

# Metapopulation in bats of Southern Brazil

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(With 2 figures)

## Abstract

The purpose was to show that displacements, promoters of genetic diversity in metapopulations, increase the probability of survival of bat species adapted to medium and long-distance flights. Samples were taken in four forest fragments, distributed in three municipalities in northern Paraná, and the maximum distance between the studied areas is 20 km. A monthly sampling was performed for each fragment, for the period of July 2008 to June 2009. We used eight nets for collection which remained open during the first four hours of the night, totalling 192 hours during a year of study. The marking occurred from October 2008 to March 2009 and was accomplished through the use of anodised metal rings of four different colours. One hundred and fifty individuals were banded and since the first capture, four displacements were recorded. After five months of collecting and marking, one *Carollia perspicillata* was found three km away. Two *Artibeus lituratus* were recorded about 20 km from the marking place: the first one after 22 months and the second one after 24 months. Additionally, one *Platyrrhinus lineatus* was captured at about 20 km, after 26 months. As they moved around over considerable distances and are not monogamous, they mate with females of other fragments, exchanging genes and reducing or even avoiding inbreeding. Thus, populations of bats have the ability to increase genetic diversity in metapopulations, provided by displacements between the forest fragments. Species that behave like this are not vulnerable to isolation.

**Keywords:** bats, displacements, gene flow, preservation.

## Metapopulação em morcegos do sul do Brasil

### Resumo

Objetivou-se mostrar que os deslocamentos, promotores da diversidade genética em metapopulações, incrementam a probabilidade de sobrevivência das populações de espécies de morcegos adaptadas para voos de média e longa distância. As amostragens foram realizadas em quatro fragmentos florestais, distribuídos em três municípios da região norte do Paraná, sendo que a distância máxima entre as áreas de estudo foi de 20 km. Uma amostragem mensal foi realizada em cada fragmento, durante o período de julho de 2008 a junho de 2009. Foram utilizadas oito redes por coleta, que permaneceram abertas durante as quatro primeiras horas da noite, totalizando 192 horas, durante um ano de estudo. A marcação ocorreu de outubro de 2008 a março de 2009 e foi realizada por meio de anilhas metálicas anodizadas de quatro cores diferentes. Cento e cinquenta indivíduos foram marcados e, desde a captura, foram registrados quatro deslocamentos. Após cinco meses da coleta e da marcação, um *Carollia perspicillata* foi encontrado a três quilômetros. Dois *Artibeus lituratus* foram registrados a cerca de 20 km do local de marcação, um destes após 22 meses e o segundo, após 24 meses. Adicionalmente, um *Platyrrhinus lineatus* foi capturado a cerca de 20 km, após 26 meses. Ao se locomoverem por razoáveis distâncias, como não são monogâmicos, os machos cruzam com fêmeas de outros fragmentos, trocando genes e reduzindo – ou mesmo evitando – a endogamia. Assim, há a possibilidade de se incrementar a diversidade genética nas metapopulações, possibilitada pelos deslocamentos entre os fragmentos. As espécies que assim se comportam não são vulneráveis ao isolamento.

**Palavras-chave:** quirópteros, deslocamentos, fluxo gênico, preservação.

## 1. Introduction

A set of populations connected by individuals who move between them constitute a metapopulation (Ricklefs, 1993; Paglia et al., 2006), as well as a population of populations. Initially, the metapopulation theory was proposed by North American ecologist Levins (1970), shortly after the release of the theory of island biogeography (MacArthur and Wilson, 1967). Historically, one was already aware of long migratory shifts of species common in Brazil, as *Tadarida brasiliensis* (I. Geoffroy, 1824), flying over 1,000 km, from the United States to Mexico, south or northbound, depending on climatic variables (temperature) and also the genus *Myotis*, which move more than 300 km, between Alabama and Tennessee, south of North America (Fleming and Eby, 2003). It is known that in southeastern and southern Brazil, the fragmented landscape is surrounded by modified environments that may or may not be unfavourable for bat species. The matrix surrounding forest fragments may be used and re-populated by species with some adaptive potential and extinguish those “*estenobiontes*” (Primack, 1993), so the degree of utilization of areas between the fragments ranges widely, causing changes in the population dynamics of species.

The size of the populations that relate to each other and form metapopulations depends on the number of individuals, migration and power of colonisation of each species. The exchange of genes between bats that seek, colonise and forage large areas is a decisive factor for the maintenance of gene flow, which is necessary to prevent a greater incidence of deleterious alleles within populations, which protect the survival of species (Pires et al., 2003).

