Acta Veterinaria Brasilica June 12 (2018) 62-70

Acta Veterinaria Brasilica

Journal homepage: https://periodicos.ufersa.edu.br/index.php/acta/index

Original Article

Population of hematophagous bats in the Andradina region, São Paulo: roost and control characterization

Ana Paula Lopes Santana[1], Cristiano de Carvalho[2], Ana Júlia Silva e Alves[3], Wagner André Pedro[2], Luzia Helena Queiroz[4]*

[1] São Paulo State University (UNESP), School of Veterinary Medicine, Post-Graduation Program on Animal Science, Araçatuba, SP, Brazil.
[2] São Paulo State University (UNESP), School of Veterinary Medicine, Araçatuba, SP, Brazil.
[3] United Metropolitan Colleges (FMU) – Preventive Veterinary Medicine Department. São Paulo, SP, Brazil.
[4] São Paulo State University (UNESP), School of Veterinary Medicine, Post-Graduation Program on Animal Science, Araçatuba, SP, Brazil. Volunteer senior professor.

A R T I C L E I N F O

Article history

Received 23 November 2017

Received in revised form 16 May 2018

Accepted 20 May 2018

Keywords:

Desmodus rotundus

Bat populations

Control of herbivorous rabies

A B S T R A C T

The present study quantified *Desmodus rotundus* population and characterized their roosts in the Andradina microregion, Sao Paulo, Brazil, in 2010 and 2012, determining the effect of bat control measures on roost numbers and types and their population. From April to June 2010, professionals from the Agriculture and Livestock Defense Coordination of the State of Sao Paulo responsible for the rabies control that consists of capturing and treating vampire bats with a vampiricide paste based on Warfarin 2%, inspected 50 bat roosts registered in 12 municipalities in the Andradina microregion, northwestern São Paulo. In September 2012, 31 of these roosts were again surveyed by the authors of this study. The vast majority (92% and 96% in 2010 and 2012, respectively) of the roosts were characterized as artificial, e.g., abandoned houses and warehouses, house attics, culverts under highways, deactivated wells and mills, bridges, disused housings, and barns. The only natural roosts found were tree hollows. The number of roosts and the bat population in roosts decreased drastically after the measures for direct control of hematophagous bats were performed, especially the number of maternity colonies, indicating that the direct selective method had a strong impact on reducing these populations.

INTRODUCTION

There are more than a thousand species of bats, but only three are hematophagous, feeding exclusively on blood and being potential reservoirs and transmitters of the rabies virus (QUEIROZ et al., 2009; BORDIGNON et al., 2017). For this reason, hematophagous bats have been systematically eliminated in Brazil since the mid-1970s as a preventive measure adopted by the National Herbivorous Rabies Control Program (Programa Nacional de Controle da Raiva dos Herbívoros, PNCRH) of the Ministry of Agriculture, Livestock and Food Supply (Ministério da Agricultura, Pecuária e Abastecimento, MAPA) (BRAZIL, 2009). However, the considerable population decrease caused by this measure has unknown consequences for the species relationship with the environment and other species as well.

Rabies is one of the most important zoonosis in the world, caused by a virus of the genus *Lyssavirus*, family Rhabdoviridae, which is characterized by nervous symptomatology that leads to death in nearly 100% of the cases. Although it has been described for at least four millennia, it is still considered as a neglected disease in several parts of the world (VIGILATO et al., 2013), causing a significant economic impact on public health and veterinary medicine (RUPPRECHT, 2009; BANYARD et al., 2014). The rabies virus affects almost all mammals, including the Primates and Didelphimorfia, but the main reservoirs are species belonging to the orders Carnivora and Chiroptera (RUPPRECHT et al., 2008). Of the 5,416 species of mammals in the world, 1151 belong to the Chiroptera Order (BORDIGNON et al., 2017) and among

* Corresponding author: luzia.h.queiroz@unesp.br

http://dx.doi.org/10.21708/avb.2018.12.2.7532

these, 180 species are found in Brazil (REIS et al., 2011; BORDIGNON et al., 2017).

The high economic, social, and public health losses due to rabies in the Americas are attributed to the widespread distribution of the vampire bat on this continent (from Mexico to Argentina) associated with interspecies transmission due to its hematophagous habit (JOHNSON; ARECHIGA-CEBALLOS, AGUIAR-SETIEN, 2014). Although the number of livestock rabies cases transmitted by bats has greatly declined since the 1960s, the economic losses continue to exceed US $ 30 million per year in the Americas (WHO, 2005). In Brazil alone, these losses totaled approximately US $ 15 million per year, leading to the death of approximately 40,000 cattle in the 1990s (KOTAIT, 1998). In the new century, herbivorous rabies has decreased significantly and, a total of 18,749 cases of the disease, including bovines, equines, goats, sheep, and swine, were reported between 2005 and 2015, according to MAPA data (BRASIL, 2017).

The adopted measures for controlling *Desmodus rotundus* population include eliminating the specimens or their colonies by applying anticoagulant substances directly on the bite sites in herbivores or on the interscapular region of bats caught in the roosts or with nets placed around the corrals (LORD, 1988). Besides this direct method, additional measures such as registering and monitoring of roosts, controlling bite rates in cattle and other species of herbivores in the farms, collecting and sending samples to the specific laboratories for rabies virus research are also carried out (BRAZIL, 2009).

