Short Note

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Albinism in the striped spear-nosed bat *Gardnerycteris crenulatum* (Chiroptera: Phyllostomidae) with an updated list of albino bats in the World

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Abstract: Albinism is a pigmentation anomaly present in all of the main vertebrate groups, including about 4% of bat species. In this article, we described a new case in a Neotropical bat *Gardnerycteris crenulatum* collected in a savanna of northern Brazil. This bat is an adult male with white and pale yellow fur, red eyes, and white skin on its entire body. We perform a review of the world list of bat species with albinism, which totals 60 species in six continents to this date.

Keywords: albinism; bats; Brazil; Mammalia; Neotropical.

Pigmentation anomalies have been described in all of the main vertebrate groups (Uieda 2000). Bats, like other mammals, are susceptible to genetic disorders that affect pigmentation. These include albinism, leucism, flavism, and melanism (Uieda 2000, Zamolo et al. 2013, Tello et al. 2014). Among these conditions, albinism stands out as a rare phenomenon arising from a genetic condition that inhibits or substantially reduces melanin production in the body. This consequentially results in the development of white fur and skin and red eyes (Griffiths et al. 2000, Uieda 2000, Hernández-Mijangos 2009, Tello et al. 2014). Many bat species are known to exhibit cases of albinism, though this condition is rare, affecting less than 4% of the known population (Uieda 2000).

Albinism has been recorded in 11 bat species in four countries of South America: Argentina, Brazil, Peru, and Venezuela (Setzer 1950, Moreira et al. 1992, Soriano et al. 1993, Veiga and Oliveira 1995, Uieda 2000, Barquez et al. 2003, Oliveira and Aguiar 2008, Pautasso et al. 2009, Ramírez et al. 2010, Falcão 2014, Rengifo et al. 2014, Tello et al. 2014, Romano et al. 2015). Of them, six are phyllostomids (*Artibeus planirostris*, *Carollia perspicillata*, *Dermanura cinerea*, *Glossophaga longirostris*, *Desmodus rotundus*, and *Sturnira erythromos*), four are molossids (*Eumops glaucinus*, *Molossus molossus*, *Molossus rufus*, and *Tadarida brasiliensis*), and one is a vespertilionid (*Eptesicus furinalis*). Zalapa et al. (2016) recently reviewed the atypical coloring bats of North and Central America and the Caribbean islands, recording 10 albino species.

A bat survey was carried out every 3 months near the municipality of *Barra do Ouro* (7°45′14″S, 47°50′25″W, 170 m) from 2012 to 2015 in the state of Tocantins, Brazil. Eight mist nets (9 × 2.5 m) were placed at ground level and opened for 6 h after sunset. This study was conducted under the permission of the Brazilian Federal Wildlife Agency (IBAMA) (license number #024/2011, process number #02029.000555/2011-20) and was in accordance with guidelines of the American Society of Mammalogists for use of wild mammals in research (Gannon and Sikes 2007). A voucher specimen of *Gardnerycteris crenulatum* was deposited in the Animal Biodiversity Laboratory of the Goiás Federal University (number CJ 1006).

Of the nearly 2000 bats captured, 11 of them belonged to *Gardnerycteris crenulatum* (six male, and five female). On February 23, 2015, we captured one striped spear-nosed bat with exceptional pigmentation. This bat was an adult male with white and pale yellow fur, red eyes, and white skin on its entire body (Figure 1). The region around the ear and neck had some prominent yellowish fur. The other individuals captured in the same region had the normal color of the species: dark upperparts; blackish brown midback with a pale stripe down from crown to rump; underparts frosted silvery buff; and washed orange (*yellowish*) around throat (Emmons and Feer 1997). The

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Figure 1: An albino male *Gardnerycteris crenulatum* with details of red eyes, white skin, and translucent ears.

albino specimen presented a forearm of 44.3 mm and a body mass of 10.1 g. Both these measurements were close to the other five normal male individuals captured in the same area [FA = 45.2–45.9 mm (n = 4); body mass = 9.5–11.3 g (n = 3)].

Although the specimen shown in this study did not present the completely white fur, it can be classified as albino according to the phenotypic classification of Lamoreux et al. (2010). The yellow fur of *Gardnerycteris crenulatum* is different from that attributed to flavism' cases. Flavism is a type of hypochromatism, with animals presenting yellow or red hair on the insufficiently pigmented skin (Červený 1980). The yellowing color observed in our specimen resembled the color of an individual of *Hipposideros diadema* recorded by Aul and Marimuthu (2006).