What is the main advantage in bats exchanging genes with other populations, through displacement, forming metapopulations? To avoid the loss of evolutionary flexibility that occurs due to reduced genetic variability, which induces the population to not respond positively to environmental variances, a fundamental process for evolutionary adaptation in environments that suffer disturbances (Stockwell et al., 2003; Begon et al., 2007).

It is important to emphasize that “k” strategists like bats, which have a long life and generate very few offspring, need mechanisms to protect their population and continue the survival of the species (Odum and Barrett, 2007).

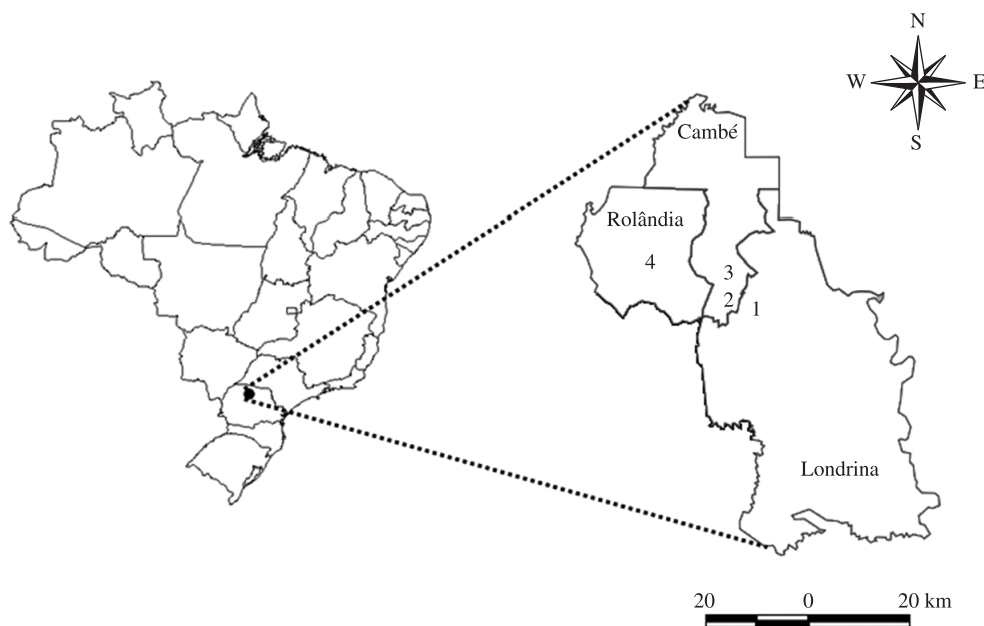
The objective here is to show that displacements, promoters of genetic diversity in metapopulations, increase the probability of survival of bat species adapted to medium and long-distance flights.

## 2. Material and Methods

### 2.1. Study area

Samples were taken in four forest fragments, distributed in three municipalities of northern Paraná: *Sítio Cazado* (23° 14' 28" S and 51° 22' 20" W), *Horto Florestal* of the State University of Londrina (23° 19' 45" S and 51° 12' 25" W), *Sítio Santana* (23° 20' 7" S and 51° 16' 44" W) and *Parque Municipal Histórico* of Cambé (23° 17' 56" S and 5° 16' 43" W) (see Figure 1). The geographic coordinates were obtained through the Google Earth Pro program, 4.2.0180.1134 version.

The maximum distance between the studied areas is of 20 km and the minimum is 4.1 km. Since the sites are close, they have similar characteristics in relation to climate



**Figure 1.** Location of forest fragments in northern Paraná (1. *Sítio Cazado*, 2. *Horto Florestal* of the State University of Londrina, 3. *Sítio Santana*, 4. *Parque Municipal Histórico* of Cambé).

and vegetation. According to Köppen's classification, the climate is humid subtropical and all fragments are remnants of semideciduous forest, which has highly diversified tree flora, compared to other forest types (Gusson, 2007).

## 2.2. Methodology

A monthly sampling was performed for each fragment, for the period of July 2008 to June 2009. We used eight nets for collection, which remained open during the first four hours of the night, totalling 192 hours over a year of study. The nets were set on trails and examined at intervals of 15 minutes (Reis, 1984), to avoid the stress of captive animals and prevent damage to the nets, caused by them.

The captured animals were marked and identified in the field with the aid of keys produced by Vizotto and Taddei (1973), Reis et al. (1993). The marking occurred from October 2008 to March 2009 and was accomplished through the use of anodised metal rings of four different colours, each colour corresponding to a fragment, to monitor possible displacements. Three sizes were used (2.5 mm, 4 mm and 6 mm in diameter) to cover bats considered small, medium and large.