In several regions of the São Paulo State and especially the Andradina region, the expansion of the sugar-alcohol agroindustry caused pasture areas to be replaced with sugar cane cultivation areas, changing the beef cattle profile (BINI, 2009; XAVIER, 2010). Therefore, in the last 10 years, the decrease of the bovine population (IBGE, 2011) diminished the food supply for bats, which together with population control measures lowered the number of hematophagous bats throughout the State, substantially decreasing the number of cases of rabies in herbivores (LOUREIRO et al., 2012).

The measures to control rabies in herbivores have been carried out intensively and systematically by the Agriculture and Livestock Defense Coordination (Coordenadoria de Defesa Agropecuária, CDA) teams of the Agriculture and Supply Department of the State of São Paulo (Secretaria de Agricultura e Abastecimento do Estado de São Paulo, SAA/SP) in recent years (DIAS et al., 2011). These teams record the cases while registering all roosts with hematophagous bats to control their population and the outbreaks of the disease. In the Andradina microregion, the occurrence of bovine rabies transmitted by hematophagous bats is sporadic, with only six cases recorded between 1981 and 2016 (TADDEI et al., 1991; QUEIROZ et al., 2009; CASAGRANDE et al.; 2014; SÃO PAULO, 2017).

The objective of this study was to characterize the roosts and to quantify the *D. rotundus* bat population in the Andradina microregion in 2010 and 2012, in order to analyze the effects of bat control on the roost numbers and types and on the bat population inhabiting these roosts.

MATERIAL AND METHODS

Study site

The bats were captured in an area of 6,891.6 km^2 that included 11 municipalities with 191,692 inhabitants in the Andradina microregion, located in the Araçatuba mesoregion (20° 53' 46"S, 51° 22' 46" W), northwestern São Paulo. The average temperature is 21° C (IBGE, 2010). According to the geomorphological characteristics, the region is located in the Western Plateau which also includes Marília, Bauru, São José do Rio Preto, and Presidente Prudente, up to the border with the State of Mato Grosso do Sul, at altitude varying between 200 and 800m (MARTINELLI, 2009). The Agricultural and Livestock Defense Office (Escritório de Defesa Agropecuária, EDA) of Andradina is responsible for the animal health defense activities in this region that includes 13 municipalities, from Bento de Abreu up to Ilha Solteira, Castilho and Itapura, on the border with Mato Grosso do Sul (Figure 1).

Analyzed roosts

In 2010, 50 roosts located in 12 municipalities of the Andradina microregion (Figure 1) were studied. Between April and June 2010, a joint action of the CDA-SAA/SP teams for controlling herbivorous rabies surveyed and recorded the roosts geographic coordinates using a GPS device (Global Positioning System), commonly used for the location of points, routes, and navigation (BRASIL, 2009). Between August and September 2012, this study research team and/or the CDA-SAA/SP teams surveyed 31 of these remaining roosts again to verify how the roost was being used currently and whether the roost population had been replaced.

Bat identification

In 2010 and 2012, the bat species in the roosts were identified by their external morphological characteristics as described in Reis et al. (2011) and when necessary, using the forearm measurements of captured bats, according to Vizotto; Taddei (1973) and Reis et al. (2011, 2017). In 2010, the CDA and EDA control teams identified only the presence of *D. rotundus* inside the roosts, and when other species of bats were found cohabiting the same site, they were not identified. In

2012, the authors of this manuscript identified the other species present as described above.

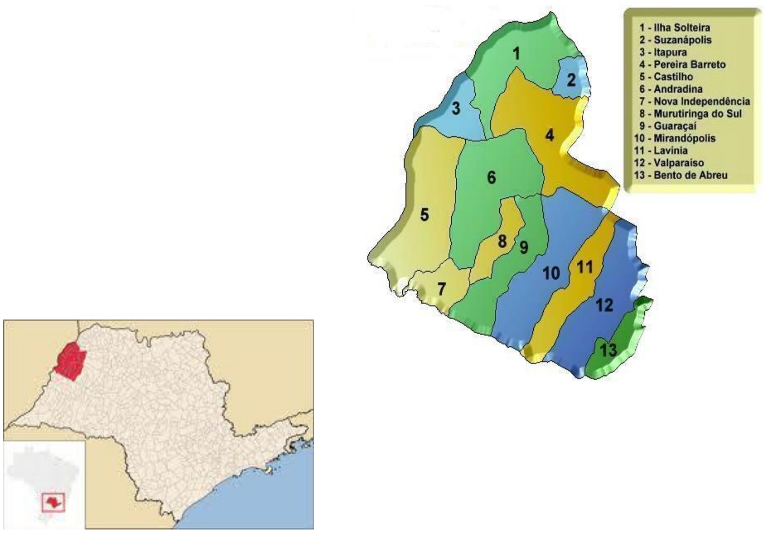
Roost characterization and population estimation

The registered roosts were characterized as active either due to the presence of hematophagous bats or evidence of the presence indicated by fecal matter (dark, shiny and with a pasty appearance, similar to burning oil). The roosts with either no stools or opaque and dry fecal matter were defined as inactive. In both sites, the ammoniacal odor characteristic of the digested blood was observed (OLIVEIRA, 2009).

The number of bats in each roost was counted by the direct visualization of the specimens. The colonies were defined as small (S), medium (M) and large (L), according to the number of bats observed: N ≤ 9 (S); 10 ≤ N ≤ 50 (M), and N> 50 (L), respectively.

