Primates (2007) 48:245–248
DOI 10.1007/s10329-007-0039-0

SHORT COMMUNICATION

Sympatry between *Alouatta caraya* and *Alouatta clamitans* and the rediscovery of free-ranging potential hybrids in Southern Brazil

Lucas M. Aguiar · Daniel M. Mellek · Kaue C. Abreu · Tiago G. Boscarato · Itiberê P. Bernardi · João M. D. Miranda · Fernando C. Passos

Received: 20 September 2006 / Accepted: 8 December 2006 / Published online: 20 February 2007

Abstract Records of sympatry between *Alouatta caraya* and *A. clamitans* are rare despite their extensive range overlap. An example of their current sympatry and the rediscovery of free-ranging potential hybrids of *A. caraya* and *A. clamitans* in the forests of the Upper Paraná River, Southern Brazil, are reported in this paper. Eight groups were observed in the study area: five monospecific groups of *A. caraya*, two of *A. clamitans*, and a group containing two adult males and two adult females of *A. caraya* and a sub-adult male and two adult females identified as *Alouatta* sp. The color of the last three individuals was a mosaic between the two species; this is consistent with previously described variations in museum specimens collected in the Paraná River in the 1940s that had been identified as potential hybrids. The results from this study emphasize the need for scientific studies in the region of the Ilha Grande National Park, one of the few regions in the Paraná River that currently harbors both howler species.

Keywords Contact zone · Hybridization · Reproductive isolation · Morphologic variation · Morphotype

Contribution number 1637 of the Departamento de Zoologia, Universidade Federal do Paraná, Caixa Postal 19020, 81531-980, Curitiba, Paraná, Brasil.

L. M. Aguiar (✉) · J. M. D. Miranda · F. C. Passos
Programa de Pós-graduação em Zoologia,
Universidade Federal do Paraná, Caixa Postal 19020,
81531-980 Curitiba, Paraná, Brasil
e-mail: lucasmoraes@ufpr.br

L. M. Aguiar · D. M. Mellek · K. C. Abreu ·
I. P. Bernardi · J. M. D. Miranda · F. C. Passos
Laboratório de Biodiversidade, Conservação e Ecologia de Animais Silvestres. Departamento de Zoologia,
Universidade Federal do Paraná, Caixa Postal 19020,
81531-980 Curitiba, Paraná, Brasil

K. C. Abreu
Instituto de Pesquisas Ecológicas (IPÊ),
19280-000 Teodoro Sampaio, São Paulo, Brasil

T. G. Boscarato
Programa de Pós-graduação em Meio Ambiente com Ênfase em Química Ambiental, Universidade Paranaense,
87502-020 Umuarama, Paraná, Brasil

Introduction

According to Groves (2001) the genus *Alouatta* comprises ten recognized species. This number varies depending on taxonomic treatment, however (Rylands et al. 2000; Gregorin 2006). The genus has the broadest geographical distribution among Neotropical primates (Platyrrhini), occurring from the south of the State of Veracruz, in Mexico, to Northern Argentina and Southern Brazil (Hirsch et al. 1991; Cortés-Ortiz et al. 2003).

In general, *Alouatta* species are distributed in a parapatric fashion, with possible contact zones between rivers that represent the limits of their distribution. Potential contact zones of *A. pigra* and *A. palliata* have been recorded between the Grijalva and Usumacinta Rivers (Cortés-Ortiz et al. 2003), those of *A. palliata* and *A. seniculus* between the Atrato and Sinú Rivers (Defler 2004), those of *A. seniculus* and *A. belzebul* between the Santa Helena, Madeira, and Tapajós Rivers (Hirsch et al. 1991; Pinto and Setz 2000), those of *A. seniculus* and *A. caraya* between the Blanco and

Guaporé Rivers (Wallace et al. 2000; Iwanaga and Ferrari 2002), those of *A. belzebul* and *A. caraya* at the head of the Parnaíba River (Chame and Olmos 1997), and those of *A. caraya* and *A. clamitans* between the Paraná and Uruguay Rivers (Hirsch et al. 1991; Di Bitetti et al. 1994; Di Bitetti 2005; Gregorin 2006).

