Mercer and Roth 2003). A detailed analysis on the evolutionary relations of *M. flaviventer* subspecies is also recommended (Pečnerová and Martínková 2012).

DIAGNOSIS

The only sympatric congeners of *Microsciurus flaviventer* are *M. mimulus* (western dwarf squirrel—Eisenberg 1989; Emmons and Feer 1997; Eisenberg and Redford 1999) and *M. santanderensis* (Santander dwarf squirrel—Thorington et al. 2012). In western Colombia, *M. flaviventer* differs from *M. mimulus* in that *M. flaviventer* is larger (*M. mimulus* is about 81% the body size of *M. flaviventer*). In *M. flaviventer*, length of head and body is 120–160 mm with a mass of 80–132 g (Eisenberg 1989; Eisenberg and Redford 1999; Hayssen 2008; Thorington et al. 2012), compared to 128–150 mm in body length and mass of 120 g in *M. mimulus* (Emmons and Feer 1997; Hayssen 2008). *M. flaviventer* has an agouti brown dorsal pelage and a banded tail (Fig. 1), whereas *M. mimulus* has a grizzled black dorsum with a pale orange buff on hair tips and no rings on its tail (Eisenberg and Redford 1999). *M. santanderensis* possesses a faint black spot on the top of the head with a cinnamon tinge, a faint middorsal black line and a pinkish buff venter (Borrero-H and Hernandez-Camacho 1957) but overlaps with *M. flaviventer* in all external measures (length of head and body [mm], 133.5–156.0—Eisenberg 1989; Hayssen 2008).

Subspecies differ slightly in pelage color. *M. f. flaviventer* can be distinguished from other subspecies by a darkish olive pelage and the middle of the dorsum is darker than other subspecies (Thorington et al. 2012). *M. f. peruanus* and *M. f. napi* have large white postauricular patches; however, *M. f. napi* can be distinguished by a yellowish rufous venter (Thomas 1900; Allen 1914; Thorington et al. 2012). *M. f. rubrirostris* has a yellow frosted tail and orange ochraceous venter (Allen 1914; Thorington et al. 2012). Similar to *M. f. rubrirostris*, *M. f. sabanillae* has an ochraceous venter; however, *M. f. sabanillae* lacks postauricular patches (Anthony 1922; Thorington et al. 2012). *M. f. simonsi* is an unspotted form with a yellow eye ring and fulvous venter (Thomas 1900; Thorington et al. 2012). *M. f. otinus* is an isolated subpopulation in central northern Colombia and has white tipped ears and white frosted tail (Thomas 1901; Thorington et al. 2012). Another isolated subspecies is *M. f. similis* in southern Colombia, and lacks auricular and postauricula patches and has an orange rufous venter (Nelson 1899; Allen 1914; Thorington et al. 2012).

Other small squirrels sympatric with *M. flaviventer* are the Neotropical pygmy squirrel (*Sciurillus pusillus*), Sanborn's squirrel (*Sciurus sanborni*), Guianan squirrel (*Sciurus aestuans*), and Bolivian squirrel (*Sciurus ignitus*—Emmons and Feer 1997). *S. pusillus* is considerably smaller (length: 89–115 mm; mass 33–45 g) than *M. flaviventer* (*S. pusillus* is about 35% the body mass of *M. flaviventer*) and has a pale gray pelage, compared to the agouti brown pelage of *M. flaviventer* (Emmons and Feer 1997). *S. sanborni* (length: 152–175 mm; mass not available), *S. aestuans* (length: 160–202 mm; mass 159–218 g), and *S. ignitus* (length: 180–195 mm; mass 225–240 g) are distinguishable from *M. flaviventer* by long ears that protrude above the crown of the head (Emmons and Feer 1997). Furthermore, *M. flaviventer* is distinguishable from other *Sciurus* species by several cranial features. In *M. flaviventer*, the postorbital process is almost directly over the base of the posterior root of the zygomatic arch, the postglenoid foramen pierces the squamosal bone, the upper 3rd premolars are present and the upper incisors are pro-odont, and there is 1 pair of transbullar septae (Fig. 2; Salazar-Bravo et al. 2002).