In general, the roosts were characterized as natural such as tree hollows and artificial, such as abandoned houses and warehouses, house attics, culverts under highways, deactivated wells and mills, bridges, disused housings, and barns. Considering how the roosts were used, they were classified as maternity (presence of females, males, and baby bats), satellite (only males were present), digester (for digestion after feeding), empty (no bats or no indication of their presence) and destroyed (lacked condition for inhabiting).

Figure 1 – Map showing the area under the responsibility of the Agricultural and Livestock Defense Office (Escritório de Defesa Agropecuária, EDA) of Andradina, Coordination of Agricultural and Livestock Defense - SAA/SP. Andradina, 2012.



Population control methods for bats

The method recommended by MAPA (BRASIL, 2009) and used by the CDA teams is direct selection, in which a 2% warfarin-based anticoagulant paste is applied on the back of the bats captured in the roosts. Bats were captured using mist nets of different sizes (7 x 2m, 10 x 2m, and 12 x 2m) that were set up inside or at the entrance the roosts during the day using wooden supports and with screens or manual nets placed inside the roosts (BRASIL, 2009). According to Loureiro et al. (2012), the Herbivores Rabies Control Program of São Paulo recommends to capture and treat as many bats as possible per roost.

The study was not submitted to the Ethics Committee for the use of animals because this research followed the routine work of CDA/SAA-SP. The study was performed following the strategies and technical norms of the Normative Instruction No. 5, March 1, 2002 (BRASIL, 2002), and the Technical Manual for Herbivores Rabies Control of the Ministry of Agriculture, Livestock and Supply (BRASIL, 2009) for controlling domestic herbivores rabies and transmitters to protect public health and control the disease.

Data analysis

The data were logged to Excel spreadsheets and to obtain the spatial characterization of the analyzed variables, the geographic coordinates determined by the Global Positioning System (GPS) were georeferenced and inserted in the geographic information system (GIS) of the ArcGIS 9.2 software.

RESULTS AND DISCUSSION

In 2010, the CDA-SAA/SP teams for herbivorous rabies control registered 50 roosts in the Andradina microregion, in the following cities: Andradina (6), Bento de Abreu (1), Castilho (9), Guaraçaí (1), Itapura (3), Lavinia (10), Mirandopólis (5), Murutinga do Sul (2), New Independence (1), Pereira Barreto (7), Suzanapólis (1), and Valparaíso (4). Out of the 50 roosts, 49 were considered for the study since the one in Itapura was found already destroyed, and of these, 31 were inspected in 2012. Tables 1 and 2 show the geographical coordinates and characteristics of the roosts in 2010 and 2012, respectively. According to data provided by the Coordination of the Herbivores Rabies Control Program of the São Paulo State, 1095 vampire bats were captured and treated by the CDA teams in 2010, with an average of 22.3 bats per roost, varying between one and 108, according to roost size.

Of the 31 roosts registered in 2012, five (three hollow trees and two abandoned houses) had been destroyed. Thus, 49 roosts were active in 2010 whereas only 26 roosts were active in 2012, and were characterized regarding type and use. Most of the roosts in the region are considered artificial, 92% (45/49) in 2010 and 96% (25/26) in 2012. Similarly, Taddei et al. (1991) reported that *D. rotundus* bat is highly dependent on artificial structures, which are used in more than 90% of cases in northwestern São Paulo.

Albas et al. (2011) carried out a study in the western São Paulo State and observed 16 artificial bat roosts, 50% of which were abandoned houses, similar to the results recorded in the Andradina region. The Western Plateau characterizes the western and northwestern regions, where the Andradina microregion is located. This topography offers few natural roosts, contrary to the Eastern region of the State that is characterized by mountains, rugged topography and areas still covered by the Atlantic Rainforest, where the number of natural roosts is still abundant (TADDEI et al., 1991).

In the central south and central east municipalities, the number of natural roosts is already approaching those of the artificial roosts. Gomes; Uieda (2004) reported 33.3% and 66.7% of natural and artificial roosts, respectively, and Rocha (2007) observed 45.5% and 54.5%, respectively. In Araguari (MG), artificial roosts make up 81.5% (44/53) of the total compared to 18.5% (10/53) of natural roosts (OLIVEIRA et al., 2009) whereas natural roosts predominate in the region of the Cordisburgo and Curvelo municipalities (ALMEIDA et al., 2002).

The roosts were classified into 10 different types in 2010, consisting of predominantly abandoned houses (49%) and culverts (21%). In 2012, five inactive (16%) and 26 active (84%) roosts were found. Of these, only one was natural (tree hollow) and the others artificial, with predominance of abandoned houses and culverts (Figure 2).

Among the roosts inhabited by hematophagous *D. rotundus* bats in 2010, 58% (25/43) were maternity type colonies and 42% (18/43), satellite type. In 2012, of the 11 roosts inhabited by *D. rotundus*, only three (27%) were characterized as maternity colonies while the majority (73%) were satellite colonies. The inspected roosts were not inhabited by other hematophagous species such as *Diphylla ecaudata*, which is widely distributed in the karstic region of Minas Gerais State, according to Almeida et al. (2002).

The results of this study regarding artificial roosts only corroborate those reported by Albas et al. (2011) and Oliveira et al. (2009) for the Presidente Prudente region and Araguari (MG), respectively. However, they differ regarding natural roosts according to the geographic region: tree hollows in the Andradina region, caves and grottos in the central-south and central-east region of São Paulo (GOMES; UIEDA, 2004; ROCHA, 2007), and caves and tree hollows in Araguari (OLIVEIRA et al., 2009). This difference is related to the landscape and relief characteristics according to Taddei et al. (1991).

