Desmodus rotundus (Mammalia: Chiroptera) on the southern coast of Rio de Janeiro state, Brazil

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Abstract

Since the 1990s, attacks by hematophagous bats on humans and domestic animals have been reported both on the continent and on the islands on the southern coast of Rio de Janeiro state. The density of vampire bats was investigated based on percentage of captures during control of *Desmodus rotundus* samplings and during bat diversity research. In the present work, 203 individuals of *D. rotundus* were captured from 1993 to 2009, which corresponds to 11.88% of all bat captures carried out for species control in local villages and 1.58% of all captures in faunistic inventories. The density of *D. rotundus* is high even on the recently occupied islands where domestic animals have been introduced. It is probable that this species dispersed from the continent to the islands due to the introduction of domestic animals.

Keywords: density, movements, public health, vampire bats.

Desmodus rotundus (Mammalia: Chiroptera), na costa sul do estado do Rio de Janeiro, Brasil

Resumo

Desde 1990 ataques de morcegos hematófagos em humanos e animais domésticos têm sido reportados tanto no continente como nas ilhas da costa sul do estado do Rio de Janeiro. A densidade de morcegos vampiros foi investigada baseada na percentagem de capturas durante amostragens para o controle de *Desmodus rotundus* e durante amostragens para pesquisas da diversidade. No presente trabalho 203 indivíduos de *D. rotundus* foram capturados entre 1993 e 2009, que correspondem a 11,88% de todas as capturas de morcegos para o controle da espécie em vilarejos locais e 1,58% de todas as capturas em inventários faunísticos. A densidade de *D. rotundus* é alta mesmo em ilhas recentemente ocupadas onde animais domésticos foram introduzidos. É provável que esta espécie disperse a partir do continente para as ilhas devido à introdução dos animais domésticos.

Palavras-chave: densidade, movimentos, saúde pública, morcegos vampiros.

1. Introduction

Desmodus rotundus (Geoffroy, 1810) is an obligatory hematophagous bat that feeds on birds and mammals, and uses a wide range of prey (e.g. Gardner, 1977; Greenhall and Schmidt, 1988). This species is responsible for heavy losses in livestock farming activities (Acha and Malaga-Alba, 1988; Delpietro et al., 1992; Brass, 1994; Nowak, 1995). Its population has gradually increased in the neotropical region (Jones, 1976), since a density increase was observed next to areas of livestock farming (Delpietro et al., 1992) and it can even be found in large Brazilian urban centres (Bredt and Uieda, 1996; Esbérard et al., 1998, 2001; Torres et al., 2005; Ferraz et al., 2007). *Desmodus rotundus* is one of the most important vectors of rabies, and many deaths are associated with bat bites (Brass, 1994). Rabies is a deadly infection caused by a virus that attacks the nervous system. This disease has been known since 300 BC and has a worldwide distribution, where it is responsible for the deaths of ca. 30,000 people per year. Annually, about four million people need preventive treatment against rabies (Brass, 1994). Even so, little importance is given to rabies and its vectors, and in many areas of Latin America, the authorities take no effective action to control hematophagous bats (Linhart, 1975).

Desmodus rotundus inhabits all kinds of environments, and high densities have been reported in cattle-raising areas in Argentina, where it can reach twice the density as found in more natural areas (Delprieto et al., 1992). In Costa Rica a density of 1.0 bat for every 13 ha was reported by Turner (1975). The frequency of capture of this bat in areas far from farms or cave areas was low or

medium, usually not as high as 2% of all bat captures of the inventory in the Atlantic Forest (e.g. Peracchi and Albuquerque, 1993; Teixeira and Peracchi, 1996; Pedro and Taddei, 1997; Portfors et al., 2000; Faria et al., 2006).

Therefore, the aims of the present study were to report the relative abundance of *D. rotundus* captured during samplings on islands and on the continent, and to compare between surveys to control this species, as well as to compare biodiversity inventories. We also discuss whether the recent human occupation of the islands in Sepetiba creek and Ilha Grande may have interfered in bat dispersion and abundance.

2. Methods

The study region comprises an area of 4,100 km², which includes the municipalities of Seropédica, Itaguaí, Mangaratiba, Angra dos Reis, Rio Claro and Paraty, and some islands on Sepetiba and Ilha Grande creeks, southeastern Rio de Janeiro state, Brazil (Figure 1). The region's vegetation is classified as Dense Tropical Wet Forest, which includes coastal restingas and mangroves (Ururahy et al., 1983). This area is currently the largest continuous forest in Rio de Janeiro state, but it has been affected by the increase in tourism and human occupation (Fidalgo et al., 2007). The coast of Rio de Janeiro state has over 400 islands, and many of them are populated. Among them stands out Ilha Grande, the largest island in Rio de Janeiro state, besides others with remnants of native vegetation (Alho et al., 2002).

