



Karyotypic analyses and morphological comments on the endemic and endangered Brazilian painted tree rat *Callistomys pictus* (Rodentia, Echimyidae)

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Abstract

The genus *Callistomys* belongs to the rodent family Echimyidae, subfamily Echimyinae, and its only living representative is *Callistomys pictus*, a rare and vulnerable endemic species of the state of Bahia, Brazil. *Callistomys* has been previously classified as *Nelomys*, *Loncheres*, *Isothrix* and *Echimys*. In this paper we present the karyotype of *Callistomys pictus*, including CBG and GTG-banding patterns and silver staining of the nucleolus organizer regions (Ag-NORs). Comments on *Callistomys pictus* morphological traits and a compilation of Echimyinae chromosomal data are also included. Our analyses revealed that *Callistomys* can be recognized both by its distinctive morphology and by its karyotype.

Key words: *Callistomys*, karyotype, banding patterns, Echimyinae.

Received: September 28, 2007; Accepted: March 17, 2008.

The Neotropical spiny rats of the family Echimyidae comprise approximately 85 recognized living species grouped in 21 genera (modified from McKenna and Bell, 1997; Woods and Kilpatrick, 2005; Emmons, 2005; Iack-Ximenes *et al.*, 2005). Echimyids have a wide distribution, ranging from Southern Paraguay to Southern Nicaragua (Anderson and Jones, 1967; Honacki *et al.*, 1982; Hartenberger, 1985). They are the most diverse of all living hystriognath rodents and the evolutionary relationships among genera are still unclear due to the paucity of data regarding their ecology, diversity and systematics (Leite and Patton, 2002; Woods and Kilpatrick, 2005).

Woods and Kilpatrick (2005) recognized four Echimyidae subfamilies: (1) the extinct Heteropsomyinae, endemic to West India; (2) Dactylomyinae, including the arboreal bamboo rats from the genera *Dactylomys*, *Kannabateomys* and *Olallamys*; (3) Echimyinae, including

the arboreal genera *Callistomys*, *Diplomys*, *Echimys*, *Phyllomys*, *Isothrix* and *Makalata*; and (4) Eumysopinae, including the semi-fossorial, arboreal and terrestrial genera *Carterodon*, *Clyomys*, *Euryzygomatomys*, *Lonchothrix*, *Mesomys*, *Hoplomys*, *Proechimys*, *Trinomys* and *Thrichomys*. Since then, several new genera of Echimyinae have been erected: *Pattonomys* to include *Nelomys semivillosus* Geoffroy, 1838 and allied species, *Santamartamys* to include *Isothrix rufodorsalis* Allen, 1899 (Emmons, 2005) and *Toromys* to include *Loncheres grandis* Wagner 1845 (Iack-Ximenes *et al.*, 2005).

Karyotypes of Echimyinae are known only for *Pattonomys semivillosus* and for some species of *Phyllomys*, *Makalata* and *Isothrix* and their chromosome numbers ranged from $2n = 22$ in *Isothrix pagurus* to $2n = 96$ in *Phyllomys medius* (Table 1).

The painted tree rat or cocoa rat *Callistomys pictus* (Pictet, 1843) is a soft-furred echimyid found in the coast of the state of Bahia, Northeastern Brazil. It was originally included in the genus *Nelomys* as a junior synonym of *Echimys*. It was afterwards alternatively classified as

Table 1 - Karyotypes of Echimyinae taxa (Suborder Hystricognathi).