Pigmentation disorder is a rare phenomenon in nature, and its impact on the survival rate is unclear. The low frequency of chromatic aberrations in bats has been associated with negative effects on the fitness and survival of affected individuals. An example of this phenomenon is such as in cases where the albino animal does not meet life expectancy due to its conspicuous appearance. Nevertheless, due to their nocturnal habits and the dark roosts that they generally select, bats are probably less vulnerable to predation than most diurnal animals (Buys et al. 2002, Rocha et al. 2013). Most cases of albinism resulted from studies in enclosed roosts such as caves, mines, and buildings (see Uieda 2000), where that conspicuity provides easy location of the bats for the researchers. Shelters found in foliage and hollow trees are more difficult to locate and access, thus presenting few records of albinism. In fact, there are only two cases of albinism observed in outdoor roosts, *Artibeus planirostris* (Uieda 2000) and *Rhinophylla pumilio* (Charles-Dominique et al. 2001). *Gardnerycteris crenulatum* roost mainly in hollow trees (Goodwin and Greenhall 1961, Handley-Jr 1976), for they provide a shelter that offers protection against visually oriented predators. Hollow trees usually present low incidence of light. Thus, the albino contrast with normal individuals living in the same shelter is not important in these conditions.

Despite the apparent fragility of depigmented animals, several studies describe adult bats, which by itself is already a sign of success of these individuals. Moreover, some studies show that albino animals (or leucistics) have a body size similar to those with normal coloration. The albino bat registered in this study was an adult and had size and weight similar to normal individuals from the same site. Baucells et al. (2013) recorded a leucistic piebald *Pipistrellus pygmaeus* with weight and forearm length above average on a sample of over 100 individuals. Uieda (2000) mentioned several cases in which albino bats have been observed for several years, which shows that albinism does not necessarily imply a short lifespan for a bat (Buys et al. 2002). Despite these indications, there is not solid evidence that supports negative or positive effects of the albinism on bats (Baucells et al. 2013).

The first citation of albinism in bats appeared in Pryer (1884), a direct observation of three individuals of *Nyctinomops plicatus* (= *Chaerephon plicatus*) in a cave. Setzer (1950) in a short note commented superficially about albinism in bats. Walley (1971) conducted a review of species with albinism and leucism, listing 14 albino species. In his article, Walley (*op. cit.*) listed albinism in two distinct species of *Molossus*, *Molossus fortis* and *M. tropidorhynchus*, actually attributed today as *Molossus molossus* (Simmons 2005). More recently, Uieda (2000) performed a robust review listing 38 species of bats with albinism in the world. Leblanc and Taupin (2004) revaluated cases of albinism, especially in Europe, increasing to 52 species with this anomaly in the world. Le blanc and Taupin (*op. cit.*) included much information based on personal communication and even photographic record. Subsequent

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Table 1: Updated list of bat species with albinism recorded in the world.