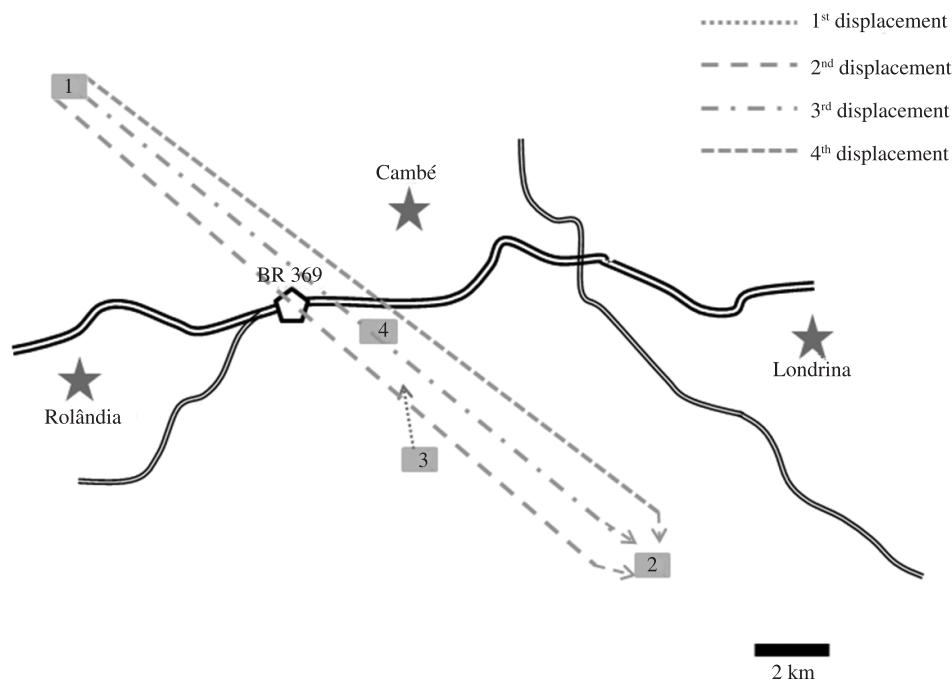
## 3. Results

Of the four hundred and ninety-five individuals captured, one hundred and fifty were banded and since the first capture, four displacements were recorded (Table 1). After five months of collecting and marking, one *Carollia perspicillata* (Linnaeus, 1758) was found 3 km from the fragment where the marking occurred (*Sítio Santana*), being near the other

remaining forest area (*Parque Municipal*) inserted in the studied area. The second displacement was recorded after one year and 10 months and one *Artibeus lituratus* (Olfers, 1818) was found at about 20 km (at the State University of Londrina) from the marking site (*Sítio Cazado*). The third displacement happened two years after the first collection, where another *A. lituratus* was located at about 20 km (also at the State University of Londrina) from the marking site (*Sítio Cazado*). And finally, a fourth movement was recorded after two years and two months, and one *Platyrrhinus lineatus* (E. Geoffroy, 1810) was captured at about 20 km (State University of Londrina) from the marking fragment (*Sítio Cazado*) (see Figure 2). For the time between marking and recapture, Gardner et al. (1991) estimated the life time of *Artibeus fimbriatus* Gray, 1838 in 4.5 years and Wilson and Tyson (1970) obtained an average of 7 years. Corroborating with these studies, we note here that the species mentioned have great potential for survival, which provides a better use of the landscape.

## 4. Discussion

If individuals of a population move between patches of certain habitats, establishing a connection, there is the formation of a metapopulation. Bats, like mammals, are evolutionarily superior when compared to other taxons. So they have three basic activities: feeding, reproduction and protection (Branco and Rocha, 1980). As they move around over large distances, and as they are not monogamous, they are obviously induced by hormones to mate with females of



**Figure 2.** Scheme of displacements in the studied landscape (1. *Sítio Cazado*, 2. *Horto Florestal* of the State University of Londrina, 3. *Sítio Santana*, 4. *Parque Municipal Histórico* of Cambé) and displacements recorded in the region.

other distant fragments. Therefore, populations of bats have the ability to increase genetic diversity in metapopulation, provided by the displacements between the forest fragments. Species that behave like this are not as vulnerable to disappearance, as those with little displacement. That is, this is simply the practice of their second strongest instinct after feeding, i.e. reproduction, through crosses between individuals from different populations. Still, in relation to mating behaviour, polygamy is seen as a potentially important factor for the effective size of a population and gene flow (Salgueiro, 2007).