Fig. 2.—Dorsal, ventral, and lateral views of skull and lateral view of mandible of an adult (sex unknown) *Microsciurus flaviventer* (American Museum of Natural History [AMNH] #73357) from Puerto Indiana, Maynas, Loreto, Peru. Photographs taken by J. Zirato. Greatest length of skull is 38.5 mm.

GENERAL CHARACTERS

Microsciurus flaviventer has a reddish brown to olivaceous dorsum with a small, pale yellow postauricular patch (Gray 1867; Patton et al. 2000). Venter ranges in color from yellow, pale orange, or grayish. The venter is brightest in the chest area and not sharply defined from the dorsal pelage (Emmons and Feer 1997). The ears are very short (below the crown of the head) and are covered in short, pale hairs. The tail is shorter than the body, slender and tapered toward the tip, and is faintly banded with pale yellow to orange and frosted with white hair (Emmons and Feer 1997; Eisenberg and Redford 1999; Patton et al. 2000; Fig. 1).

Length of head and body in *M. flaviventer* ranges between 120 and 160 mm; length of tail is 80–155 mm; hind foot length is 39–43 mm; and ear length is 16–17 mm (Eisenberg 1989; Eisenberg and Redford 1999). *M. flaviventer* body mass ranges from 86.2 to 132 g (Eisenberg and Redford 1999; Hayssen 2008). Measurements taken from confirmed male and female specimens suggest that females are slightly smaller than males in head and body length (males = 136.3 mm, females = 133.5 mm), tail length (males = 110 mm, females 109.9 mm), and mass (males = 98.0 g, females = 86.2 g—Hayssen 2008).

The coronoid process in *M. flaviventer* is reduced and anteriorly displaced relative to arboreal dwarf squirrels (flying squirrels, *Petaurillus* and *Petinomys*) and the condylar process is reduced to low prominence and is recurved to form a hook (Hautier et al. 2009). The lower mandible in *M. flaviventer* is distinguishable from phylogentically related species of *Sciurus* by slight differences, including a shortened coronoid, an elongated condyloid, and a smaller diastema (Swiderski and Zelditch 2010). Ranges (mm) of cranial measurements from 22 *M. flaviventer* specimens were: greatest length of skull, 35.3–40.3; greatest zygomatic breadth, 20.5–24; interorbital breadth, 12.4–14.3;

breadth of braincase, 17.6–19; and length of nasals, 9–11 (Allen 1914). *M. flaviventer* can be distinguished from *S. pusillus* by a smaller skull (greatest length of skull, 28.1 mm; greatest zygomatic breadth, 19.6; interorbital breadth, 11.6; breadth of braincase, 15.0; and length of nasals, 8.0—Jessen et al. 2013).

DISTRIBUTION

Microsciurus flaviventer is found in the Amazon basin of South America throughout western and southeastern Colombia, Ecuador, southern Perú, Brazil west of Río Negro, and Madeira (Emmons and Feer 1997; Eisenberg and Redford 1999; Patton et al. 2000). Recent observations in Santa Rosa, Bolivia (Salazar-Bravo et al. 2002) represent the southernmost recorded distribution (Fig. 3). *M. flaviventer* occurs primarily in lowland and foothill regions of the Andes up to 2,000 m in elevation (Emmons and Feer 1997; Eisenberg and Redford 1999).

There are 2 groups of subspecies: 1 group of 2 subspecies occurs in western Colombia, whereas a 2nd group, containing the remaining 6 subspecies, occurs in the Amazon basin. The distribution of the 8 recognized subspecies of *M. flaviventer* cannot be fully ascertained beyond where type specimens were collected, and accurate geographical boundaries that separate each of these subspecies remain unclear (Fig. 3). No fossils of *M. flaviventer* are known.