In this study, the number of individuals per roost was lower than those observed by Gomes; Uieda (2004) in municipalities in São Paulo State and those reported by Oliveira et al. (2009) in Araguari (MG), where the number of maternity colonies was lower but inhabited by more individuals, reaching more than 300 individuals in the older colonies.

In 2010, no data were provided regarding the presence of other bat species, either in single colonies or in cohabitation with *D. rotundus* in the roosts. However, in 2012, other non-hematophagous species such as *Carollia perspicillata* were found in eight of the roosts (Table 2), cohabiting with *D. rotundus* in three of them and with *Platyrrhinus lineatus* in one. The species *Glossophaga soricina* and *Chrotopterus auritus* were found in one roost each. Bats of the species *C. perspicillata* have also been found in 14 (87.5%) of the 16 roosts investigated in the Presidente Prudente region while cohabiting with *D. rotundus* in 12 (75%) of them (ALBAS et al., 2011). Likewise, Taddei et al. (1991) observed that this species is commonly observed cohabiting with the common vampire. There are also reports in the literature regarding *D. rotundus* cohabiting with *Platyrrhinus lineatus*, *Glossophaga soricina* and *Carollia perspicillata* in roosts in Cordisburgo and Curvelo (MG), where other species not registered in our region have also been described (ALMEIDA et al., 2002). However, we found no reports in the national literature of cohabitation between the species *Chrotopterus auritus* and *D. rotundus*, this being the first report and an interesting fact since this species is carnivorous, and supposedly could feed on the vampires.

Table 1 – Characterization and location of *Desmodus rotundus* roosts registered from April to June 2010 in the Andradina microregion, SP.

Roost	Municipality	Roost type	Use	Population (estimate)	Longitude	Latitude
1	Andradina	Abandoned house	Satellite	S	463950	7700862
2	Andradina	Tree hollow	Empty	-	470309	7701182
3	Andradina	Tree hollow	Empty	-	469933	7701181
4	Andradina	Abandoned house	Digester	-	462085	7707314
5	Andradina	Tree hollow	Maternity	M	463329	7707286
6	Andradina	Abandoned house	Satellite	S	468175	7713598
7	Bento Abreu	Culvert	Satellite	S	526868	7654673
8	Castilho	Bridge	Satellite	S	447611	7683787
9	Castilho	Culvert	Empty	-	442851	7699174
10	Castilho	House attic	Maternity	S	444233	7683622
11	Castilho	Deactivated mill	Maternity	S	443439	7687709
12	Castilho	Abandoned house	Maternity	S	435718	7682424
13	Castilho	Abandoned house	Maternity	M	443119	7679960
14	Castilho	Abandoned house	Satellite	S	435689	7682362
15	Castilho	Disused housing	Maternity	M	433868	7682816
16	Castilho	Disused housing	Maternity	L	433839	7682816
17	Guaraçaí	Abandoned house	Satellite	S	478086	7679305
18	Itapura	Tree hollow	Maternity	L	457636	7716864
19	Itapura	Bridge	Satellite	S	457008	7713573
20	Lavínia	Culvert	Satellite	S	453590	7714855
21	Lavínia	Culvert	Maternity	S	504095	7661304
22	Lavínia	Abandoned house	Digester	-	502826	7662134
23	Lavínia	Barn	Maternity	S	499769	7671788
24	Lavínia	Abandoned house	Maternity	S	500432	7660444
25	Lavínia	Abandoned house	Satellite	S	480904	7638943
26	Lavínia	Abandoned house	Satellite	S	403828	7660565
27	Lavínia	Deactivated well	Maternity	M	490168	7656567
28	Lavínia	Abandoned house	Maternity	S	494145	7660596
29	Lavínia	Culvert	Satellite	S	488441	7651370
30	Mirandópolis	Culvert	Satellite	S	495990	7665700
31	Mirandópolis	Deactivated well	Maternity	S	494518	7667759
32	Mirandópolis	Deactivated well	Satellite	S	491398	7674829
33	Mirandópolis	Abandoned house	Maternity	M	501068	7686452
34	Mirandópolis	Culvert	Satellite	S	491969	7687618
35	Murutinga do Sul	Abandoned house	Satellite	S	486926	7672828
36	Murutinga do Sul	Abandoned house	Maternity	S	463709	7665384
37	Nova Independência.	Abandoned house	Digester	-	461314	7665655
38	Pereira Barreto	Abandoned warehouse	Maternity	L	451201	7671070
39	Pereira Barreto	Abandoned house	Satellite	S	467475	7716763
40	Pereira Barreto	Abandoned house	Satellite	S	467475	7716763
41	Pereira Barreto	Abandoned house	Maternity	M	467735	7716855
42	Pereira Barreto	Abandoned house	Maternity	S	467735	7716825
43	Pereira Barreto	Abandoned house	Maternity	M	488958	7697608
44	Pereira Barreto	Abandoned house	Maternity	M	489276	7698007
45	Suzanápolis	Abandoned house	Satellite	S	487481	7702310
46	Valparaíso	Culvert	Maternity	L	494352	7730319
47	Valparaíso	Culvert	Maternity	S	510552	7655982
48	Valparaíso	Culvert	Maternity	M	507929	7658228
49	Valparaíso	Abandoned house	Maternity	M	509024	7657275