Taxa	Referred as	2n	FN	Locality	Reference
<i>Callistomys pictus</i>		42	76	Ilhéus, BA, Brazil	Present paper
<i>Pattonomys semivillosus</i>	<i>Echimys semivillosus</i>	94	114	Venezuela	Aguilera <i>et al.</i> , 1998; Emmons, 2005
<i>Isothrix bistriata</i>		60	116	Rio Juruá, AC and UHE Samuel, RO, Brazil	Patton <i>et al.</i> , 2000; Leal-Mesquita, 1991*
<i>I. negrensis</i>		60	112	Rio Negro, AM, Brazil	Bonvicino <i>et al.</i> , 2003
<i>I. pagurus</i>		22	38	Manaus, AM, Brazil	Patton and Emmons, 1985
<i>I. sinnamariensis</i>		28	42	French Guiana	Vié <i>et al.</i> , 1996
<i>Makalata</i> sp.	<i>Makalata armata</i>	70	120	UHE Samuel, RO, Brazil	Leal-Mesquita, 1991*
<i>Makalata didelphoides</i>		66	106	Balbina Hydroelectric Dam on the Uatumã River, AM, Brazil	Lima <i>et al.</i> , 1998
<i>Phyllomys blainvilli</i>		50	94	BA and PE, Brazil	Souza, 1981 [#] apud Leite, 2003; Leite, 2003
<i>P. dasythrix</i>		72	ND	RS, Brazil	Leite, 2003
<i>P. aff. dasythrix</i>	<i>Echimys</i> sp.	90/92	ND	SP and RS, Brazil	Yonenaga, 1975; Leite, 2003
<i>P. medius</i>	<i>Echimys dasythrix</i>	96	ND	SC, Brazil	Sbalqueiro, 1998 apud Leite, 2003
<i>P. nigripinus</i>		52	ND	RJ, Brazil	Leite, 2003
<i>P. pattoni</i>	<i>Echimys</i> sp. / <i>E. thomasi</i>	80/72	112/114	ES and RJ, Brazil	Zanchin, 1988 ^{&} apud Leite, 2003

FN = autosomal fundamental number; ND = not described. Abbreviations of Brazilian States: AC = Acre; AM = Amazonas; BA = Bahia; ES = Espírito Santo; PE = Pernambuco; RJ = Rio de Janeiro; RO = Rondônia; RS = Rio Grande do Sul; SC = Santa Catarina; SP = São Paulo; UHE = Usina Hidrelétrica. *Leal-Mesquita ERB (1991) Estudos citogenéticos em dez espécies de roedores brasileiros da família Echimyidae. MSc dissertation. Departamento de Biologia, Instituto de Biociências, Universidade de São Paulo, São Paulo, Brazil; [#]Souza MJ (1981) Caracterização cromossômica em oito espécies de roedores brasileiros das famílias Cricetidae e Echimyidae. Ph.D. thesis. Departamento de Biologia, Instituto de Biociências, Universidade de São Paulo. São Paulo, Brazil; [&]Zanchin NIT (1988) Estudos cromossômicos em orizomíneos e equimídeos da Mata Atlântica. Porto Alegre. MSc dissertation. Instituto de Biociências. Universidade Federal do Rio Grande do Sul. Porto Alegre, RS, Brazil.

Nelomys (Pictet, 1843; Goldman, 1916; Thomas, 1916), *Echimys* (Tate, 1935; Moojen, 1952) and *Isothrix* (Waterhouse, 1848; Ellerman, 1940; Cabrera, 1961; Honacki *et al.*, 1982; Patton and Emmons, 1985) and it has only recently been placed in its own genus *Callistomys* (Emmons and Vucetich, 1998).

In a review of the genus *Isothrix*, Patton and Emmons (1985) followed Cabrera (1961) and Honacki *et al.* (1982) and kept *Nelomys pictus* within *Isothrix*. The same *I. pictus* was later classified as *Nelomys* (Emmons and Feer, 1990) and then included in *Echimys* (Woods, 1993; Emmons and Feer, 1997). Emmons and Vucetich (1998) examined the fossil mandible of one specimen identified as *Lasiuromys villosus* (a synonym of *Isothrix bistriata*) by Winge (1888) and several specimens of *Nelomys pictus* (including the holotype) and concluded that they belonged to the same genus. A comparison of these specimens with the three genera in which *Nelomys pictus* had been previously included led Emmons and Vucetich (1998) to conclude that *N. pictus* did not belong to any of them. Considering its distinct morphology, these authors suggested a new genus, *Callistomys*, to contain *N. pictus* and *Callistomys* sp. (formerly identified as *Lasiuromys villosus*).

Here we report new cytogenetic data on the endemic, rare and endangered Echimyinae *Callistomys pictus*, including Ag-NOR staining, CBG- and GTG-banding, as well as comments on the external morphology, cranial anatomy and geographical distribution of the species.

The specimen reported herein was incidentally captured in April 2002, preyed and injured by a domestic dog in a cacao plantation at Fazenda Santo Antônio (14°41'46" S, 39°15'22" W), Ilhéus, state of Bahia, Brazil. Ilhéus is the type-locality of *Nelomys pictus* Pictet, 1843. The animal was sacrificed according to Ethical Issues in the Use of Animals (Colégio Brasileiro de Experimentação Animal, COBEA, 1991), tissues were deposited in the collection of the Instituto de Biociências, Universidade de São Paulo (IBUSP) and the voucher specimen was deposited at the Museu de Zoologia, Universidade de São Paulo (MZUSP), São Paulo, Brazil, under the number MZUSP 31404.