FORM AND FUNCTION

In the genus *Microsciurus*, normal vertebral numbers are 7 C, 12 T, 7 L, and 3 S, total 29. Nevertheless, some specimens of *M. flaviventer* have been documented to have 4 sacral vertebrae (Thorington and Thorington 1989). The dental formula for *M. flaviventer* is i 1/1, c 0/0, p 2/1, m 3/3, total 22 (Allen 1914).

The foreleg limb bones of *M. flaviventer* are unique in their proportions, with the humerus equal in length to the radius. Longer forelimbs in the Amazon dwarf squirrel increase the squirrel's ability to climb larger diameter trees and to allow the squirrel to spend considerable time in a vertical position on the tree while foraging (Thorington and Thorington 1989). In tree squirrels, forelimb muscles from the trunk attach at midshaft on the humerus, decreasing the mobility of the shoulder. Longer forelimbs can compensate for this lack of mobility and allow the

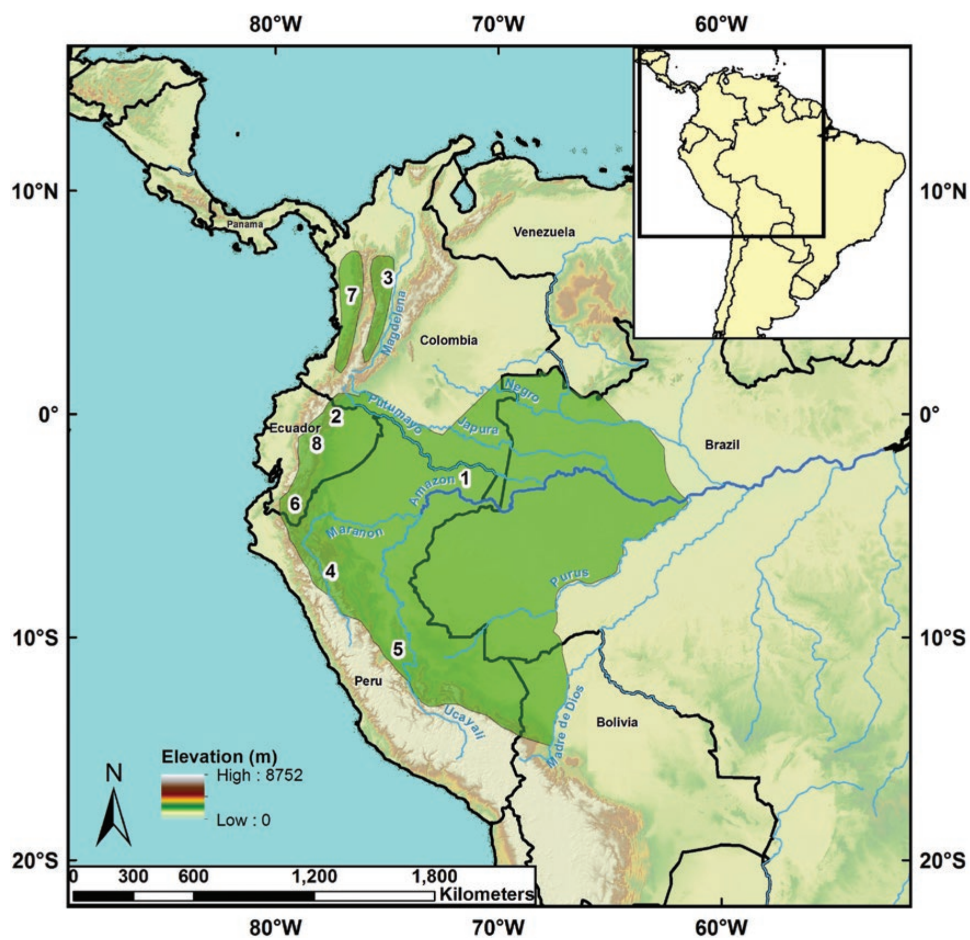

Fig. 3.—Geographic distribution of *Microsciurus flaviventer.* Subspecies ranges are not shown as accurate geographical boundaries are unclear. Approximate type localities for each subspecies are: 1, *M. f. flaviventer*; 2, *M. f. napi*; 3, *M. f. otinus*; 4, *M. f. peruanus*; 5, *M. f. rubrirostris*; 6, *M. f. sabanillae*; 7, *M. f. similis*; and 8, *M. f. simonsi*.