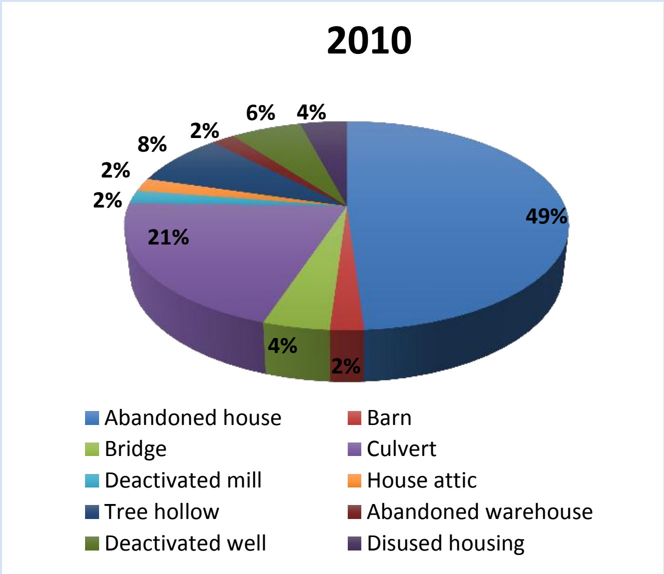
S = small (N ≤ 9 bats), M = medium (10 ≤ N ≤ 50), L = large (N > 50 bats). Source: Herbivores Rabies Control Program, Agricultural and Livestock Defense Coordination (CDA), Department of Agriculture and Supply of the State of São Paulo.

Table 2 – Characterization and location of *Desmodus rotundus* roosts inspected in August and September 2012 in the Andradina region, SP.

Nº	Municipality	Type	Use	Species Found	Population	Longitude	Latitude
1	Andradina	Tree hollow	Destroyed			470309	7701182
2	Andradina	Tree hollow	Destroyed			469933	7701181
3	Andradina	Abandoned house	Destroyed			462085	7707314
4	Andradina	Tree hollow	Destroyed			463329	7707286
5	Bento de Abreu	Culvert	Maternity	*D. rotundus*	M	526911	7654689
6	Castilho	Bridge	Empty			447551	7683754
7	Castilho	Culvert	Empty			451704	7694670
8	Castilho	Deactivated mill	Satellite	*D. rotundus*	S	443352	7687924
9	Castilho	Abandoned house	Satellite	*D. rotundus*	S	435718	7682424
10	Castilho	Abandoned house	Satellite	*D. rotundus*	S	433868	7682816
11	Castilho	Roofless house	Destroyed			433839	7682816
12	Itapura	Tree hollow	Satellite	*D. rotundus*	S	457008	7713573
13	Itapura	Bridge	Other species	*Glossophaga soricina*	S	453551	7714835
14	Lavínia	Culvert	Other species	*Chrotopterus auritus*	S	495532	7666944
15	Lavínia	Culvert	Other species	*Carollia perspicillata*		504695	7661304
16	Lavínia	Abandoned house	Empty			490088	7656563
17	Lavínia	Abandoned house	Other species	*Carollia perspicillata*	S	493785	7660497
18	Lavínia	Abandoned house	Other species	*Carollia perspicillata*	M	500237	7660433
19	Lavínia	Deactivated well	Empty			488265	7651183
20	Lavínia	Abandoned house	Other species	*Carollia perspicillata and Platyrrhinus lineatus*		494049	7660709
21	Lavínia	Culvert	Satellite Cohabitation	*D. rotundus and Carollia perspicillata*	S	502826	7662134
22	Mirandopolis	Abandoned house	Satellite	*D. rotundus*	S	491969	7687618
23	Mirandópolis	Culvert	Empty			494379	7667721
24	Mirandópolis	Deactivated well	Empty			500937	7686398
25	Mirandópolis	Culvert	Empty			492282	7669135
26	Pereira Barreto	Abandoned house	Satellite	*D. rotundus*		467475	7716763
27	Pereira Barreto	Abandoned house	Empty			467735	7716855
28	Pereira Barreto	Abandoned house	Maternity	*D. rotundus*	S	467475	7716763
29	Valparaiso	Culvert	Other species	*Carollia perspicillata*	L	516902	7654477
30	Valparaiso	Culvert	Maternity Cohabitation	*Carollia perspicillata and D. rotundus*	S	510529	7655881
31	Valparaiso	Culvert	Satellite Cohabitation	*Carollia perspicillata and D. rotundus*	S	507889	7658140

S = small (N ≤ 9 bats), M = Medium (10 ≤ N ≤ 50), L = Large (N > 50 bats).

Figure 2 – Distribution of roost types housing hematophagous bats in the Andradina microregion, SP, in 2010 and 2012.