Morphology - We employed Wahlert (1974, 1983, 1985) and Woods and Howlands (1979) for the nomenclature of cranial foramina. Dental nomenclature followed Iack-Ximenes *et al.* (2005) which was modified from Lavocat (1976) with further considerations from Butler (1985), Jaeger *et al.* (1985), Flynn *et al.* (1986), Jaeger

(1989), Bryant and McKenna (1995), and Candela (1999a; 1999b; 2002). Besides the specimen from Fazenda Santo Antônio, Ilhéus, state of Bahia, eight other specimens of *Callistomys pictus* were examined, as follows: Brazil: Bahia: South America: NHM: 52.1.5.22 (skull, mounted skin) and 80.9.15.1 (skull, mounted skin); Brésil: MHNN: 94.2464A (mounted skin) and 94.2463 (mounted skin); Fazenda 7 Voltas, Ilhéus, Bahia: MZUSP: 31404 (skeleton, skin); Lavapés de Dentro, Rio do Braço, Bahia: MN: 11207 (skin, skull); Ilhéus, Bahia: MN15453 (skin, skull) and 31546 (skin, skull); no locality: MNK: 4809 (skull, skin) (Abbreviations: NHM: Natural History Museum, London, England; MHNN: Museum d'Histoire Naturelle du Neuchâtel, Neuchâtel, Switzerland; MZUSP: Museu de Zoologia, Universidade de São Paulo, São Paulo, Brazil; MNK - Museum für Naturkunde, Berlin, Germany, MN: Museu Nacional do Rio de Janeiro, Universidade Federal do Rio de Janeiro, Rio de Janeiro, Brazil).

External morphology: fur includes only soft hairs; hairs brown at base with tip white or black. Pelage is dense and long. *Callistomys* has a unique color pattern among echimyid rats: body white with black coat, extending from the top of head, nape, and back to the basis of tail. Tail densely haired, black at base and white distally. Limbs broad and stout, hands and feet relatively short but broad. *Cranial anatomy:* Skull is large and strong, rostrum and nasals medium sized and broad. Lateral wings of frontal well-developed forming a roof over orbital region; postorbital process of zygoma rounded and formed by squamosal. Petrosal bone covered by squamosal posteriorly. Incisive foramina long and fusiform, mostly formed by premaxillar. Septum of incisive foramina wide and long and formed by premaxillar. Palatal region rectangular, long and slender; palatine extending up to M1. Sphenopalatine foramen double. Mesopterygoid fossae with slit-shaped lateral openings. Alisphenoid region wide; alisphenoid channel not differentiated; buccinator and masticator foramina confluent; foramen ovale medium sized; maxillary vein passes through foramina; transverse canal foramen well-developed. Bullae round, inflated, with tiny stiliform process, tegmen timpani short and wide; external auditory meatus opening in a short and strong tube. Upper molariforms tetralophodonts; anteroloph and the fourth loph (metalloph+protoloph) connected lingually as well as mesoloph and posteroloph. In young adults and younger specimens hypoflexus and mesoflexus deep, isolates anteroloph protoloph U-shaped from mesoloph posteroloph; but in older ones, the M1-M3 with narrow mure connecting protocone to hypocone. Lower molar trilophodonts and dP4 tetralophodont with metafossetid between first loph (anterolophid+metallophid) and mesolophid; mesolophid connected by mure to hipolophid; hipolophid and posterolophid connected labially by hypoconid.

Distribution - *Callistomys pictus* occurs in Bahia State, Brazil, and most records are from the municipality of

Ilhéus and nearby areas (Moojen, 1952; Emmons and Vucetich, 1998; Vaz, 2002, 2005). *C. pictus* was recently recorded in Serra da Jibóia, Elisio Medrado, Bahia State, about 150 km North of Ilhéus (Encarnaçao *et al.*, 2000). Two specimens were collected by Auguste de Meuron, a tobacco dealer, and the locality was labeled as "Brésil". De Meuron lived in the city of Salvador, formerly known as Bahia, a name now used for the state. In view of the specimens from other species (*P. pattoni*, *T. setosus*) sent by de Meuron to the MHNN, it is possible that the specimens of *Callistomys pictus* came from Salvador (MHNN: 94.2464A and 94.2463) or from somewhere in the neighbourhood. *Callistomys pictus* is endemic to the Atlantic forest of the state of Bahia, Brazil, where it is also found in cacao plantations shaded by native trees. *C. pictus* is either locally rare or difficult to capture with traditional live trapping methods, since ecological studies with a high sampling effort carried out in different habitats in South Bahia did not record the species (Pardini, 2004; Moura RT, 1999, MSc Dissertation, Universidade Federal de Minas Gerais, BH, Brazil). Nevertheless, *Callistomys pictus* seems to be more common in cacao plantations in Ilhéus, where local people reported frequent sightings of the animal.