Although the contact zone between *A. caraya* and *A. clamitans* is extensive, historical or recent records of their sympatry are rare. The first indications of sympatry were the specimens collected by A. Mayer in the forests of the Upper Paraná River in the 1940s. The capture site of *A. caraya* (Iguaçu National Park) is, however, approximately 300 km from the capture site of *A. clamitans* (a location known as the ''Sertão do Rio Paraná'') (data obtained in Lorini and Persson 1990). At that time three females were collected at the ''Sertão do Rio Paraná'' and deposited as *Alouatta* sp. in the Museu de História Natural do Capão da Imbúia (MHNCI). The hair coloration of these specimens does not correspond to the patterns known for the two species that occur in the region. The hair is, however, distinctly arranged in a mosaic between the typical female colorations of *A. caraya* and *A. clamitans*, and cannot, therefore, be regarded as distinct from those species (Gregorin 2006). Systematic studies of these specimens emphasized the possibility they were hybrids of these species in that site (Lorini and Persson 1990; Gregorin 2006).

The most recent recorded case of sympatry was published by Di Bitetti (2005), who reported the existence of both species in the Provincial Piñalito Park, between the Paraná and Uruguay Rivers in Argentina. Recent efforts, however (Aguiar 2006; Aguiar et al. 2007), did not find these species coexisting in the region of the Upper Paraná River.

In December of 2005 our team collected a specimen of *A. clamitans* that had been run over on the BR-487 highway, next to the border between the States of Paraná and Mato Grosso do Sul, in the immediate surroundings of the Ilha Grande National Park. We then organized an expedition to search for both howler species in this park. In this paper we report the current existence of sympatry and the rediscovery of morphotypes with intermediate coloration which are possible free-ranging hybrids between *A. caraya* and *A. clamitans*.

Materials and methods

Study area

The sampled area included a 17-km stretch of riparian forest and an adjacent forest fragment (''Mata do Bugio'' 150 ha) (Fig. 1). This region belongs to the left margin of the Paraná River, from Porto Figueira (municipality of Alto Paraíso) to 4 km upstream of Porto Camargo (Municipality of Icaraíma), State of Paraná, Southern Brazil. The region is located in the Federal Area for Environmental Protection (APA) of the Islands and Flood Plains of the Paraná River, in the immediate surroundings of the Ilha Grande National Park (23°15′ to 24°05′S and 53°40′ to 54°17′W), in the flood plains of the Upper Paraná River. Average annual temperature is 22°C, with 1,200 to 1,300 mm of rainfall and a *Cfa* climate according Köeppen's classification (Campos 2001). The forests in the region are flooded periodically and are classified as seasonal semideciduous alluvial forest. This vegetation is characterized by low arboreal diversity, with *Cecropia pachystachya* the dominant species in riparian forests (Souza et al. 2004). Some authors regard this region as an ecotone between the Atlantic Rainforest and the Cerrado (Campos 2001; Souza et al. 2004).

Methods

Field efforts to search for the primates in the study site occurred in April 2006, with separate incursions into the riparian and mainland forests. The former was searched for 2 days using a boat that went upstream for 17 km starting in Porto Figueira, followed by a 17 km return using hiking trails. The mainland forest was searched during 1 day by means of a 3 km walk outside the hiking trails. Primates were located by use of binoculars.

Results

Three primate species were detected and identified as forming monospecific groups on the riparian forests—five groups of *A. caraya*, two groups of *A. clamitans*, and a group of *Cebus nigritus*. In a site known as ''Paredão das Araras'' (23°21′10.1″S and 53°44′08.5″W) there was a record of a group of *A. caraya* living about 30 m from a group of *A. clamitans.*

In the ''Mata do Bugio'' (23°22′52.3″S and 053°45′39.6″W) a group of seven *Alouatta* individuals was found and followed. This group comprised two adult males and two adult females of *A. caraya*, and a sub-adult male and two adult females identified a priori as *Alouatta* sp.. These individuals had a mosaic coloration pattern—the front, head, face and legs were dark brown (characteristic of *A. clamitans*), yet the tail, hands and feet were pale yellowish-brown (characteristic of *A. caraya*). The coloration pattern of the

sub-adult male is shown in Fig. 2. At first, all the animals in this group were resting in the same tree. Later, two females of *Alouatta* sp. were observed grooming a single adult male of *A. caraya* while a female of *A. caraya* and a sub-adult male of *Alouatta* sp. fed on leaves of the tree where they were located.