The occupation of those islands was established in the XVI century, when the slave trade was their main economic activity. Next, there were the coffee and sugarcane cycles, which resulted in huge deforestation in the region, including some islands, such as Ilha Grande and Ilha da Gipóia (Maciel et al., 1984; Araujo and Oliveira, 1988; Alho et al., 2002). Human occupation has been increasing with the development of tourism and hotel industries and over the last 20 years, many islands have become more densely occupied and received domestic animals.

From 1993 to 2009, 351 sampling nights were carried out to capture *D. rotundus* or to make inventories of the bat fauna in different localities of the southern coast of Rio de Janeiro state (Esbérard et al., 2006; Esbérard and Bergallo, 2008). Twenty-one localities were surveyed (Figure 1), mostly in the villages where attacks by *D. rotundus* on humans and domestic animals were reported. During surveys for vampire bat control, each site was netted until attacks on domestic animals were no longer observed or reported (one to six nights). We used four or more nets set all night long next to the attacked animal and also over streamlets, forest edges or existent trails in the forested area nearby

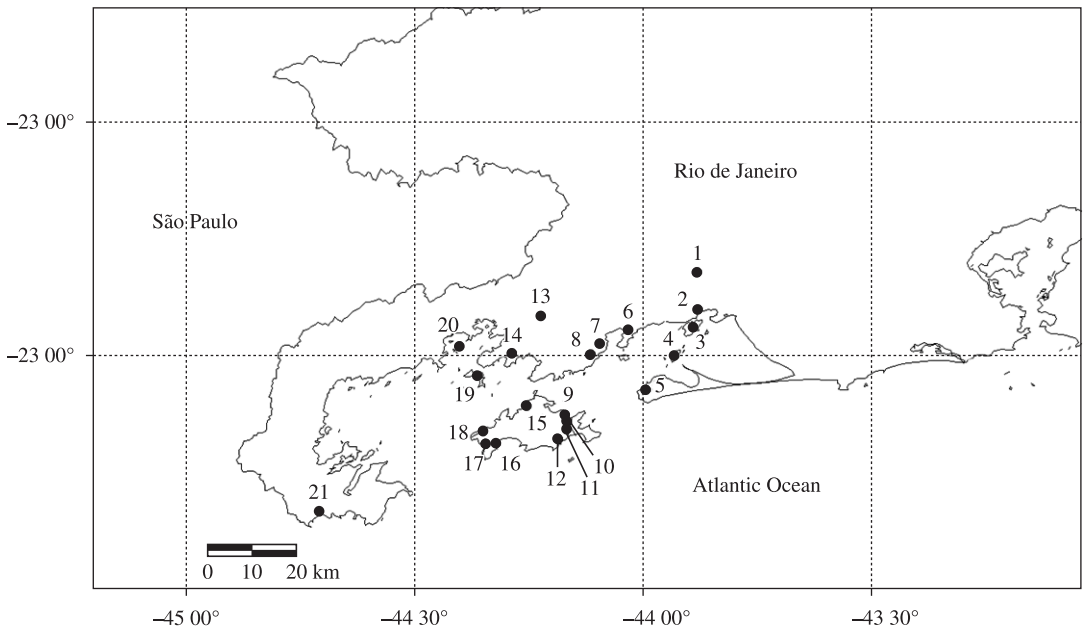

Figure 1. Location of the surveyed sites on the southern coast of Rio de Janeiro state from 1993 to 2009. 1) Campus of the Universidade Federal Rural do Rio de Janeiro (Seropédica); 2) Parada Costa Verde (Itaguaí); 3) Ilha de Jaguanum (Mangaratiba); 4) Ilha de Itacuruçá (Mangaratiba); 5) Ilha da Marambaia (Mangaratiba); 6) Terras do Sahy Farm (Mangaratiba); 7) Portobello Farm (Mangaratiba); 8) Rio das Pedras Ecological Reserve (Mangaratiba); 9) Praia Preta, Ilha Grande (Angra dos Reis); 10) Cachadaço Trail, Ilha Grande (Angra dos Reis); 11) Abraão Village, Ilha Grande (Angra dos Reis); 12) Dois Rios Village, Ilha Grande (Angra dos Reis); 13) Lídice (Angra dos Reis); 14) Angra dos Reis (centre); 15) Jararaca Trail, Ilha Grande (Angra dos Reis); 16) Praia do Bananal, Ilha Grande (Angra dos Reis); 17) Praia do Aventureiro, Ilha Grande (Angra dos Reis); 18) Praia de Provetá, Ilha Grande (Angra dos Reis); 19) Ilha da Gipóia (Angra dos Reis); 20) Ilha das Palmeiras (Angra dos Reis); 21) Praia do Sono (Paraty).

