

UPDATED LIST OF BAT SPECIES POSITIVE FOR RABIES IN BRAZIL

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SUMMARY

This paper presents an updated list of bat species positive for rabies in Brazil. It was developed based on database research via the internet, of international and national literature and annals of the most important technical and scientific meetings related to rabies and chiroptera in Brazil from 1996 to 2009. The new list of rabies positive bats consists of 41 species, belonging to 25 genera and three families: Phyllostomidae 43.9%, Vespertilionidae 29.3% and Molossidae 26.8%. In addition, questions were raised regarding the lack of data, including sex, age, circumstances and location of bat capture and incomplete and outdated species identification. Results of genetic and antigenic studies performed on Brazilian rabies positive bats were shown.

KEYWORDS: Chiroptera; Rabies; South America.

The class Mammalia has 5,416 species and the Order Chiroptera comprises the second largest group of mammals in number, with 1,120 species. Nine families, 64 genera and 167 species of bats live in Brazil⁵³. Bats are one of the most important reservoirs and vectors of the rabies virus in the world, according to studies of antigenic and genetic characterization^{33,46,83}.

In the United States of America, the first case in humans transmitted by bat was reported in 1951 and according to RUPPRECHT (2000)⁵⁴, it is likely that other cases of human rabies have gone largely unrecognized in the past, because the attention of the health authorities was focused at that time on the widespread distribution of rabies in dogs. Since then, the predominant source of infection in humans shifted from terrestrial animals to insectivorous bats and nowadays, the majority of naturally acquired, indigenous human rabies cases in the United States have resulted from variants of rabies viruses associated with insectivorous bats¹².

Similarly, in Mexico, two major variants have been identified associated with specific terrestrial hosts and species of bats, *Tadarida brasiliensis* and the hematophagous bat *Desmodus rotundus*⁸³. In other Latin American countries the two major rabies virus variants identified are the dog and the bat *D. rotundus*. Variants associated with insectivorous bats *T. brasiliensis* and *Lasiurus cinereus* have also been identified^{24,34,47}.

In Brazil, great progress has been made in the control of the disease in domestic animals mainly as a result of improved canine vaccination programs and other procedures followed in some states, such as educational programs, sterilization and stray animal control. The number of cases had fallen steadily from 1980, over 170 cases, to under five cases

in 2007⁴. Genetic and antigenic studies identified variants associated with dogs and the hematophagous bat *D. rotundus*, as well as variants associated with various species of insectivorous bats and species of frugivorous bats of the genus *Artibeus*, with the variant associated with *D. rotundus*^{28,31,33,60}. *D. rotundus* has been responsible for outbreaks of rabies in humans in the northern region of Brazil, like those which occurred in 2003 and 2004 in Maranhão and Pará states, involving 64 deaths^{8,23}. In this region people live in or near the forest or mangrove ecosystems, their houses are precarious and they are commonly harassed by this bat. Outbreaks of bat-related rabies have been linked to the continued deforestation of the Amazon region, which has displaced vampire bats across northern Brazil and increased contact with humans⁵⁹.

Since great diversity exists among bat species, involving different habits and widespread distribution, knowledge regarding their behavior, population dynamic, shelters in rural and urban areas and the circumstances of capture of positive specimens is essential to developing actions aimed at rabies control in these species. The rabies virus has been isolated from 36 species of bats present in the country¹⁷. Moreover, observation confirms that 29 species have been exploring refuges in houses and their surroundings⁷⁷ increasing the chance of contact with humans and domestic animals. Among the 863 cases of rabies diagnosed in bats between 2001 and 2007 in Brazil, 424 were non-hematophagous bats (49.1%), 250 were hematophagous (29%) and in 189, the species was undetermined (21.9%)⁴⁸. However, these data can be underestimated in relation to hematophagous bats because few specimens of *Desmodus rotundus* have been sent for rabies diagnosis.

Alterations in the environment due to urban and suburban development for the expanding human populations may have reduced both bat roosting

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and foraging habitats. In addition, urban ecosystems offer a large amount of food and shelter associated with a lack of predators, consequently some bat species have adapted to roosting in buildings.

The objective of this study was to present an update of rabies positive bats in Brazil. In addition, questions were raised regarding the lack of data in numerous reports, including sex, age, circumstances and location of capture and incomplete and outdated species identification.

This paper was developed based on database research via the internet of international (PubMed, ScienceDirect and LILACS) and national (SciELO) literature and annals of the most important events related to rabies and chiroptera during the period from 1996 to 2009 (May) using as keywords: rabies, bats, Brazil, chiroptera. This period was selected because the last list of rabies positive bats in Brazil by UIEDA *et al.* was published in 1996⁸⁰.