Taxon	Country	Source
Megachiroptera		
Pteropodidae		
Rousettus leschenaulti	India	Karim (1983)[a]
Microchiroptera		
Rhinolophidae		
Rhinolophus cornutus	Japan	Sawada (1990)[a]
Rhinolophus euryale	France	Dorst (1957)[a]
Rhinolophus ferrumequinum	South Africa (?)	Allen (1939)[a]; Fontanel (2001)[b]; Frontera (2002)[b]; Prévost et al. (2011)
Rhinolophus hipposideros	Slovakia	Horáček (1995)[a]; Redant (2002)[b]
Hipposideridae		
Hipposideros armiger terasensis[1]	Japan	Hsu (2003)
Hipposideros diadema nicobarensis	Nicobar Islands	Aul and Marimuthu (2006)
Hipposideros lankadiva	India	Khajuria (1984)[a]
Hipposideros ruber	Tanzania	Howell and Mainoya (1974)[a]; Howell (1980)[a]
Rhinopomatidae		
Rhinopoma hardwickii	India	Khajuria (1972)[a]
Rhinopoma microphyllum	India	Bhati (1988)[a]; Devkar et al. (2011)
Emballonuridae		
Taphozous georgianus	Australia	Swamson (1980)[b]
Taphozous sp.[2]	India	Dhanya et al. (2015)
Nycteridae		
Nycteris nana	Zaire	Verschuren (1955)[a]; Nowak (1994)
Phyllostomidae		
Artibeus lituratus[3]	Mexico	Pozo and Escobedo-Cabrera (1998)[a]; Zalapa et al. (2016)
Artibeus planirostris	Brazil	Uieda (2000)
Carollia perspicillata	Brazil, French Guyana	Charles-Dominique et al. (2001)[b]; Falcão (2014)
Dermanura cinerea	Brazil	Oliveira and Aguiar (2008)
Desmodus rotundus	Argentina, Trinidad, Brazil, Mexico	Verschuren (1955)[a], Moreira et al. (1992)[a], Greenhall (1993)[a]; Uieda (2000); Ramírez et al. (2010); Sánchez-Hernandez et al. (2010)
Diaemus youngii	Brazil	Uieda et al. (in prep.)
Glossophaga longirostris	Venezuela; Mexico	Setzer (1950)[a];
Glossophaga soricina	?/Mexico	Schneider (1925)[a4]; García-Morales et al. (2010)
Macrotus waterhousii	Mexico	Sanchez et al. (1989)[a]
Micronycteris minuta	Costa Rica	Gamba-Ríos (2010)
Gardnerycteris crenulatum	Brazil	Present study
Rhinophylla pumilio	French Guyana	Charles-Dominique et al. (2001)[b]
Sturnira erythromos	Argentina	Barquez et al. (2003)
Mormoopidae		
Pteronotus parnellii	Mexico	Sanchez et al. (1989)[a]
Molossidae		
Chaerephon plicatus	Borneo	Pryer (1884)[a]
Eumops glaucinus	Brazil	Sodré et al. (2004)
Molossus molossus	Cuba, Peru, Brazil, Venezuela, Puerto Rico	Allen (1939)[a]; Heatwole et al. (1964)[a]; Veiga and Oliveira (1995)[a]; Soriano et al. (1993); Tello et al. (2014)
Molossus rufus	Peru	Rengifo et al. (2014)
Mormopterus francoismoutoui	La Réunion	Ramasindrazana et al. (2014)
Tadarida brasiliensis	Argentina, USA	Herreid and Davis (1960)[a]; McCoy (1960)[a]; Romano et al. (2015)
Miniopteridae		
Miniopterus schreibersii[6]	Australia, Japan[6]	Smith (1968); Kahrau (1972)[a]; Oyabu (1982)[a]; Lumsden (2001)[b]
Vespertilionidae		
Antrozous pallidus	USA	Setzer (1950)[a]
Eptesicus capensis	South Africa	Allen (1939)[a]
Eptesicus furinalis	Argentina	Pautasso et al. (2009)

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Table 1 (continued)

Taxon	Country	Source
Eptesicus fuscus	USA	Baker (1983)[b]
Eptesicus serotinus	Germany	Allen (1939)[a]; Haensel (1968)[b]; Stratmann (1971)[a]; Červený (1977, 1980)[a]; Laskowska (2002)[b]; Obada and Gas (2003); Pelz (2004)[b]
Lasiurus borealis	?	Allen (1939)[a]
Myotis bechsteinii	Czech Republic	Zukal et al. (1994)[a]
Myotis daubentonii	Czech Republic, Denmark, Poland	Červený (1977, 1980)[a]; Červený and Bürger (1977)[a]; Tupinier (1989)[a]; Suter and Kuhn (2003)[b]
Myotis emarginatus	France	Leblanc and Taupin (2004)
Myotis lucifugus	USA, Canada	Dubkin (1952)[a]; Walley (1974)[a]; Smith (1982)[a]; Brigham and James (1993); Talerico et al. (2008)
Myotis macrodactylus	Japan	Harada et al. (1991)[a]
Myotis myotis	France, Germany, Czech Republic	Andera[5]; Tupinier (1989)[a]; Dietz and Schunger (2001)[b]; Cart (2003)[b]; Krištín (2003); Leblanc and Taupin (2004)
Myotis mystacinus	?	Schober and Grimmberger (1989)[a]
Myotis nattereri	Poland, Grain Bretain	Goldsmith (1998)[b]
Myotis sodalis	USA	Caire and Thies (1988)[a]; Brack and Johnson (1990)[a] Brack et al. (2005)
Myotis velifer	USA	Caire and Thies (1988)[a]
Nyctalus noctula	Croatia/?	Đulić and Mikuška (1968), Schober and Grimmberger (1989)[a]
Pipistrellus abramus	Japan	Hsu (2003)
Pipistrellus pipistrellus	Germany	Červený (1977)[a]; Sendor (2001)[b]
Pipistrellus pygmaeus	Spain	Alcalde (2009)
Pipistrellus subflavus	?	Zukal et al. (1994)[a]
Plecotus auritus	Germany	Lehnert (1991)[a]; Buys et al. (2002)[b7]
Plecotus austriacus[8]	?	Haensel et al. (1993 *apud* Buys et al. 2002)
Scotophilus leucogaster	Sudan	Fahr (2001)[b]
Vespertilio sinensis[9]	Japan	Mukohyama (1990)[a]