(maximum of 20 m distance from prey or feeding roost of *D. rotundus*). During sampling for the biodiversity inventory, the nets remained opened all night long and were set mainly on large trails in forested areas, on forest fragment edges, and also in banana plantations, backyards and at longer distances from any attacked animal (over 50 m). On some nights (two to four), some nets were set next to potential prey, such as domestic animals in order to capture and indentify hematophagous species. Sampling for the biodiversity inventory was carried out from 1 to 189 nights in each location.

An active search to locate roosts of *D. rotundus* was accomplished in all localities, including hollow trees, caves and abandoned houses, with or without the inhabitants help. The attacks of *D. rotundus* were confirmed by the presence of wounds or bleeding in living or dead prey, as well as from information from inhabitants of the islands.

Desmodus rotundus specimens captured during this procedure were killed for other research purposes related to biometric and genetic studies. Euthanasia was performed using ether. Samplings were previously authorised by the Instituto Brasileiro do Meio Ambiente e Recursos Naturais Renováveis and all carcasses were deposited in the reference collection of the Laboratório de Diversidade de Morcegos in the Universidade Federal Rural do Rio de Janeiro (IBAMA, process 1755/89-SUPESRJ).

3. Results

Two hundred and three specimens of *D. rotundus* were captured: 68 on the continent and 135 on the islands (Table 1). *Desmodus rotundus* corresponded to 13.97 ± 9.20% (mean ± sd) out of 573 bat captures during samplings for vampire control and 1.54 ± 0.72% out of 9,887 bat captures during faunal inventories. Even on the surveyed islands (N = 6) this species density may be considered high: 135 individuals (1.63% out of 8,258 captures), but inferior to values observed on the continent (3.09% out of 2,202 captures). Despite the sampling effort accomplished, we did not find roosts occupied by this bat species in any of the localities surveyed. The other two species of hematophagus bats were rare, with *Diphylla ecaudata* Spix, 1823 represented by two individuals in one locality and *Diaemus youngi* (Jentink, 1893) with three individuals in three localities.

The accumulation curve of *D. rotundus* suggest a continuous increasing of the density ($y = 0.45x^2 - 1771.6x + 0.2^{-6}$, $r = 0.97$, $F = 286.241$, $p < 0.001$) in the localities surveyed (Figure 2). Sixteen species were attacked or suspected to be attacked by *D. rotundus*: nine mammals, comprising humans, and seven birds (Table 2). The species most frequently attacked was the chicken [*Gallus gallus* (Linnaeus, 1758)] in 12 out of 21 localities surveyed.

4. Discussion

Desmodus rotundus may be considered either a common or less common species at different localities in the southern coast of Rio de Janeiro. During samplings for the species inventory, this bat species represented over 1.5% of all captures, whereas a high capture rate was observed on the nights intended solely for vampire control (11.88%). The majority of the bat species obtained during inventories show intermediate frequencies and can be considered common or

Table 1. Total captures of *Desmodus rotundus* and other species of hematophagus bats in southern Rio de Janeiro state from 1993 to 2009.

nº	Localities	Type of survey	Nights	Captures	*D. rotundus*	nº other species
	Mainland localities					
1	UFRRJ Campus	Inventory	4	132	1 (0.76%)	-
2	Parada Costa Verde	Inventory	1	75	1 (1.33%)	-
6	Terras do Sahy Farm	Inventory	2	154	2 (1.30%)	1 *D. youngi*
7	Portobello Farm	Control	11	348	21 (6.03%)	-
8	Rio das Pedras Ecological Reserve	Inventory	42	1,289	34 (2.64%)	-
13	Lidice	Control	2	8	2 (25.00%)	-
14	Angra dos Reis (centre)	Control	1	6	1 (16.67%)	-
21	Praia do Sono	Control	2	190	6 (3.16%)	-
	Islands					
3	Ilha de Jaguanum	Inventory	6	186	4 (2.15%)	-
4	Ilha de Itacuruçá	Inventory	23	977	3 (0.31%)	2 *D. ecaudata***
5	Ilha da Marambaia	Inventory	33	1,991	39 (1.96%)	1 *D. youngi*
9*	Ilha Grande	Inventory	189	3,042	45 (1.48%)	-
19	Ilha da Gipóia	Inventory	33	2,041	40 (1.95%)	1 *D. youngi*
20	Ilha das Palmeiras	Control	2	21	4 (19.04%)	-
	Total		351	10,460	203 (1.94%)	

nº – Number on map. *Includes the localities 9-12 and 15-19. **Netted near the chicken house.