RUSCHI (1952)⁵⁵ published the first list of rabies positive bats in 1952, in which 26 species were recorded in Brazil. This work will be launched in a supplementary list, which adds another 15 species (Table 1).

The new list of rabies positive bats consists of 41 species (24% of the species already recorded in Brazil), belonging to 25 genera and three families: Phyllostomidae 43.9%, Vespertilionidae 29.3% and Molossidae 26.8%. The Phyllostomidae family (frugivorous, hematophagous, nectarivorous, carnivorous, omnivorous and insectivorous) included 15 genera and 18 positive species, followed by Molossidae (insectivorous), with six genera and 11 positive species, while Vespertilionidae (insectivorous) accounted for four genera and 12 rabies positive species (Table 1).

Data showed that the number of positive species from the Phyllostomidae family is higher in relation to Vespertilionidae and Molossidae families which could be explained by the fact that this family comprises the highest number of species in Brazil (90 species); however, 20.0% of rabies positivity in this group is low compared to the Vespertilionidae (24 species) and Molossidae (26 species) families in which 50.0% and 42.3% positivity were recorded, respectively.

The high positivity in these families is probably due the proximity of these animals with the human population. Since species from these bat families use roofs, basements and attics inside human habitations as shelters, citizens complain of their presence and surveillance is more active. In contrast, the majority of the species of the Phyllostomidae family diagnosed as positive live far from urban areas, except for *A. lituratus*, which is commonly observed in almost all urban areas in Brazilian cities.

The hematophagous bat *D. rotundus* is the most frequent positive species in the literature, due its epidemiological importance in the transmission of rabies to herbivores and humans. In this report, the majority (86.9%) of specimens were captured in nets near shelters in rural and natural areas.

While this review was being conducted, certain difficulties were observed, such as the lack of data concerning the bats determined as positive for rabies. Sex, age and how the bat was captured were frequently not described. Sometimes only the genus or the feeding preference was mentioned. However, the main problem observed was the use of

Table 1
Updated list of Brazilian bat species positive for rabies

Species	References
Molossidae	
<i>Eumops auripendulus</i>	21, 80
<i>Eumops glaucinus</i>	21, 52
<i>Eumops perotis</i>	17
<i>Cynomops abrasus</i>	21, 27
<i>Cynomops planirostris</i>	52
<i>Molossops neglectus</i>	4
<i>Molossus molossus</i>	11, 15, 21, 52, 57, 79, 80, 82
<i>Molossus rufus</i>	21, 52, 55, 58, 62, 80
<i>Nyctinomops laticaudatus</i>	14, 19, 21, 25, 44, 58, 67, 79, 80
<i>Nyctinomops macrotis</i>	21, 43, 49, 79, 80
<i>Tadarida brasiliensis</i>	11, 15, 43, 57, 58, 80, 81, 82
Phyllostomidae	
<i>Anoura caudifer</i>	55
<i>Anoura geoffroyi</i>	55
<i>Artibeus fimbriatus</i>	20, 25, 71
<i>Artibeus lituratus</i>	11, 14, 15, 19, 21, 25, 32, 34, 35, 43, 50, 52, 58, 60, 66, 72, 80, 82
<i>Artibeus planirostris</i>	21, 55, 60, 80
<i>Carollia perscipillata</i>	43, 78, 80, 82
<i>Chrotopterus auritus</i>	55
<i>Desmodus rotundus</i>	13, 21, 22, 29, 32, 43, 55, 56, 58, 61, 64, 68, 80, 82
<i>Diaemus youngi</i>	80
<i>Diphylla ecaudata</i>	16, 55, 80
<i>Glossophaga soricina</i>	55, 70
<i>Lonchorrhina aurita</i>	55
<i>Lophostoma brasiliense</i>	55
<i>Micronycteris megalotis</i>	55
<i>Phyllostomus hastatus</i>	55
<i>Platyrrhinus lineatus</i>	55, 80
<i>Trachops cirrhosus</i>	80
<i>Uroderma bilobatum</i>	7
Vespertilionidae	
<i>Eptesicus brasiliensis</i>	43, 65
<i>Eptesicus diminutus</i>	19, 26, 65
<i>Eptesicus furinalis</i>	3, 21, 52
<i>Histiotus velatus</i>	5, 14, 42, 43, 58
<i>Lasurus blossevillii</i>	15, 41, 43, 52, 55
<i>Lasiurus cinereus</i>	11, 15, 21, 43, 58
<i>Lasiurus ega</i>	14, 21, 39, 43, 52, 55, 58
<i>Lasiurus egregius</i>	75
<i>Myotis albescens</i>	26
<i>Myotis levis</i>	43
<i>Myotis nigricans</i>	15, 21, 25, 40, 43, 52, 55, 58
<i>Myotis riparius</i>	43

outdated species names. Naturally, circumstances occur in which it is difficult to define the species of bat, in such cases, specimens must be sent to an expert.