Cytogenetics - Metaphases from the male of *Callistomys pictus* were obtained from bone marrow and spleen 40 min after an *in vivo* subcutaneous injection of 0.1% colchicine. Conventional staining with Giemsa, Ag-NORs staining (Howell and Black, 1980), GTG- (Seabright, 1971) and CBG-banding (Summer, 1972) were carried out following standard cytogenetic procedures.

The karyotype of *Callistomys pictus* revealed $2n = 42$ and FN (number of autosomal arms) = 76 (Figure 1A) and consisted of 18 pairs of meta or submetacentric autosomes decreasing in size (pair 1 to 16, 18 and 20) and two pairs of small acrocentrics (17 and 19). The X and Y chromosomes were, respectively, medium and small acrocentrics; the X being perfectly distinguishable as a medium sized acrocentric. GBG-banding allowed the recognition of all autosome pairs and the sex chromosomes (Figure 1B). CBG-banding evidenced small heterochromatic blocks in the pericentromeric regions of some autosomes and in the sex chromosomes (Figure 2A). The single Ag-NOR was detected in a secondary constriction at the long arm of pair 13 (Figure 2B).

Callistomys pictus, the only living species of the genus, differs from other extant Echimyidae in many major cranial characters and could represent the last survivor of an old clade of Echimyinae. Other species of this genus represented by a single fossil from the Upper Pleistocene-Recent collected at Lapa do Capão Seco, Lagoa Santa, Minas Gerais State, Brazil, was recognized (Emmons and Vucetich, 1998). A cladistic analysis based on morphological data of Echimyidae placed *Callistomys* in the basal position of the Dactylomyinae/Echimyinae clade (Carvalho and Salles, 2004). The authors found a

