

ROADKILLED BATS (MAMMALIA: CHIROPTERA) IN TWO HIGHWAYS OF SANTA CATARINA STATE, SOUTHERN BRAZIL

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ABSTRACT

Among all roads threats, roadkills in highways are considered the greatest source of anthropic pressure on wild vertebrate populations. In Brazil, data on bat-vehicles collisions are scarce and underestimated in studies on roadkilled fauna. Herein we present the first records of bat-vehicles collisions in the southern region of Santa Catarina state, Brazil. Eleven individuals were recorded, belonging to at least four species. *Sturnira lilium* presented the highest frequency of collisions, followed by *Artibeus lituratus*. The diet and foraging behavior are the most likely factors that explain the number of roadkilled bats in highways.

Keywords: *Artibeus lituratus*; collisions; mortality; road ecology; *Sturnira lilium*.

Establishment and operation of highways result in isolation and fragmentation of natural environments, increase edge effects and modify landscape structure and function (Do Prado *et al.* 2007, Gumier-Costa & Sperber 2009). Among all roads threats on biodiversity, roadkills are the greatest source of pressure on wild vertebrate populations (Bager *et al.* 2007, Gumier-Costa & Sperber 2009, Ratton *et al.* 2014). Many variables can affect animal roadkills, but fragmentation of natural areas and availability of food throughout highways are the main characteristics that influence the frequency of collisions (Clevenger *et al.* 2003, Lesiński 2007, Gumier-Costa & Sperber 2009, Santos *et al.* 2012).

Despite of some studies show that bats perceive vehicles as threats (*i.e.* Baxter *et al.* 2006, Altringham & Kerth 2016), making roads as a geographic barrier, reducing the ability of bats to access suitable foraging or roosting sites, bat kills by collisions with vehicles is an worrying factor, especially regarding to migratory species (Zurcher *et al.* 2010, Lesiński *et al.* 2011). Most of data on bat roadkills comes from Europe,

where several studies were developed (Bafaluy 2000, Lesiński 2007, Gaisler *et al.* 2009, Kerth & Melber 2009, Lesiński *et al.* 2011, Berthinussen & Altringham 2012, Medinas *et al.* 2013).

In Brazil, data on bat-vehicles collisions are scarce (Novaes & Dornas 2011) and, when reported in roadkill ecology studies, bats are identified at order or family level (Coelho *et al.* 2008, Bueno & De Almeida 2012, Santos *et al.* 2012). Furthermore, due to its low body mass, flight velocity and nocturnal behavior, finding bats carcasses is difficult, resulting in subsampling of the group in roadkill studies (Bafaluy 2000, Lesiński 2007, Lesiński *et al.* 2011, Berthinussen & Altringham 2012, Medinas *et al.* 2013).

High abundance of certain plant species through the highways, associated to the presence of flight and forest corridors created by highways, seem to be the mainly factors to improve collision rate between bats and vehicles (Lesiński 2007, 2008, Gaisler *et al.* 2009, Medinas *et al.* 2013). Besides, young individuals that fly in low heights (Lesiński 2007) and species that forage in understory (Lesiński *et al.* 2011) may be those of the

most affected by highways. Despite of these factors, species of roadkilled bats may vary among regions, indicating other differences in structure of local assemblages (Lesiński 2007, Kerth & Melber 2009). Due to the lack of studies about bat-vehicles collisions, there is a clear necessity to obtain data on bat mortality in highways of different regions and landscapes (Lesiński *et al.* 2011). The present note aim to report the first records of bat-vehicles collisions in the southern region of Santa Catarina state, southern Brazil.

Data were obtained in two studies on roadkill fauna carried out from April 2014 to August 2015 in two highways of the southern region of the state of Santa Catarina, Brazil (Figure 1). The climate is classified, according to Köppen, as Cfa: subtropical, constantly humid, with no dry season defined, with hot summer and annual rainfall average from 1220 to 1660 mm (Alvares *et al.* 2013). The region is inserted in the Ombrophyllous Dense Forest phytophysiognomy of the Atlantic Forest biome (IBGE, 2012).

The first study was carried out in the SC-108 highway, between Criciúma (28°40'12"S; 49°21'44"W) and São Joaquim (28°17'09"S; 49°75'30"W) municipalities. This section corresponds to a 131 km

of paved road, in altitude from 40 m to 1400 m above sea level. Samplings were made each 15 days, from August 2014 to August 2015, by two researches by car at a velocity of 40 km/h or lower, totalizing 27 days of samples. The second study was carried out in the SC-445 highway, between Urussanga (28°31'49"S; 49°19'01"W) and Morro da Fumaça (28°35'48"S; 49°14'43"W) municipalities. This section corresponds to 15 km of paved road, in altitude from 20 m to 60 m above sea level. Samplings were made each 15 days from April 2014 to April 2015, by bicycle at an average velocity of 20 km/h, totalizing 27 days of samples.