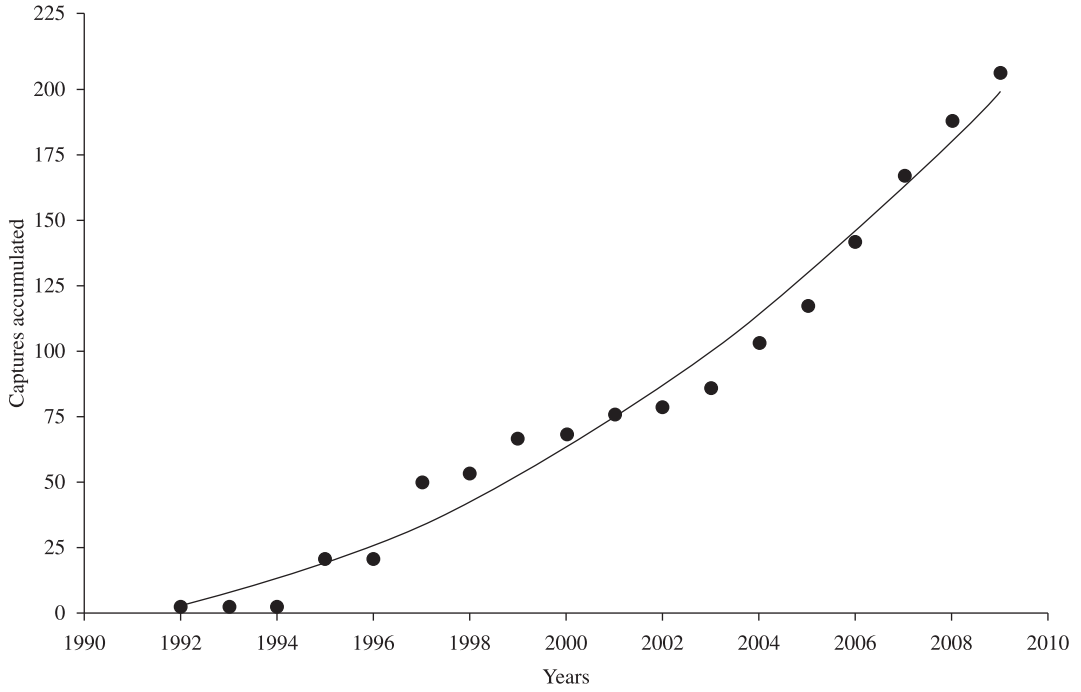

Figure 2. Accumulation curve of *Desmodus rotundus* by year on the southern coast of Rio de Janeiro state from 1993 to 2009.

Table 2. Confirmed or reported prey of *Desmodus rotundus* in the surveyed localities of southern coast of Rio de Janeiro state from 1993 to 2009. The numbers refer to the legend of Figure 1.

Vulgar name	Scientific name	Localities
Horse	*Equus cabalus* (Linnaeus, 1758)	1, 2, 7, 18
Dog	*Canis familiaris* (Linnaeus, 1758)	3, 4, 15, 16, 19, 20
Fowl	*Galus gallus* (Linnaeus,1758)	3*, 4, 8-11, 14-17, 19, 21
Donkey	*Equus asinus* (Linnaeus,1758)	6, 7, 19, 21
Eland	*Taurotragus oryx* (Wagner 1885)	7
Sambar Deer	*Cervus unicolors* (Kerr,1792)	7
Ox	*Bos taurus* (Linnaeus, 1758)	7, 12
Swine	*Sus scrofa* (Linnaeus, 1758)	8, 14
Man	*Homo sapiens* (Linnaeus, 1758)	14, 16, 19, 21
Goat	*Capra hircus* (Linnaeus, 1758)	19
Goose	*Anser cygnoides* (Linnaeus,1758)	19
Duck	*Cairina moschata* (Linnaeus, 1758)	19
Turkey	*Meleagris gallopavo* (Linnaeus, 1758)	19
Peacock	*Pavo cristatus* (Linnaeus, 1758)	19**
Helmeted Guinea fowl	*Numida meleagris* (Linnaeus, 1758)	19, 20
Unknown Species		13