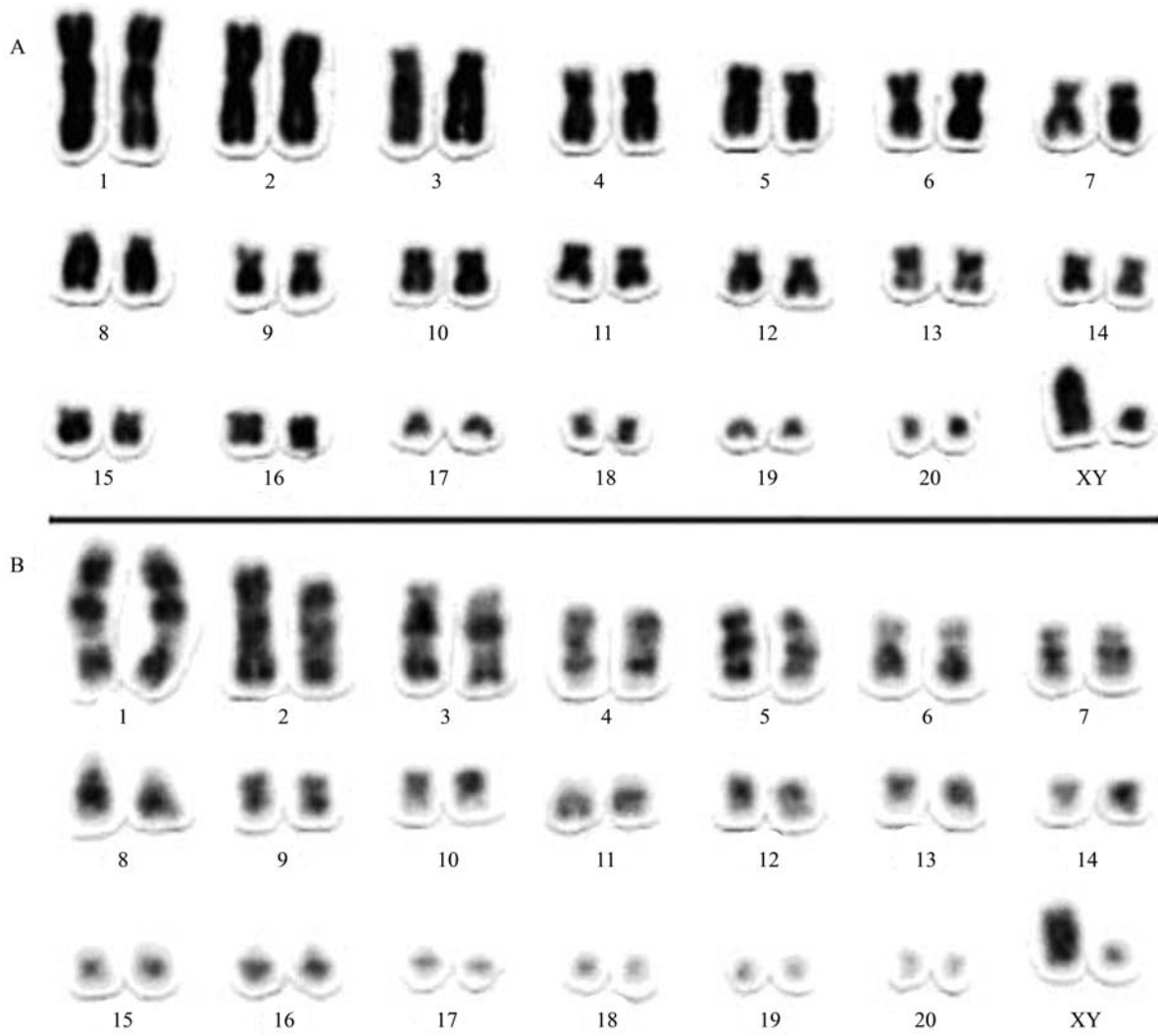


Figure 1 - Karyotype of a male *Callistomys pictus* with $2n = 42$ and $FN = 76$ after: (A) Conventional staining and (B) GTG-banding.

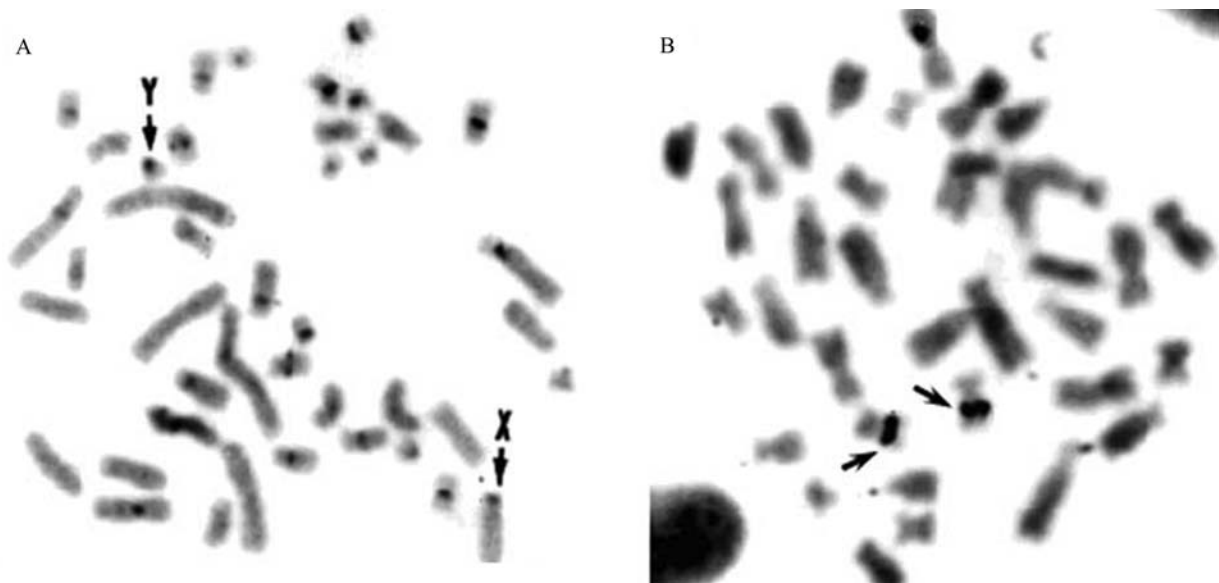


Figure 2 - Metaphases of *Callistomys pictus* after: (A) CBG-banding, arrows indicate the X and Y chromosomes and (B) Ag-NORs, arrows indicate the NOR-bearing pair 13.