squirrel to climb larger trees (Thorington and Thorington 1989). Additionally, longer hind limbs of *M. flaviventer* (86–92% of the body length versus 71–72% in larger squirrel species) provide extra force during leaping and bounding (Thorington and Thorington 1989; Youlatos 1999). *M. flaviventer*, a smaller squirrel, needs more force to leap over the same gap as a larger squirrel, and *M. flaviventer* compensates with longer hind limbs (Thorington and Thorington 1989).

The mandible demonstrates a strong trend toward dwarfism with an abbreviated coronoid process anteriorly displaced and a condylar process that is reduced to a low prominence and is curved backward like a hook (Fig. 2; Hautier et al. 2009); however, the coracoid process is poorly developed relative to dwarf flying squirrels (*Petaurillus*—Michaux et al. 2008; Hautier et al. 2009). It is likely that dwarf squirrels use their coronoid process for grasping and removing fragments of bark from trees (Hautier et al. 2009).

ONTOGENY AND REPRODUCTION

There is almost no information describing the ontogeny and reproduction of *Microsciurus flaviventer*. Documented litter size is small, with 1 female specimen carrying 2 embryos (Eisenberg and Redford 1999). A lactating female *Microsciurus flaviventer* was recorded in November by Hice (2003). Six mammae occur in females (Allen 1914; Emmons and Feer 1997; Eisenberg and Redford 1999). At the headwaters and central Rio Juruá, 4 male specimens with scrotal testes were collected in October, the dry season, and February, the wet season (Patton et al. 2000).

ECOLOGY

Microsciurus flaviventer lives in lowland and foothill forests of the Andes between < 100 up to about 2,000 m, and persists in lightly disturbed forests (Eisenberg and Redford 1999; Mena and Medellin 2010). *M. flaviventer* is most commonly associated with evergreen lowland tropical rainforest and individuals have been observed in all forest levels, from forest floor to canopy, although they are more frequently observed in the understory (Youlatos 1999; Buitron-Jurado and Tobar 2007). However, in Bolivia, *M. flaviventer* has been documented in subtropical forest patches consisting of small diameter trees (4–20 cm diameter at breast height), spiny cactus (no scientific name provided), and a few large trees in the genera *Hevea* and *Bertholletia* (Salazar-Bravo et al. 2002).

Density of *M. flaviventer* at 2 locations in Ecuador was estimated as 0.1 and 1.6 individuals/10 km transect; and density estimates of 0.3 individuals/10 km transect were estimated in Peru (Emmons 1984). A 2nd, more recent survey estimated a density of 51.07 ± 21.9 squirrels/km^2 (Zapata-Rios et al. 2006).

Nests (or dreys) have been described as a bolus of leaves lined with plant fibers (Emmons and Feer 1997). One such nest was located 3.5 m from the ground in the top of a small palm (Emmons and Feer 1997).

Microsciurus flaviventer actively forages for arthropods on the boles of large trees as well as vines and downed logs. *M. flaviventer* strips and eats bark (Moynihan 1976) and a substance scraped from bark of live trees such as *Inga* (Emmons and Feer 1997). *M. flaviventer* feeds on fungi and potentially on frog eggs (Vasco-Palacios et al. 2008).

Two species of sucking lice (suborder: Anoplura; *Hoplepleura sciuricola* and an undescribed species of *Enderleinellus*) were reported on *M. flaviventer* specimens collected from the Manu Biosphere Reserve, Peru (Smith et al. 2008). In the Peruvian Amazon, a survey for the hard-backed tick *Ixodes luciae* (Order Ixodida), which uses small rodents during the subadult life stage, did not record this ectoparasite from the 2 collected specimens of *M. flaviventer* (Diaz et al. 2009).