* Possible including *Diphylla ecaudata* attacks; ** Possible including *Diaemus youngi* attacks.

less common (Esbérard et al., 2006; Esbérard and Bergallo, 2008; Esbérard, 2009). In natural areas, the density of this bat is usually medium or low, rarely exceeding more than 2% of the total of captures (Peracchi and Albuquerque, 1993; Teixeira and Peracchi, 1996; Pedro and Taddei, 1997; Portfors et al., 2000; Faria et al., 2006). Higher densities were usually associated with farming (Delprieto et al., 1992) or proximity to roosts (Taddei and Pedro, 1996). Even in forest remnants inside urban areas, densities moderate to high (3-4%) of these hematophagus bats can be achieved (Esbérard, 2003). The other Desmodontinae species showed lower frequency, both with 0.05% of the total captures and 2.40% of the total of hematophagus bats.

In the present study, *D. rotundus* was observed feeding on a wide range of prey, which was expected because this species is far more generalist than the other two vampire

species (e.g. Gardner, 1977; Greenhall and Schmidt, 1988). Attacks on humans were reported in four localities and confirmed in one locality through the capture of two individuals when entering a residence of a previously attacked person. Attacks on humans are considered rare events (Bredt et al., 1996), and they are more frequent in the northern and northeastern regions of Brazil (e.g. Almansa and Garcia, 1980; Carranza and Del-Campo, 1980; Schneider et al., 2001; Gonçalves et al., 2002; Mayen, 2003). McCarthy (1989) stated that *D. rotundus* attacked humans after a reduction of the local swine population, and then the attack rate on humans decreased when the bats targeted new species as prey. But in some localities humans can be a most frequent prey, as reported by Baer (1991) findings of 17.5% of 70 vampire bats feeding on people in Colima, Mexico.

Apparently the high density of prey may stimulate the dispersion of *D. rotundus* to islands where domestic animals were introduced, since no attack or dead animals such as dogs was reported before the introduction of birds on Ilha da Gipóia. The apparent recent dispersion of the species to the studied islands, where attacks have frequently been reported, is a more likely hypothesis than the existence of specimens before human occupation. Hematophagous bats forage in an area 5-8 km away from their day roost, but there are reports of their commuting distances of up to 20 km (Málaga-Alba, 1954; Crespo et al., 1961; Greenhall and Schmidt, 1988; Medina et al., 2007). In vampire bats studied with radio-telemetry, the average distance from the day roost to foraging site is 1.89 km (Wimsatt, 1969), which is similar to the longest distance between the studied islands and the continent (maximum of 2 km). It is not impossible that on the islands nearer to the mainland the animals use a mainland locality for roosting and forage periodically or on a daily-basis to the islands. Such a hypothesis seems to be less likely, since the high daily energy loss would result in a low reproductive investment (McNab, 1973). Besides, Turner (1975) analysed the average commuting distance and noticed that *D. rotundus* changes roosts in order to decrease the distance from the cattle previously attacked. Since *D. rotundus* can adapt to artificial and natural roosts, it may find on the islands hollow trees, caves, basements, abandoned houses and other suitable structures (Gomes and Uieda, 2004), and the availability of these roosts may not be a limiting factor.

The existence of such a high population density of this bat previous to increased human occupation of those islands also seems unlikely, because it would require a large source of prey to maintain a large long-term population of this bat. In the studied region, 43 species of non-flying mammals are currently found, but medium or big sized native species are rare or even absent (Pereira et al., 2001). Taking into account that each hematophagous bat ingests ca. 20 g of blood/night (McNab, 1973), we can imagine that to maintain all adult specimens of *D. rotundus* captured on Ilha Grande, at least 0.9 kg of blood/night and 329 kg of blood per year would be necessary. If we estimate the amount of blood as 10% of body mass, it would require on this island, for instance, at least between 20 to 30 adult bovines. If this amount of cattle is not at hand, such a high density of vampire bats would have resulted in a great number of humans attacked every night. However, the number of attacks on humans is apparently scanty and restricted to certain localities, and the number of bovines and equines on this island has always been kept to the minimum; the maximum reported were three adult specimens, which were excluded from the island in 1998.