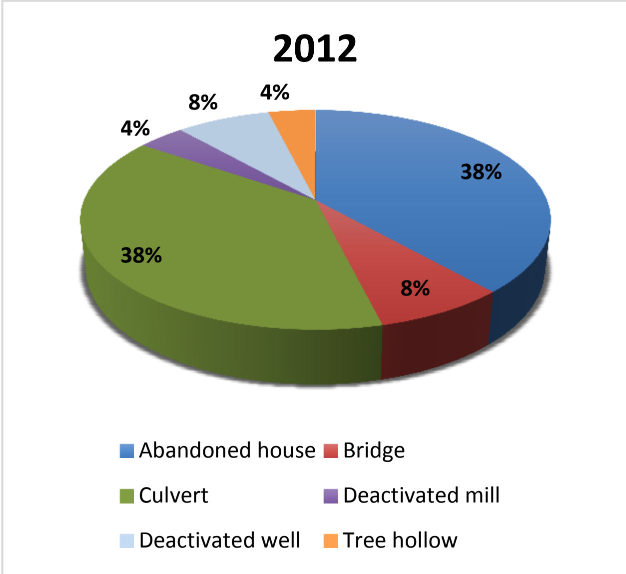
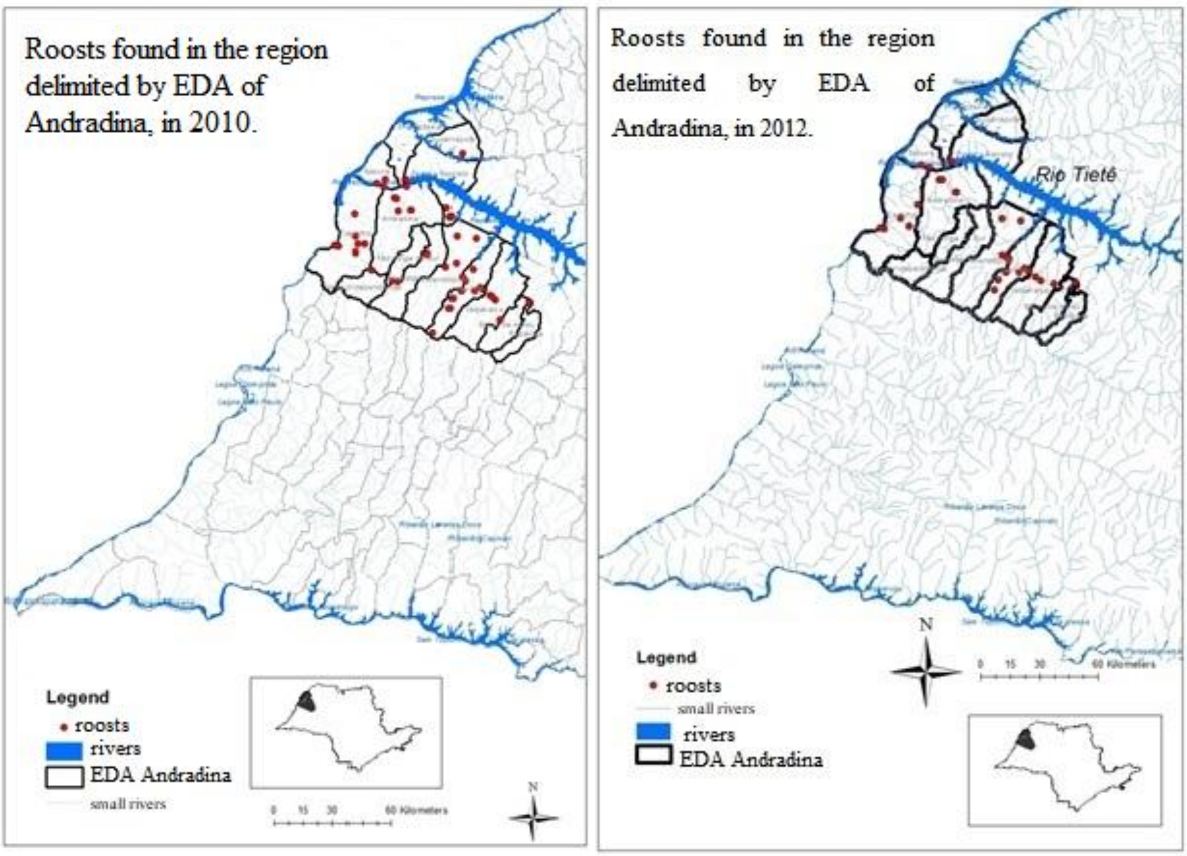


Figure 3 maps the geographical coordinates of the roosts in relation to the rivers of the region. It is observed that most roosts are close to water sources such as rivers and streams, suggesting that water resources appear to be key factors in the establishment of *D. rotundus*, as previously reported by Taddei et al. (1991). Several roosts were observed in the culverts under the Marechal Rondon Highway from Bento de Abreu to Valparaíso, suggesting that this artificial roost type should be monitored frequently since it provides low light and water, and cannot be destroyed.

Figure 3 – Hydrographic map showing the location of the hematophagous bat roosts observed in the Andradina region/SP, in 2010 and 2012.



Taddei et al. (1991) suggested that during the dry season, in São Paulo, common bats (*D. rotundus*) move forming colonies near the riverbed and attacks on herbivores also occur in properties close to the rivers, thus favoring the appearance of rabies. This hypothesis was not supported by Gomes et al. (2007), who investigated the appropriate areas for hematophagous attack in the region of São José da Boa Vista (SP) and Gomes; Monteiro (2011), who studied the occurrence of bovine rabies and its spatial distribution in the State of São Paulo. Both studies emphasized that the particular topography of the studied region should be also considered and not only the distribution of the rivers in the area. The Andradina region has several roosts close to the rivers; however, rabies incidence is low, with only five cases recorded between 1981 and 2016 (TADDEI et al., 1991; QUEIROZ et al., 2009; CASAGRANDE et al.; 2014; SÃO PAULO, 2017), corroborating the observations of Gomes et al. (2007) and Gomes; Monteiro (2011).