One report describes *M. f. napi* partitioning food resources with the pygmy marmoset (*Cebuella pygmaea*), a species of Callitrichinae monkey, in the Putumayo region of Colombia (Moynihan 1976). The 2 species used the trunk of the same tree (*Inga*) for feeding, but at different times of the day. In contrast to the diurnal activity of *M. flaviventer*, the pygmy marmoset is more crepuscular in foraging and drills its incisors into the bole of the tree to obtain exudates (Moynihan 1976). This temporal division allows the 2 similarly sized species to occur and feed in the same areas (Moynihan 1976).

Microsciurus flaviventer has been observed to follow mixed-species flocks of tropical birds in the Ecuadorian Amazon (Buitron-Jurado and Tobar 2007). In this association, *M. flaviventer* traveled with flocks of birds for up to 20 min and foraged for insects at heights of 2–10 m in the trees while in close proximity to individual birds within the flock (Buitron-Jurado and Tobar 2007). What benefit either *M. flaviventer* or the birds attain from this association is unclear, but it is likely that both mammal and bird species increase foraging success based on information from other mammal–bird foraging associations (Pitman and Balance 2009; Oommen and Shanker 2010).

BEHAVIOR

Microsciurus flaviventer is diurnal, usually active in early morning, and has been seen alone and in pairs (Emmons and Feer 1997; Buitron-Jurado and Tobar 2007). *M. flaviventer* produces different vocalizations including an alarm call that consists of a series of soft chucks, as well as a soft, descending bird-like trill (Emmons and Feer 1997).

Locomotory behavior, not including gliding, is similar between *M. flaviventer* and Japanese giant flying squirrels (*Petaurista leucogenys*—Stafford et al. 2003). *M. flaviventer* is among the most arboreal of tree squirrels and frequently jumps between branches (Youlatos et al. 2008). *M. flaviventer* makes significant use of clawed locomotion that permits relatively fast vertical displacement along large tree trunks and branches in the lower portions of the forest (Youlatos and Samaras 2011). Quadrupedal bounding and vertical leaps typify *M. flaviventer* locomotion, whereas feeding posture is predominantly clinging with claws to vertical supports of nonsmooth vertical trunks less than 5 cm or above 20 cm in diameter (Youlatos 1999). Thorington and Thorington (1989) document the elongated hind limbs present in the genus *Microsciurus*, which agrees with the hypothesis of Emmons (1975), that smaller squirrels should have longer limbs adapted for an arboreal lifestyle.

GENETICS

Microsciurus flaviventer and other South America Sciurini arose only 3 million years ago, in the Pliocene, and this clade has diversified rapidly (Simpson 1980; Roth and Mercer 2008). The Sciurini is a relatively recent clade, thought to have originated with 1 species that crossed the land bridge formed by the Isthmus of Panama (Mercer and Roth 2003; Pečnerová and Martínková 2012).

In an analysis of allozymes of New World tree squirrels, the genus *Microsciurus* is more closely related to the genus *Sciurus* (North and South American species) than to the Neotropical genus *Sciurillus* (Neotropical pygmy squirrel—Hafner et al. 1994) and subsequent molecular genetic analyses using *mtcyb*, *irbp*, *12S* ribosomal, *16S* ribosomal, and *c-myc* exon 3 gene trees support this relationship and further suggest a strong affinity to the South and Central American species of *Sciurus* (Mercer and Roth 2003; Steppan et al. 2004; Pečnerová and Martínková 2012).

CONSERVATION

Microsciurus flaviventer has been reported as locally common to rare (Emmons and Feer 1997). Little is known of the distribution, ecology, reproduction, and population trends of *M. flaviventer*, thus the conservation status of the species is listed as "Data Deficient" under the International Union for Conservation of Nature and Natural Resources *Red List of Threated Species* (Amori et al. 2008). Consequently, it is not possible to determine current threats to this species' persistence. Threats to *M. flaviventer* persistence are likely similar to other tropical forest species and include habitat loss and logging (Da Silva et al. 2005; Kelt and Meserve 2014).

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