Discussion

The sympatry observed in this study indicates that this region of the Paraná River can be regarded as a zone of faunistic contact, reflecting the vegetational limits of the Cerrado and the Atlantic Rainforest. *Alouatta caraya* is a howler that is characteristic of Central Brazil, occurring mostly within the limits of the Cerrado (Wallace et al. 2000; Gregorin 2006), whereas

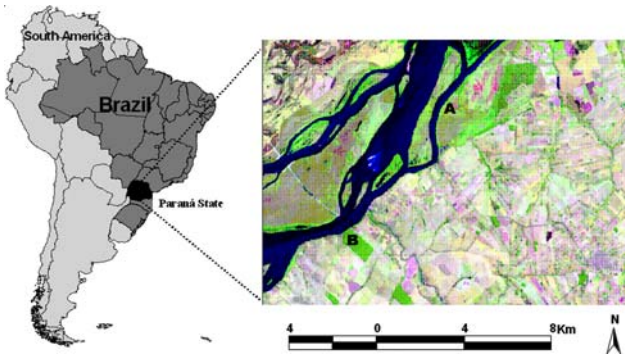

Fig. 1 Study area in the surroundings of the Ilha Grande National Park, Upper Paraná River. Occurrence of sympatry (*A* ''Paredão das Araras'') and of the morphotypes with intermediate coloration (*B* ''Mata do Bugio'')

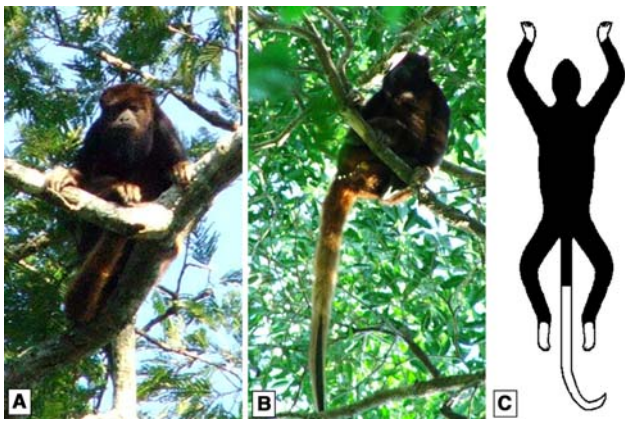

Fig. 2 Sub-adult male of *Alouatta* sp. Note the *dark brown* coloration with portions of *red* hair, the *pale yellowish brown* coloration of the hands (**a**) and the tail (**b**). An illustrative schematic diagram is shown in (**c**)

A. clamitans is characteristic of the south and southeast of the Atlantic Rainforest (Gregorin 2006).

The occurrence of sympatry among congeneric Neotropical primates is thought to be rare, because of the similarity of their niches, particularly in comparison with Old World primates (Peres and Janson 1999; Ferrari 2004). Habitat destruction might cause sympatry to be even more uncommon because of competition between sympatric species. Some authors have pointed out that the absence of *A. clamitans* in other regions of the Paraná River might be because of severe anthropogenic disturbance of those environments (Di Bitetti et al. 1994; Codenotti et al. 2002; Di Bitetti 2005; Aguiar 2006). In contrast, the same authors asserted that *A. caraya* is more tolerant of the effects of forest fragmentation and is still found in those habitats. The sympatry of both howler species in the region of the Ilha Grande National Park seems, therefore, to indicate the existence of a relatively preserved area where both species can coexist. In contrast with observations by Di Bitetti (2005) in Argentina, the sympatry region in our study is located on the left margin of the Paraná River. In Argentina, Di Bitetti recorded this range overlap in the region between the Paraná and Uruguay Rivers, and suggested that *A. caraya* was replacing *A. clamitans* near the margins of the Paraná River because of anthropic effects on the forest.