On at least one of the islands, Ilha da Gipóia, specimens of the helmeted guinea fowl *Numida meleagris* (Linnaeus, 1758) were introduced by inhabitants as a way to control snakes [Jararacas, *Bothrops jararaca* (Wied, 1924)]. Those birds, acquired when juvenile, were raised in semi captivity since 2002 and started being exploited as prey by *D. rotundus* in the same year. *Desmodus rotundus* attacks exterminated ca. 100 adult birds by the beginning of 2003. A new lot of birds (ca. 100 subadults) were introduced in July 2005, which started being attacked in August, resulting in an estimated loss of 1/3 of all birds in the same year. From 2006 on, the remaining birds (approximately 25% of the total introduced since 2005) started being managed, sleeping in a henhouse built for protection and provided with light all night long, which resulted in a decrease in the attack rate, but did not completely prevent attacks. A new lot was introduced in 2007, with part of the birds resting during the night inside the henhouse and part over branches. A new mortality estimated in 2/3 of all new birds occurred within less than six months. In this locality, the capture and euthanasia of *D. rotundus* was periodically carried out (33 nights from 2004 to 2009, with the capture of 40 specimens) resulting only in a temporary reduction of the attack rate. Vampire bat attacks were also observed on this island on two adult goats, a Rottweiller dog, a donkey, and one human, probably as an outcome of the prey reduction or of the management started in 2006. The presence of a high population density of hematophagous bats before 2002 on this island would be easily detected by attacks on other domestic animals before the introduction of the helmeted guinea fowl, such as peacocks, turkeys, dogs or even humans. The hypothesis that hematophagous bats move from the continent to the island may be still sustained by the lack of captures during some sampling periods (2005 and 2008) and a high capture rate during other periods (2004, 2005 and 2007). Another interesting fact was the capture of a specimen of *D. youngi* on the 31st sampling night, which coincided with the mortality, reported a few weeks before, of part of the peacocks that slept 180 m away from the nets, on branches over 10 m high (see Costa et al. (2008) for other cases in this region). Such a fact suggests that both *D. youngi* and *D. rotundus* may have arrived on the island recently. The species had not been observed in the locality until then and there was no previous record of death or attack on this bird species in this site.

In Ilha da Marambaia, vampire bat attacks on domestic animals introduced were reported during the island occupation phase with farming and cattle raising activities (in the

1940s and 1960s). Currently the number of herbivores is scant and the activities on the island are restricted almost exclusively to fishery and military training. Inhabitants reported the continuous death of domestic birds by attacks of hematophagous bats in previous years, before the surveying accomplished in the present study. Between October 2006 and December 2007, seven inhabitants were attacked by *D. rotundus* in at least two different localities. We captured a couple of *D. rotundus* at 8:00 PM while entering a house on this island, where the attack on one inhabitant for several nights was reported. More than 30 vampire bats were netted and sacrificed between the 2006 and 2009 samplings on this island.

Desmodus rotundus is a gregarious species, which forms groups composed of a dominant male, a subordinate male and several females, and it is possible that all or part of them disperse and forage together (Forment et al., 1971; Wilkinson, 1986, 1988, 1990). It is more likely that bats captured in the present study moved from the continent to one or more islands, where they settled until the reduction of abundance or extinction of prey, and then moved to another island or even returned to the continent. At least on three other islands, which have not been sampled yet, attacks on domestic animals (dogs, chickens and peacocks) have already been reported.

The presence of *D. rotundus* outside the rural area is considered a consequence of deforestation (e.g. Schneider et al., 1996, 2001). Such a fact does not seem to be coherent at least in the region studied, since the southeastern coast of Rio de Janeiro state has presently the largest forested area of the whole state and shows the best conservation status (Rocha et al. 2003). Besides, deforestation is currently rare, and in this region livestock farming activities are very scant (Ururahy et al., 1983; CIDE, 1996).

Due to the importance of *D. rotundus* in the transmission of the rabies virus (Constantine, 1988; Brass, 1994), measures to control this bat are strongly requested. In order to minimise the frequency of attacks it is important to avoid the introduction of new domestic animals onto the islands and the existence of this bat species in those sites must be informed if attacks occur. Measures to avoid attacks on human beings must be taken, such as guiding inhabitants to install a nylon or wire net in every opening of their houses. Settling a regular control of the species by a team properly trained for this procedure, and to start a local information network to report attacks may be useful. Due to the flow of the rabies virus among the specimens of *D. rotundus* (Langoni et al., 2008), a sanitary and epidemiological monitoring of the whole southern coast of Rio de Janeiro state is also important.

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