The most commonly used identification key for Brazilian bat species is VIZOTTO & TADDEI (1973)⁸⁴; however, several nomenclatures have been subsequently revised in meetings, congresses and relevant papers. The names of some species cited in published papers are listed below; however, these names have been revised, with the current name shown in parenthesis: *Dasypterus intermedius* (= *Lasiurus ega*); *Molossus ater* (= *M. rufus*); *Molossops abrasus* (= *Cynomops abrasus*); *Tonatia brasiliense* (= *Lophostoma brasiliense*); *Artibeus jamaicensis* (= *A. planirostris*); and *Lasiurus borealis* (= *L. blossevillii*).

In 1996, UIEDA *et al.*⁸⁰ mentioned the new names of *Dasypterus intermedius* and *Molossus ater*. *Cynomops* was considered a subgenus of *Molossops* until it was recognized as a genus by BARQUEZ *et al.* (1999)⁹, GREGORIN (2000)³⁰ and PETERS *et al.* (1999)⁵¹.

Until recently, species of the genus *Lophostoma* were included in the genus *Tonatia*; however, LEE Jr. *et al.* (2002)³⁶ showed that these species did not correspond as a monophyletic taxon. The name was altered to *Lophostoma* and only the species *T. bidens* and *T. saurophila* remained in the genus *Tonatia*⁵³.

Regarding *A. jamaicensis* and *A. planirostris*, significant controversy exists among taxonomists. Some authors consider *A. planirostris* as a subspecies and others as a different species. In this work, it has been recognized as a distinct species, in agreement with LIM (1997)³⁸, who reported that the distribution of *A. planirostris* ranges from the Amazon Basin (South of Orinoco) to southern South America, while *A. jamaicensis* is restricted to northern South America (North of the Orinoco) and Central America.

Lasiurus blossevillii is similar to *L. borealis* and for a long time the terms were used interchangeably. However, genetic studies by BAKER *et al.* (1998)⁶ and MORALES & BICKHAM (1995)⁴⁵ indicated that they are different species. *L. borealis* is restricted to the Central West, including Canada, the USA and northeastern Mexico, while specimens found south of this geographic limit would be included in *L. blossevillii*.

Regarding the circumstances of locating positive bats, observation showed that 52.59% of the bats were found in atypical situations, such as on the ground, including one report of *D. rotundus* in a residential garden in an urban area²⁹, inside houses (11.34%) and hanging in buildings (8.24%). Two cases of positive colonies captured while roosting in roofs (1.03%) were reported, but the first specimens of these colonies were captured on the ground, leading to the location of the shelter^{3,43}.

The exception in relation to the circumstances of capture are hematophagous bats captured in shelters (21.65%), due to the specific kind of surveillance focused on this species in Brazil: 19 reports of *D. rotundus*, one report of *D. ecaudata* and one of *D. youngi*. One *D. rotundus* was captured while feeding on a human⁶⁸ (1.03%). The remaining 4.12% represents other interesting cases, such as *Carollia perspicillata* captured during a bat survey of *D. rotundus* in a region of the State of Goiás that did not present symptomatic characteristics for the disease⁷⁸, one *Histiotus velatus*⁵ and one *Chrotopterus auritus*⁶⁹,

both captured in caves and one *Myotis nigricans* captured during flight by a child⁴⁰.

According to RUPPRECHT (2000)⁵⁴, a significant proportion of sick bats discovered by the citizens are rabid. The prevalence of rabies among obviously ill bats submitted by the citizens to health department laboratories typically ranges from 3% to 15%. Samples of mostly healthy bats captured during flight suggest the prevalence of rabies is less than 1%. Thus, effective public health media that communicate the message not to handle any dead or live bats regardless of appearance or circumstances is still required.