The animals identified in this study as *Alouatta* sp. are probably hybrids between *A. caraya* and *A. clamitans*. Their pattern is the same as that observed for the female MHNCI.031 that was captured in the ''Sertão do Rio Paraná'' in 1945. With two other females, that specimen was identified by Lorini and Persson (1990) and Gregorin (2006) as a possible hybrid between the species. The possibility these animals with aberrant color pattern represent natural variations or other processes, for example inbreeding or genetic drift cannot yet be excluded, however. Irrespective of the real cause, this study confirms the current existence of these animals in nature, and that this particular coloration pattern can also occur in males (previous specimens were all females).

The behavior of the animals in the group of the Mata do Bugio (e.g. rest, feeding, and grooming simultaneously in a single tree) corroborate the notion that the individuals form a cohesive group. Although Cortés-Ortiz et al. (2003) reported the existence of mixed groups between the sister species *A. palliata* and *A. pigra*, the group with possible hybrids observed in this study is of particular interest for two reasons. First, the striking difference in coloration between the species does not seem to be a reproductive barrier.

Alouatta caraya and *A. clamitans* are sexually dimorphic in their coloration as adults. In general, adult males of *A. caraya* are black, and adult females are pale yellowish-brown, whereas males of *A. clamitans* are red and its females are dark brown. These characteristics have been thought to result from sexual selection (Bicca-Marques and Calegaro-Marques 1998; Hirano 2003), serving as mate choice signals and as prezygotic isolation mechanisms. If the existence of hybridization is corroborated, the different coloration of the species is not the only relevant factor, nor the only interspecific reproductive barrier. Second, the divergence between these species (5.1 Ma, Cortés-Ortiz et al. 2003) is not sufficient for evolution of pre-zygotic reproductive isolation between them. The species are not closely related—*A. caraya* being more closely related to Amazon species whereas *A. clamitans* is more closely related to another Atlantic Rainforest species, *A. belzebul* (Cortés-Ortiz et al. 2003).

The Ilha Grande National Park and its surrounding areas are among the few regions that still harbor both howler species, and thus deserve more intense scientific investigation. Genetic, behavioral, and ecological studies will be instrumental in assessing the fitness of these morphotypes and revealing the nature of such variations.

Acknowledgments We thank Marcelo Brunning, Rodrigo F. Moro-Rios, Gabriela Ludwig, Eduardo Carrano, Marcio R. Pie, APA das Ilhas e Várzeas do Rio Paraná, APA Municipal de Alto Paraíso, Parque Nacional de Ilha Grande, Universidade Federal do Paraná, Conselho Nacional de Pesquisa e Desenvolvimento Tecnológico (CNPq). Dr Jean P. Boubli and two other reviewers provided helpful comments on the manuscript. Contract grant sponsor: Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq).

References

Aguiar LM (2006) Os primatas do corredor do Alto Rio Paraná (região de Porto Rico, estados do Paraná e Mato Grosso do Sul): ocorrência, georreferenciamento e parâmetros populacionais [dissertation]. Curitiba (PR): Universidade Federal do Paraná. 104p. Available from: Universidade Federal do Paraná, Curitiba, PR

Aguiar L, Ludwig G, Svoboda WK, Teixeira GM, Hilst CLS, Shiozawa MM, Malanski LS, Mello AM, Navarro IT, Passos FC (2007) Use of traps to capture black and gold howlers (Alouatta caraya) on the Islands of the upper Paraná River, Southern Brazil. Am J Primatol 69:241–247

Bicca-Marques JC, Calegaro-Marques C (1998) Behavioral thermoregulation in a sexually and developmentally dichromatic Neotropical primate, the black-and-gold howling monkey (*Alouatta caraya*). Am J Primatol 106:533–546

Campos JB (2001) Parque Nacional de Ilha Grande, re-conquista e desafios. IAP/Coripa, Maringá