In 2010, out of 49 roosts, 43 (88%) were inhabited by hematophagous bats, while in 2012, of the 31 roosts visited, only 11 roosts (35%) were inhabited by hematophagous bats. Therefore, 21 roosts were either destroyed or emptied, or had other bat species but not *D. rotundus*. Considering the relative percentage of roosts inhabited by vampires in the two analyzed years, it can be affirmed that the control measures, i.e., the treatment with the vampiricide paste applied by the CDA teams reduced by 53% the number of roosts with *D. rotundus*. This result is lower than the 72.5% decrease in the number of roosts inhabited by hematophagous bats after treatment with vampiricide paste described by Oliveira et al. (2009) in Minas Gerais.

Studies in the Northwest region of São Paulo showed no rabies cases in *D. rotundus*, however cases of the disease were recorded in other species of bats, transmitted by rabies virus genetic variants of *Desmodus* (QUEIROZ et al., 2012) and a seroprevalence of 7.2% among bats of this species (CASAGRANDE et al., 2014). This result demonstrates that the rabies virus still circulates in this population despite the control measures performed, as it has been observed in the colonies investigated in Peru (STREICKER et al., 2012).

The PNCRH/MAPA also advocate for health and environmental education among the control actions. They seem to be fundamental for preserving bat species, clarifying the risks involved in their handling because of rabies, both hematophagous and non-hematophagous species, since both may constitute reservoirs and vectors of the virus, and the need to notify the disease in herbivores to improve its control.

CONCLUSIONS

In the Northwest region of São Paulo, the roosts available to the bats are predominantly artificial, showing the human impact on the changing environment, which sometimes favors the population growth of some species, as in the case of the hematophagous bat *D. rotundus*. The results show a marked decrease in the number of roosts and the number of bats inhabiting these roosts after applying direct measures to control the population of hematophagous bats, especially on the number of maternity colonies, demonstrating the strong impact of the direct selective method on the reduction of these populations.

Acknowledgments.- We are thankful to Dr. Fernando Gomes Buchala, Coordinator of Agricultural and Livestock Defense of São Paulo State; Dr. Paulo Antonio Fadil (EDA Ribeirão Preto - CDA-SAA/SP) current Coordinator of the State Herbivores Rabies Control Program for allowing the publication of the data. Thanks are also due to Dr. Vladimir de Souza Nogueira Filho (EDA Bauru - CDA-SAA/SP), Program Coordinator during the research period and to the CDA teams for control of hematophagous bats for providing the data on the roosts recorded in the Andradina region, SP. We are also thankful to the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) for the financial support (Proc. 578281/2008-2).

REFERENCES

ALBAS, A. et al. Os morcegos e a raiva na região oeste do Estado de São Paulo. **Revista da Sociedade Brasileira de Medicina Tropical**, v. 44, n. 2, p. 201-205, 2011.

ALMEIDA, E. O. et al. Combate ao *Desmodus rotundus rotundus* (E. Geoffroy, 1810) na região cárstica de Cordisburdo e Curvelo, Minas Gerais. **Arquivo Brasileiro de Medicina Veterinária e Zootecnia**, v. 54, n. 2, p. 117-126, 2002.

BANYARD, A. C. Lyssaviruses and Bats: Emergence and Zoonotic Threat. **Viruses**. v. 6, n. 8, p. 2974–2990. 2014.

BINI D.L.C. Mudanças na pecuária bovina de corte e algumas implicações sócio-espaciais na região de Araçatuba (SP). **Revista Formação**, v. 2, n. 16, p. 26-36. 2009.

BORDIGNON, M. O. et al. Sobre os morcegos Brasileiros. In: REIS, N. R.; PERACCHI, A. L.; BATISTA, C. B.; PEREIRA, A. D. (Ed) **História Natural dos Morcegos Brasileiros. Chave de Identificação de Espécies.** Rio de Janeiro: Technical Books Editora. 2017. p. 18-20.

BRASIL. Ministério da Agricultura, Pecuária e Abastecimento. **Instrução Normativa n° 5, de 1° de março de 2002.**

BRASIL. Ministério da Agricultura, Pecuária e Abastecimento. **Controle da raiva dos herbívoros**. Brasília, DF. 2009.

BRASIL. Ministério da Agricultura, Pecuária e Abastecimento. Programa Nacional de Controle da Raiva dos Herbívoros e Outras Encefalopatias. **Dados sobre a raiva em herbívoros e suínos no Brasil**. Disponível em <http://www.agricultura.gov.br/assuntos/sanidade-animal-e-vegetal/saude-animal/programas-de-saude-animal/DADOSRAIVAATE2015.pdf> Acesso: 17 jul. 2017.

CASAGRANDE, D. K. A. et al. Rabies surveillance in bats in Northwestern State of São Paulo. **Revista da Sociedade Brasileira de Medicina Tropical**, v. 47, n.6, p. 709-715, 2014.

DIAS, R.A. et al. Modelo de risco para circulação do vírus da raiva em herbívoros no Estado de São Paulo, Brasil. **Revista Panamericana de Saúde Pública**, v. 30, n. 4, p. 370-376, 2011.

GOMES M.N.; MONTEIRO A.M.V. Raiva bovina no estado de São Paulo e sua distribuição espacial entre 1992 e 2003. **Arquivo Brasileiro de Medicina Veterinária e Zootecnia**, v. 63, n.2, p. 279-286, 2011.