All roadkilled specimens of bats were photographed and had its forearm size measured and they were identified to the lowest possible taxonomic level. The taxonomic identification was based in keys by Gardner & Handley-Jr (2008), Marques-Aguiar (2008), Wilson (2008) and Miranda *et al.* (2011); and the identification of the guilds followed Kalko (1998). The species conservation status followed International Union for Conservation of Nature - The IUCN Red List of Threatened Species (IUCN 2015), Ministério do Meio Ambiente (MMA 2014) and the List of Threatened Species of Santa Catarina state (CONSEMA 2011).

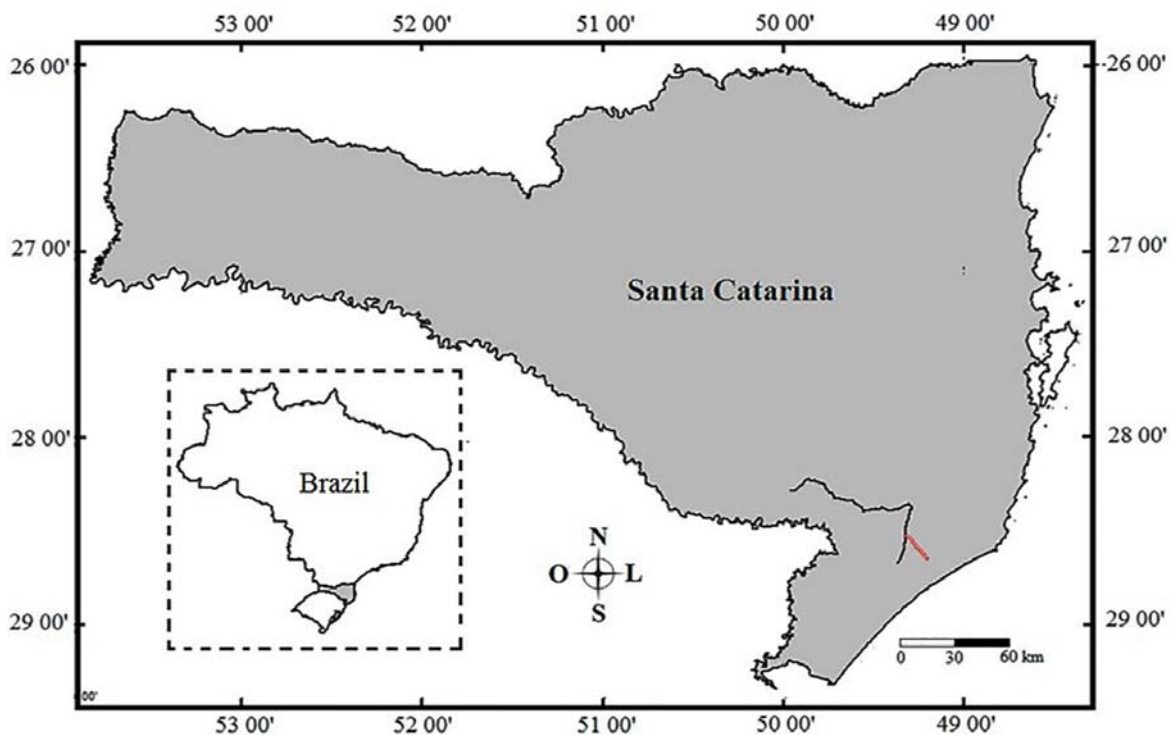


Figure 1. Location of the two highways where roadkilled bats were sampled in the southern region of Santa Catarina state, Brazil, from April 2014 to August 2015. Black line = SC-108 highway; Red line = SC-445 highway.

We recorded 11 adult individuals, from two families and at least five genera and six species (Table 1; Figure 2). The uncertain number of genera and species is because one individual was identified only at family level due to decomposition of the carcass. Among the families recorded, Phyllostomidae was the richest (N = 4) and

the most abundant (N = 9). Among recorded taxa, *Sturnira lilium* had the greatest number of records (N = 4), corresponding to 36.4% of the samples. *Artibeus lituratus* presented the second greatest number in records (N = 2), with 18.2% of the samples. Only *Myotis ruber* is classified as “Near Threatened” by (IUCN, 2015).