Chame M, Olmos F (1997) Two howler species in Southern Piauí, Brazil? Neotrop Primates 5:74–77

Codenotti TL, Silva VM, Albuquerque VJ, Camargo EW, Silveira RMM (2002) Distribuição e situação atual de conservação de *Alouatta caraya* (Humboldt, 1812) no Rio Grande do Sul, Brasil. Neotrop Primates 10:132–141

Cortés-Ortiz L, Bermingham E, Rico C, Rodríguez-Luna E, Sampaio I, Ruiz-García M (2003) Molecular systematics and biogeography of the Neotropical monkey genus, *Alouatta*. Mol Phylogenet Evol 26:64–81

Defler TR (2004) Primates of Colombia. Conservation International, Bogotá

Di Bitetti MS (2005) Perspectivas para a conservação de primatas em Misiones. In: Galindo-Leal C, Câmara IG (eds) Mata Atlântica: Biodiversidade, Ameaças e Perspectivas. Fundação SOS Mata Atlântica, São Paulo, Conservação Internacional, Belo Horizonte, pp 194–199

Di Bitetti MS, Placci G, Brown AD, Rode DI (1994) Conservation and population status of the brown howling monkey (*Alouatta fusca clamitans*) in Argentina. Neotrop Primates 2:1–4

Ferrari SF (2004) Biogeography of Amazonian primates. In: Mendes SL, Chiarello AG (eds) A primatologia no Brasil 8. IPEMA/SBPr, Vitória, pp 101–122

Gregorin R (2006) Taxonomia e variação geográfica das espécies do gênero *Alouatta* Lacépède (Primates, Atelidae) no Brasil. Rev Bras Zool 23:64–144

Groves CP (2001) The taxonomy of primates. Smithsonian Institution Press, Washington

Hirano ZMB (2003) Secreção epidérmica de *Alouatta guariba clamitans* (Primates, Atelidae) [Thesis]. Ribeirão Preto (SP): Universidade de São Paulo, 144p. Available from: Universidade de São Paulo, Ribeirão Preto

Hirsch A, Landau EC, Tedeschi ACM, Menegheti JO (1991) Estudo comparativo das espécies do gênero *Alouatta* Lacèpéde, 1799 (Platyrrhini, Atelidae) e sua distribuição geográfica na América do Sul. In: Rylands AB, Bernardes AT (eds) A primatologia no Brasil 3. Fundaçao Biodiversitas, Belo Horizonte, pp 239–262

Iwanaga S, Ferrari SF (2002) Geographic distribution of red howlers (*Alouatta seniculus*) in Southwestern Brazilian Amazonia, with notes on *Alouatta caraya*. Int J Primatol 23:1245–1256

Lorini ML, Persson VG (1990) A contribuição de Andre Mayer a história natural no Paraná (Brasil) II. Mamíferos do terceiro planalto paranaense. Arq Bras Biol Tecnol 33:117–132

Peres CA, Janson CH (1999) Species coexistence, distribution, and environmental determinants of neotropical primate richness: a community-level zoogeographic analysis. In: Fleagle JG, Janson CH, Reed KE (eds) Primates communities. Cambridge University Press, Cambridge, pp 55–74

Pinto LP, Setz EZF (2000) Sympatry and new locality for *Alouatta belzebul discolor* and *Alouatta seniculus* in the Southern Amazon. Neotrop Primates 8:150–151

Rylands AB, Schneider H, Langguth A, Mittermeier RA, Groves CP, Rodríguez-Luna E (2000) An assessment of the diversity of new world primates. Neotrop Primates 8:61–93

Souza MC, Romagnolo MB, Kita KK (2004) Riparian vegetation: ecotones and plant communities. In: Thomaz SM, Agostinho AA, Hahn NS (eds) The Upper Paraná River and its floodplain: physical aspects, ecology and conservation. Backhuys Publishers, Leiden, pp 353–367

Wallace RB, Painter RLE, Rumiz DI, Taber AB (2000) Primate diversity, distribution and relative abundances in the Rios Blanco y Negro Wildlife Reserve, Santa Cruz Department, Bolivia. Neotrop Primates 8:24–28