[a]Cited in Uieda (2000); [b]Cited in Leblanc and Taupin (2004).

1. Recorded as *Hipposideros terasensis* by Hsu (2003) (see Simmons 2005 and Thong 2012).
2. Species not identified by the authors, but distinct of *Taphozous georgianus*.
3. Recorded as *Artibeus intermedius* by Pozo and Escobedo-Cabrera (1998) (see Simmons 2005).
4. Schneider (1925) mentions *G. soricina* in Suriname and the Caribbean islands, however does not refer to the exact location of albino individuals.
5. Leblanc and Taupin (2004) cited a photograph taken in 1982 by Andera.
6. *Miniopterus schreibersii lato sensu*. The record for Japan must be assigned to other species. Currently *M. schreibersii* has been restricted to Eurasian and North Africa populations (Hutson et al. 2008).
7. Leblanc and Taupin (2004) cited Buys et al. 2000a,b. These two articles are based on the same record. The first is in Dutch and the second in English. The correct citation of article "b" is Buys et al., (2002) and not Buys et al. (2000a,b).
8. Buys et al. (2002) mentions the occurrence of albinism in *P. austriacus* based on a whitish specimen described by Haensel et al. (1993). We did not have access to original publishing of Haensel and collaborators.
9. Cited as *V. superans*. However, *sinensis* was the oldest name available for this species (see Horáček 1997).

studies focusing on bats' albinism include the following works: Buys et al. (2002), Barquez et al. (2003), Hsu (2003); Sodré et al. (2004), Aul and Marimuthu (2006), Oliveira and Aguiar (2008), Alcalde (2009), Pautasso et al. (2009); Gamba-Ríos (2010), García-Morales et al. (2010), Ramírez et al. (2010), Sánchez-Hernandez et al. (2010), Falcão (2014), Ramasindrazana et al. (2014), Rengifo et al. (2014), Tello et al. (2014), Romano et al. (2015), Zalapa et al. (2016); Uieda et al. (in prep.). These studies, including the present study, recognize 60 species of albino bats, i.e. 4.6% of the approximately 1300 species of bats total (Fenton and Simmons 2014).

Table 1 presents an updated list of albino bats of the world. To date, albinism has been described in 60 species of 11 families of bats.

There is only one record of Pteropodidae, the other 10 families are Rhinolophidae, Hipposideridae, Rhinopomatidae, Emballonuridae, Nycteridae, Phyllostomidae, Mormoopidae, Molossidae, Miniopteridae, and Vespertilionidae.

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Of the seven world continents, albinism has been recorded in six of them (bats do not occur in Antarctica). North and South America had the highest number of species with albinism records with 14 each, followed by Europe with 13 species and Asia with 12 species. Africa and Australia have the lowest number of species of albinism, six and two respectively. One species (*Miniopterus schreibersii*) had albinism records in two continents (Asia and Australia). However, currently *M. schreibersii* has been restricted to Eurasian and North Africa populations (Hutson et al. 2008).

With 25 species, the Vespertilionidae family presents the largest number of albinism cases (Table 1). According to Baucells et al. (2013), this higher frequency is probably because most efforts in bat research have historically been carried out with this taxonomical group. However, it is worth highlighting that in addition to cosmopolitan, the Vespertilionidae family has the highest species richness in various regions, such as Europe and the United States. In the Neotropics, where the dominant family is the Phyllostomidae, most species with albinism were verified within this group with 13 species. Thus, in addition to historical aspects of studies, the greatest richness of species within a family is also related to the number of cases of albinism reported.

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