Minnesota residents (U.S.A.) who submitted bats to the Department of Health for rabies testing in 2003 were surveyed by telephone regarding the circumstances of the bat encounter and their knowledge of bats and rabies. While most people submitting bats for rabies testing were aware that bats could carry rabies, few knew they should submit the bat for testing³⁷. In the Center for Zoonosis Control in the State of São Paulo (Centro de Controle de Zoonoses, CCZ-SP), despite more than 20 years transmitting information concerning bats and rabies to citizens who complain about their presence, because of the noise, the smell of their urine and the excrement they produce, the staff of the Chiropteran Section have observed that the ecological role of these animals remains largely unknown and much so-called information is based on prejudice, fear and erroneous concepts.

In southeastern Brazil, particularly the state of São Paulo, the largest number of bats identified as rabies positive was reported (38 reports), and data were published regarding these facts. In contrast, only four reports from northern states^{7,56,64,80}, five from northeastern states^{16,22,33,61,80} five from states in the Western-Central region^{25,33,44,56,78} and three reports from southwestern states^{5,11,80} were found during the research. It is highly likely that these results are underestimated due to the limited number of published reports concerning positive bats in these regions of the country.

Considering the positive cases reported in São Paulo State, the most common species found with rabies were the frugivorous bat *A. lituratus* and the insectivorous bat *M. nigricans*. According to CUNHA *et al.* (2006)²¹ the highest proportion (33.7%) of rabies virus was found in *A. lituratus* in the period from 1997 to 2002 in bats from 235 towns in the north and northwestern areas of the state. QUEIROZ *et al.* (2009)⁵² reported that both the *A. lituratus* and the *M. nigricans* represented 30% of the bats diagnosed as positive in the northwestern region of São Paulo State, from 1993 to 2007. The genera *Artibeus* and *Myotis* represented, respectively, 40.2% and 18.3% of the bats tested for rabies from 261 municipalities in the period between April 2002 and November 2003⁵⁸. These two species were also the most common rabies positive species according to MARTORELLI *et al.* (2009)⁴³, each representing 17.6% in the period 1988 to 2009.

Among the few papers^{11,14,17,20,21,25,43,52,62,66,67,70,78,79,81,82} reporting the sex of rabies positive bats, 47 were female: 13 belonging to Molossidae, 23 to Vespertilionidae and 11 *A. lituratus* of the Phyllostomidae family; 43 were male belonging to Molossidae (13), Vespertilionidae (14) and Phyllostomidae (16). CUNHA *et al.* (2006)²¹ reported 68 positive bats, 33 females and 35 males, but species were not shown.

Regarding bat age, reports are also scarce^{20,21,25,43,66,67,70,78,82}. The majority were adults (88%) belonging to Molossidae (7), Vespertilionidae

Table 2
Antigenic rabies studies performed with Brazilian bat samples

Reactivity profiles (N-Mabs)	AgV*	References	Bat species in which the reaction patterns were detected
AgV C12+	NC	26, 28, 42	<i>Histiotus velatus</i>
AgV C4+C10+C12+C18+C19+	NC	17, 28	<i>Nyctinomops macrotis</i> , <i>Nyctinomops laticaudatus</i>
AgV C4+ C10+ C12+	NC	3, 17, 28, 63, 86	<i>Eptesicus furinalis</i> , <i>Eumops auripendulus</i> , <i>E. perotis</i> , <i>E. glaucinus</i> , <i>N. laticaudatus</i> , <i>Eptesicus sp.</i> , <i>Myotis nigricans</i> , <i>Histiotus sp.</i>
AgV C4+C10+C19+	NC	17, 28	<i>N. laticaudatus</i>
AgV C4+C9+C10+C12+C19+	3	2, 14, 17, 63, 86	<i>Artibeus lituratus</i> , <i>A. planirostris</i> ***, <i>A. fimbriatus</i> , <i>Diphylla ecaudata</i> , <i>Desmodus rotundus</i> , <i>Molossus molossus</i> , <i>M. rufus</i> , <i>Lasiurus ega</i> , <i>Myotis sp.</i>
AgV C4+C9+C10+C12+	4	2, 17, 63, 86	<i>Tadarida brasiliensis</i> , <i>M. nigricans</i> , <i>E. furinalis</i> , <i>M. molossus</i> , <i>Lasiurus sp.</i>
AgV C4+C9+C10+	NC	28, 63	<i>Lasiurus blossevillii</i> ***, <i>Myotis albescens</i> , <i>M. molossus</i>
AgV C1±C4+C9+C10+C12+	6	17	<i>Lasiurus cinereus</i>
AgV C4+C10+	NC	86	<i>Histiotus sp.</i>
AgV C1+C4+ C9+C10+ C12+C15+ C18+ C19+	NC	7	<i>Uroderma bilobatum</i>

*Not Compatible; ***Artibeus jamaicensis* and *Lasiurus borealis* - outdated name

(7) and Phyllostomidae (8). Only three specimens were identified as young, two of them captured in their shelter²⁰ and another found on a sidewalk²⁴.