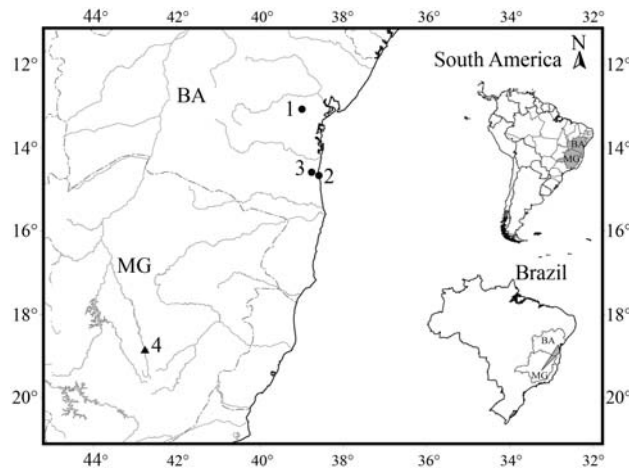


Figure 3 - Geographic distribution of *Callistomys*: (●) *Callistomys pictus*; (▲) *Callistomys* sp. 1) The states of Bahia (BA) and Minas Gerais (MG) are indicated on the right in the maps of South America and Brazil. Specific localities in Bahia (1-3) and Minas Gerais (4) are indicated on the left side of the map: 1. Elísio Medrado (12°56'47" S, 39°31'18" W, 390 m); 2. Ilhéus (14°47'20" S, 39°02'58" W, 52 m); 3. Rio do Braço (14°40'35" S, 39°15'40" W, 38 m); and 4. Lagoa Santa (19°37'38" S, 43°53'23" W, 760 m).

slightly distinct topology when fossil taxa were included: *Callistomys*, *Maruchito triflodonte* Vucetich *et al.*, 1993 (a fossil echimyid genus from Middle Miocene), and the Dactylomyinae/Echimyinae formed a basal politomy. These results suggest that *Maruchito* and *Callistomys* can be related, as previously proposed by Emmons and Vucetich (1998). *Callistomys* occurs in the Bahia State of Brazil and is restricted to the Atlantic Forest in a few localities from Ilhéus to Elísio Medrado. Subfossil specimens from Minas Gerais were collected by Lund and the genus does not seem to presently occur near Lagoa Santa (Emmons and Vucetich, 1998), suggesting a recent reduction in its geographic distribution (Figure 3). Records of *Callistomys pictus* from Lagoa Santa are restricted to Pleistocene fossil specimens.

The taxonomy of Echimyinae is still very complex and the diploid numbers can be helpful in species identification since karyotypes seem to be important diagnostic markers (Table 1), except for *Isothrix bistrata*, *I. negrensis* and *Echymys* sp. with $2n = 90/92$. Diploid numbers within Echimyinae are usually high, with the exception of *Isothrix pagurus* and *I. sinnamariensis*, with $2n = 22$ and $2n = 28$, respectively (Patton and Emmons, 1985; Vié *et al.*, 1996), and of the odd $2n = 42$ and $FN = 76$ described herein for *Callistomys pictus*.

Our results show that the karyotype associated to the restricted geographical range and the unique set of morphological traits are useful in identifying *Callistomys pictus*. Our data bring important new information thus reducing the knowledge gap of Brazilian biodiversity and, most importantly, contributing to improve conservation and management initiatives. This is specially important for species

like *Callistomys pictus*, which was included as vulnerable in the red list of endangered species published by the Brazilian Institute for Environment (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis, IBAMA) in 2003. In fact, as pointed out by Costa *et al.* (2005), the major threat to endangered small mammals is the scarcity of scientific knowledge about their distribution, systematics, taxonomy and natural history, since most of them are rare and poorly known and very few sites of Brazil have been adequately surveyed.

Acknowledgments

The authors are grateful to George Mendes Taliaferro Mattox and the GMB Editor for the English and critical review, to Glaciene Tomaz de Oliveira for technical assistance, and to José Mário Beloti Ghelleri, Kenji Kato, Mateus Paciência, Ricardo Braga Neto, Sergio Souza and Alexandre Percequillo for fieldwork support and logistics. Grants from the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) and Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP; # 1999/11.653-6 to YYY and 2005/04557-3 to MJJS) are also acknowledged.

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Associate Editor: Fausto Foresti

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