Costa et al. (2006) reported the displacement of a male *Artibeus fimbriatus* in the state of Rio de Janeiro, which was recaptured 20 days after the first capture, at a distance of 21.7 km, with descent testicles, which indicates the maintenance of gene flow between mainland and islands in the southern state. This fact clearly suggests the establishment of a metapopulation.

Bianconi et al. (2006) recaptured, after banded 653 bats of seven species, 54 individuals of six species in three different forest fragments in southern Brazil, and *C. perspicillata* and *A. lituratus* were recaptured more frequently, suggesting high mobility, showing, as the authors say, that the species are spatially arranged to use the landscape as a whole.

Esberárd (pers. obs.) cited a displacement of 71 km of an individual of the species *A. lituratus* and even small movements of *C. perspicillata*, *Glossophaga soricina* (Pallas, 1766), *Anoura caudifer* (E. Geoffroy, 1818), *A. fimbriatus*,

*Artibeus obscurus* Schinz, 1821 and *P. lineatus*. When the bats move, they promote an increase in reproductive success, which could be in decline by the reduction of their populations generated by fragmentation of habitats. Consequently the variability increases within populations that are interrelated and it is known that genetic variability is vital for the maintenance of populations (Frankham et al., 2002).

Large displacements of *Molossidae* have always been clear (Altringham, 1996), forming large colonies, where sometimes millions of individuals live, which surely exchange genes. This knowledge is also essential for future studies with phyllostomidae families and probably other families that are in the south and the rest of Brazil. That is, you need to know that these individuals can exchange genes between populations, living as metapopulations and trying to survive, despite the resistance imposed by the destruction and loss of habitat, since many regions show mosaics only (Begon et al., 2007). Some areas have small populations or are inhabited because individuals fail to disperse to reach them (Andrewartha and Birch, 1954). However the bats fly and several species of bats, especially of the genera *Artibeus*, *Uroderma*, *Carollia* and *Phyllostomus* probably treat the modified habitats as homogeneous compared to frequent records of their environmental plasticity (Fenton et al., 1992; Medellín et al., 2000; Sazima et al., 1994; Zortéa and Chiarello, 1994; Pedro et al., 1995; Reis and Muller, 1995; Reis et al., 2003).

**Table 1.** Species recorded, frequency of occurrence and number of marked individuals.

Species recorded	<i>Horto Florestal</i>		<i>Parque Municipal</i>		<i>Sítio Santana</i>		<i>Sítio Cazado</i>		<i>Marked individuals</i>	
	N	%	N	%	N	%	N	%	N	%
	<b>Family Phyllostomidae</b>									
Subfamily Desmodontinae										
<i>Desmodus rotundus</i> (E. Geoffroy, 1810)							2	0.9		
Subfamily Glossophaginae										
<i>Glossophaga soricina</i> (Pallas, 1766)	1	0.73								
Subfamily Carollinae										
<i>Carollia perspicillata</i> (Linnaeus, 1758)	10	7.35	12	13.6	15	30.6	77	35	21	14
Subfamily Phyllostominae										
<i>Phyllostomus hastatus</i> (Pallas, 1767)	1	0.73								
Subfamily Sternodermatinae										
<i>Artibeus lituratus</i> (Olfers, 1818)	43	31.6	30	34.1	16	32.7	29	13	47	31.3
<i>Artibeus fimbriatus</i> Gray, 1838	1	0.73	5	5.68			2	0.9	5	3.3
<i>Artibeus planirostris</i> (Spix, 1823)							5	2.3	2	1.3
<i>Platyrrhinus lineatus</i> (E. Geoffroy, 1810)							8	3.6	4	2.7
<i>Sturnira lilium</i> (E. Geoffroy, 1810)	73	53.7	36	40.9	16	32.7	75	34	61	40.7
<i>Vampyressa pusilla</i> (Wagner, 1843)	2	1.48								
<b>Family Vespertilionidae</b>										
Subfamily Vespertilionae										
<i>Myotis nigricans</i> (Schinz, 1821)	5	3.68	5	5.68	2	4	24	11	10	6.7
<b>Total</b>	<b>136</b>	<b>100</b>	<b>88</b>	<b>100</b>	<b>49</b>	<b>100</b>	<b>222</b>	<b>100</b>	<b>150</b>	<b>100</b>

It is obvious, therefore, the fact that the bats were inserted within the context of metapopulation. For migratory vespertilionids and *Molossidae*, insertion is more evident, since they have narrow and elongated wings, which provide long flights. Now phyllostomids must also be addressed, cited in the course of the text, which exploit large areas and different fragments in a landscape with patches of vegetation.

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