This information can be important due to the fact that some species of bats live in colonies with females forming maternal colonies where males are segregated, thus females have more corporal contact than males. On the other hand, in some species males compete for the highest positions in the hierarchy against females. These circumstances could provoke rabies transmission. Rabies transmission by milk, the transplacental route and prenatal infection are described in the literature^{18,73,74}. The bat's age could be important to know if this type of transmission is occurring. Only with reports of these data will be possible to accumulate knowledge to establish their importance in the epidemiological rabies cycle.

Tables 2 and 3 show the antigenic and genetic studies performed on Brazilian bat samples. According to these studies, all the samples investigated were genotype 1 and indicated that the rabies virus can be transmitted between domestic animals and bats²⁸. These results suggest that there is considerable diversity among Brazilian bat rabies virus variants, that some of these rabies virus variants may be associated with bats from other countries and further suggest a possibility that species-specific viral variants exist among the Brazilian bat rabies virus^{32,33}. These findings showed that rabies virus variants exhibit epidemiological characteristics that are reflected in aspects of the ecology of the reservoir bats, such as migratory patterns and range³³.

While these studies are important to understand the epidemiology of rabies, they only covered a few isolated areas of Brazil. Considering the large number of bat species in Brazil, the territorial extension of rabies virus circulation in the country and the low number of isolates analyzed, it is currently difficult to establish the intraspecies and interspecies relations

Table 3
Genetic rabies studies performed on Brazilian bat samples

Variant Host	References	Bat species in which the variant host was detected
<i>Desmodus rotundus</i>	32	<i>Molossus rufus</i>
<i>Desmodus rotundus</i>	32, 33, 60	<i>Artibeus lituratus</i>
<i>Desmodus rotundus</i>	32, 60	<i>Artibeus planirostris</i>
<i>Desmodus rotundus</i> / <i>Eptesicus spp</i>	32	<i>Eumops auripendulus</i>
<i>Desmodus rotundus</i>	7	<i>Uroderma bilobatum</i>
<i>Eptesicus spp</i>	32, 33	<i>Eptesicus furinalis</i>
<i>Molossus spp</i>	10, 32, 33	<i>Molossus molossus</i>
<i>Molossus spp</i>	32	<i>Cynomops abrasus</i>
<i>Desmodus rotundus</i>	10, 31, 32, 33, 60	<i>Desmodus rotundus</i>
<i>Nyctinomops spp</i> / <i>Eptesicus spp.</i>	32, 33	<i>Nyctinomops laticaudatus</i>
<i>Histiotus velatus</i>	10	<i>Histiotus velatus</i>

of this virus. Thus, more extensive epidemiological studies are required to clarify the complexity of the epidemiological cycles involving rabies infection and bats.

Moreover, bats play an important ecological role in the control of insects, which can cause an impact on agriculture and urban areas, and as pollinators and seed dispersal agents^{76,85}. The guano that bats produce is

a valuable fertilizer in both natural and agricultural systems. In addition, the guano is the basis of the food chain in cave habitats, which makes possible the survival of a large number of parasites species that serve as food for animals at other levels in the food chain¹.

With the identification of an increasing number of bats presenting this zoonosis in urban areas, the controversy about risk of social interaction between bats and humans is growing. Only further studies that clarify the zoonotic profile of these animals can control or prevent, and adequate measures can be established, with the consequent transmission of relevant information that can guide the population to coexist harmoniously with bat populations.

RESUMO

Lista atualizada das espécies de morcegos positivas para raiva no Brasil

Esse artigo apresenta uma lista atualizada de espécies positivas para raiva no Brasil e foi desenvolvida a partir da base de dados na internet da literatura nacional, internacional e dos anais das mais importantes reuniões técnicas e científicas, envolvendo raiva e morcegos no Brasil durante o período de 1996 a 2009. A nova lista de morcegos positivos para raiva consiste de 41 espécies, pertencentes a 25 gêneros e três famílias: Phyllostomidae 43.9%, Vespertilionidae 29.3% e Molossidae 26.8%. Também foram discutidas questões como a falta de dados sobre sexo, faixa etária e circunstâncias de captura dos animais e identificação incompleta ou desatualizada das espécies. Resultados dos estudos genéticos e antigênicos realizados em amostras de morcegos brasileiros positivos para raiva foram apresentados.

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