Table 1. Taxa list, trophic guilds followed Kalko (1998) and number of roadkilled individuals registered in the two highways in southern Santa Catarina state, southern Brazil, between 2014 and 2015.

Taxon	Trophic guild	Number of roadkilled individuals
Phyllostomidae		
<i>Anoura caudifer</i>	narrow-space gleaning nectarivore	1
<i>Artibeus lituratus</i>	narrow-space gleaning frugivore	2
<i>Artibeus fimbriatus</i>	narrow-space gleaning frugivore	1
<i>Sturnira lilium</i>	narrow-space gleaning frugivore	4
Phyllostomidae (Not identified)	-	1
Vespertilionidae		
<i>Lasiurus ega</i>	edge and gap aerial insectivore	1
<i>Myotis ruber</i>	edge and gap aerial insectivore	1
Total	3 guilds	11



Figure 2. Bats roadkills on highways (SC-108 and SC-445) in southern Santa Catarina, Brazil, from April 2014 to August 2015, where: A) *Artibeus lituratus*, B) *Sturnira lilium*, C) *Lasiurus ega*, D) *Myotis ruber*.

In the southern region of Brazil, bats suffer by the anthropic pressure caused by roads and highways, as in other Brazil regions and countries, as Spain (Bafaluy 2000), Czech Republic and Austria (Gaisler 2009), Poland (Lesisnki 2009, Lesisnki *et al.* 2011) and United States of America (Russel *et al.* 2009). The highest abundance and richness of the Phyllostomidae family among species recorded are related to its dominance in tropical communities (Gardner 2008) and also in the sampled region (*i.e.* Carvalho *et al.* 2009, Carvalho *et al.* 2013). In addition, many phyllostomid species forage in understory or use this layer to displacement, due to the greater availability of roosts and food (Kalko 1998). Already, most species of Vespertilionidae present different behavior, foraging mainly on the edge and in the spaces between the vegetation in the upper strata (Kalko 1998).

Sturnira lilium is one of the most abundant species in southern region of Santa Catarina state (Carvalho *et al.* 2009; Carvalho *et al.* 2013), what may contribute to the number of roadkill events. Besides of it, the prevalence of *S. lilium* in roadkilled bats can be due to its diet and foraging behavior. This species feeds mainly on *Solanum* and *Piper* genera (Fleming 1972, Mello *et al.* 2008), typical pioneer plants that usually colonize anthropic areas, as road margins (Tabarelli & Mantovani 1999, Clarke *et al.* 2005). Also, these genera are distributed in understory, due to its shrubby habit (Tabarelli & Mantovani 1999, Bardelli *et al.* 2008), forcing bats to fly and feed near the soil, what improves the chances of collisions (Tabarelli & Mantovani 1999, Lesiński 2007, 2008).

The presence of street lighting and water bodies can attract insects and, consequently, attract insectivorous bats as *Lasiurus ega* and *M. ruber*, which use these as efficient sites to foraging activities (Altringham & Kerth 2016). If these places were nearby the highways, they can increase bat roadkills. It's also known that some species, such as *Anoura caudifer*, *Artibeus lituratus* and *A. fimbriatus*, are commonly recorded in peri-urban areas in southern Brazil (Pacheco *et al.* 2010). These areas present great amount of roosts and refuges to bats, but also intense vehicle traffic which can lead to an increase in bat mortality rate by vehicle collision.

Nevertheless, the number of roadkilled animals

can be underestimated due to carcass removal by scavengers or posterior death nearby highways (Turci & Bernarde 2009, González-Gallina *et al.* 2013). This is the first study in Brazil to identify such a number of chiropterans at species level. Many studies highlight the underestimated number of animals roadkilled (Slater 2002, Ratton *et al.* 2014); however, even punctual data about bat roadkills are important to the knowledge about the mortality and composition of local assemblages.

Data on roadkilled fauna are important to create and adopt mitigation measures in highways and roads and then, test their effectiveness (Costa *et al.* 2015). Despite of it, few actions are developed to keep connectivity of natural elements in landscape, aiming to diminish lethal events in these areas (González-Gallina *et al.* 2013). Investigations on the effectiveness of natural crossing structures in highways for bats are still scarce and inconsistent. It is known that many species use underground and green passages and fauna underpasses (Altringham & Kerth 2016). Thus, avoiding roadkills starts with the previous studies on highways installation (*i.e.*, before its construction), which may perform the localization of most likely habitats to bat roosts and foraging sites, in order to implement mitigation and conservation actions.

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