GOMES M.N. et al. Áreas propícias para o ataque de morcegos hematófagos *Desmodus rotundus* em bovinos na região de São João da Boa Vista, Estado de São Paulo. **Pesquisa Veterinária Brasileira,** v. 27, n. 7, p. 307-313, 2007.

GOMES M.N.; UIEDA W. Abrigos diurnos, composição de colônias, dimorfismo sexual e reprodução do morcego hematófago *Desmodus rotundus* E. Geoffroy (Chiroptera, Phyllostomidae) no Estado de São Paulo, Brasil. **Revista Brasileira de Zoologia**, v. 2, n.3, p.629-638, 2004.

IBGE - Fundação Instituto Brasileiro de Geografia e Estatística 2010. Disponível em: <http://www.sidra. ibge.gov.br> Acesso em: 20 Mar. 2015.

IBGE 2011. Pesquisa da Produção da Pecuária Municipal. Fundação Instituto Brasileiro de Geografia e Estatística. Disponível em <http://www.ibge.gov.br/home/estatistica/pesquisas/pesquisa_resultados.php?id_pesquisa=21> Acesso em 19 Nov. 2012.

JOHNSON, N., ARECHIGA-CEBALLOS, N., AGUIAR-SETIEN, A. Vampire bat rabies: Ecology, epidemiology and control. **Viruses**, v. 6, p. 1911-1928, 2014.

KOTAI, I. Controle da raiva dos herbívoros**.** Manual Técnico no.1, Instituto Pasteur, São Paulo, SP. 1998.

LORD, R.D. Control of vampire bats. In: GREENHALL, A.M.; SCHMIDT, U. (Eds), Boca Raton, Florida: CRC Press, p.215-226. 1988.

LOUREIRO, J.G.P. Programa Estadual de Controle da Raiva dos Herbívoros e Programa de Educação Sanitária. Coordenadoria de Defesa Agropecuária, Campinas, SP. 2012.

MARTINELLI, M. 2009. Relevo do Estado de São Paulo. Cofins - **Revista Franco Brasileira de Geografia,** n. 7.

OLIVEIRA, P.R. Levantamento, cadastramento e estimativa populacional das habitações de morcegos hematófagos, antes e após atividades de controle, no município de Araguari-MG. **Arquivos do Instituto Biológico, São Paulo**, v. 76, n. 4, p. 553-560. 2009.

QUEIROZ, L.H. et al. Perfil epidemiológico da raiva na região Noroeste do Estado de São Paulo no período de 1993 a 2007. **Revista da Sociedade Brasileira de Medicina Tropical**, v. 42, n. 1, p. 9-14. 2009.

QUEIROZ, L. H. et al. Rabies in southeast Brazil: a change in the epidemiological pattern. **Archives of Virology**, v. 157, n. 1, p. 93-105, 2012.

REIS, N.R. et al. Mamíferos do Brasil. 2ª ed. Seropédica, RJ: Editora da Universidade Federal Rural do Rio de Janeiro, 2011. 439p.

REIS, N.R. et al. História Natural dos Morcegos Brasileiros. Chave de Identificação de Espécies. 1ª ed. Rio de Janeiro: Technical Books Editora. 2017. 416 p.

ROCHA, F. A. ; UIEDA, W. ; SOUZA, L. C. . Body lesions in the common vampire bats from southeastern Brazil and their possible relation to the intraspecific rabies transmission. In: **XIV International Bat Research Conference,** 2007, Mérida. Bat Research News. Williamsport, Pennsylvania, US: Lycoming College, v. 44. p. 310-311. 2007.

RUPPRECHT, C. E. Bats, emerging diseases, and the human interface. **PLOS Neglected Tropical Diseases**, v. 3: e451. 2009.

RUPPRECHT, C. E. et al. Can rabies be eradicated? **Developments in Biologicals (Basel)**, v. 131, p. 95–121, 2008.

SÃO PAULO, SECRETARIA DA SAUDE, INSTITUTO PASTEUR. Dados Estatísticos. Disponível em http://www.saude.sp.gov.br/instituto-pasteur/paginas-internas/vacinacao/dados-estatisticos. Acesso em 17 jul. 2017.

STREICKER, D.G. et al. Ecological and anthropogenic drivers of rabies exposure in vampire bats: implications for transmission and control. **Proceedings of the Royal Society B,** v. 279, p. 3384- 3392, 2012.

TADDEI, V. A. Distribuição do morcego vampiro *Desmodus rotundus* (Chiroptera, Phyllostomidae) no Estado de São Paulo e a raiva dos animais domésticos. Impresso Especial CATI, Secretaria de Agricultura e Abastecimento, Governo do Estado de São Paulo, São Paulo. 107p. 1991.

VIGILATO, M. A. N. et al. Progress towards eliminating canine rabies: policies and perspectives from Latin America and the Caribbean. **Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences**, 368, 2012.0143, 2013.

VIZOTTO, L. D.; TADDEI, V. A. Chave para determinação de quirópteros brasileiros**.** Revta Fac. Filosofia Ciências e Letras de São José do Rio Preto - **Boletim de Ciências,** n. 1. 72p., 1973.

WORLD HEALTH ORGANIZATION. WHO Experts consultation on rabies: first report 5-8 Oct. 2004. Geneva, Switzerland: World Health Organization. Technical report, vol. 931, p. 1-88, 2005.

XAVIER, C. V. A expansão da agroindústria sucroalcooleira na região de Andradina e a crise da reprodução do capital. **Revista Eletrônica da Associação dos Geógrafos Brasileiros.** v.7, n. 11, 2010.