

Minireview

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Haematophagous Bats in Brazil, Their Role in Rabies Transmission, Impact on Public Health, Livestock Industry and Alternatives to an Indiscriminate Reduction of Bat Population

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Summary

Haematophagous bats exist only in Latin America, from México to the Northern provinces of Argentina. They are represented by three species, *Desmodus rotundus*, *Diphylla ecaudata* and *Diaemus youngii*. While two species feed only on blood of wild birds, one species, *D. rotundus*, causes losses feeding on livestock and could be a vector for rabies virus. The cases in which humans were bitten by the bat have increased in Brazil. Bats became a target of control activities by farming communities and local governments. Indiscriminate actions such as poisoning bats and destroying their roosts put the lives of other bat species, which are extremely important for the ecologic balance, at risk. The vaccination of exposed livestock against rabies, which would protect the endangered livestock, is not regularly carried out. The importance and current status of *D. rotundus* in the transmission of rabies in Brazil, the Public Health aspects, the importance for the livestock industry are shown and the consequences of reducing bat population are discussed. Alternatives to an indiscriminate bat-population reduction in the control of rabies are proposed.

Haematophagous bats: life cycle and feeding habits

Latin America possesses the richest bat fauna in the world, including haematophorous, fruitophorous, insectiphorous, nectarphorous and carnivorous bat species. They play an important role in the dispersion of seeds, the pollination of plants and the reduction of night-flying insects like mosquitoes (Walker, 2001).

The haematophagous bats belong to the order Chiroptera, family Phyllostomoidea, subfamily Desmodontidae, which has three species: *D. rotundus*, *Diphylla ecaudata* and *Diaemus youngii*. Only *D. rotundus* feeds on mammals and is known as the 'common vampire bat'. *Diphylla ecaudata*, the hairy-legged vampire bat, and the rare *Diaemus youngii*, feed on forest-habituating birds (Brass, 1994).

Desmodus rotundus lives in small colonies of 10–200 animals, in places of difficult accessibility. Other bat species form colonies of thousands of animals in less hidden places. They may use several refuges and can share a refuge with other bat species. Their home range was described between 10 and 20 km² (Arellano-Sota, 1988). Migratory movements and changes of roosts are still poorly known.

At night, bats fly out, approaching possible food sources orientating themselves with their highly developed ultrasound system. They are also able to move on the ground, jumping, using their thumps as forefeet, with their wings folded. Their activity seems to be related to moonlight intensity, they prefer the darkest hours of the night to feed (Flores-Crespo et al., 1974). The bats were observed to hunt in groups of two to six individuals, and these hunting groups exist as a social structure inside the roosts (Greenhall, 1971).

Desmodus rotundus bites its victim with its sharp incisor teeth, leaving a characteristic wound. The bat saliva possesses enzymes that avoid the blood clotting and two channels on each side of the tongue permit them to suck blood. *Desmodus rotundus* feeds on snakes, lizards, turtles, reptiles, amphibians, ocelots, opossum, skunks and other small mammals. If livestock is available, it feeds on cattle, horses, mules, goats, swine, poultry, sheep, and also humans. One bat drinks between 15 and 25 ml in one blood-meal, and an animal could be visited by several bats at night (Constantine, 1979). The consequences could be the transmission of rabies virus, causing paralytic rabies. The incubation time of paralytic rabies is between 25 and 150 days. The affected animals suffer from muscular tremors, excessive salivation, spasms which are caused by the alterations of the Central Nervous System. These alterations lead always to a final paralysis of the respiratory system and death.

History of haematophagous-bat transmitted rabies and control campaigns in Brazil

During 1906–1908, in the South of Brazil, state of Santa Catarina, about 4000 cattle and 1000 horses and mules died of paralytic rabies. Bats were observed by people at daylight hours, approaching animals and trying to bite. Carini (1911) suspected that these bats were involved in the transmission. Haupt and Rehaag (1921, 1925) two German veterinarians, who were called to investigate the outbreaks, could prove the presence of Negri bodies in the brain of captured bats.

The method of rabies identification at that time was the histological examination demonstrating Negri bodies in the brain of the infected bat. Anjaria and Jhala (1985) detected with this technique in 76.28% of rabies-positive specimens Negri bodies, compared with 92.50% with the direct fluorescent antibody technique and 91.36% with the direct

immunoperoxidase technique Torres and Queiroz Lima (1936) inoculated some extract of the brain of a rabid vampire bat into calves and rabbits, observing that the test animals developed paralytic rabies.

Since the identification of bats as a vector for rabies, farmers have been complaining about the losses of livestock. In 1966, the estimation of annual loss of livestock in Latin America caused by paralytic rabies was about 1.0 million head of cattle, with a direct loss of 100 million US\$ (Steele, 1966).

In 1967, 1062 haematophagous bats from the Brazilian states of Rio de Janeiro, Espirito Santo, Santa Catarina, Alagoas, Paraíba and the Amazonian region were examined (Da Silva et al., 1967). The bats were captured while trying to feed on cattle and swine at daylight hours, one had tried to attack a farmer. Eight *D. rotundus* were found to be positive for rabies: the histological diagnosis was confirmed in mice. The virus was found in brain, lungs and salivary glands of the bats. In 1968, 8614 cases of bovine rabies were reported in Brazil (Ministerio da Agricultura do Brasil, 1969). A total of 1 121 800 doses of rabies vaccine were produced in the same year. In 1986, 44–50 million US\$ losses in live stock caused by bat-transmitted rabies in livestock in Latin America per annum were reported (Acha and Szyfres, 1986).

In 1991, 99 cases of rabies in bats in Latin America and the Caribbean were reported (Pan-American Health Organization, 1991). This represents 0.7%, of a total of 14 011 cases of rabies.

In the north of the state of Rio de Janeiro in 1997, the death of 57 cattle with nervous symptoms were investigated (Sales, 1997). In 81%, the cause of their death was rabies. Rabies outbreaks in cattle have been frequent in this area, and farmers only vaccinate sporadically.

In 1968, a first extensive programme to 'control' the population of bats was initiated by the National Institute for Livestock Research, in Mexico, with the collaboration of the United Nations Development Program/Food and Agriculture Organization, and the Agency for International Development. The aim of these campaigns was to find economic and feasible ways to reduce the bat population, which in reality led to the killing of an enormous quantity of bats. Coumarin derivatives with an anti-thrombin activity were applied, capturing bats, passing the substance in form of a paste on their bodies and releasing them (Thompson et al., 1972; Delpietro, 1983; Delpietro 1984; Konolsaisen, 1987). The habit of bats to lick themselves and other bats in their colonies assured the distribution of the mortal anticoagulant. Coumarin derivatives have also been applied orally in horses (Da Silva et al., 1997) and by intraruminal route in cattle (Arellano-Sota, 1988). *Desmodus rotundus* ingests the Coumarin with the blood and die. In the 'Campaign against rabies in herbivorous' of the Brazilian Ministry of Agriculture in 1969, research to invent a method of capturing vampire bats with the help of ultrasound was encouraged, with the final aim 'facilitar seu exterminio' (facilitate their extermination). Farmers destroyed caves of bats with explosives, or set up traps and nets. In the 1960s, more than 8000 bat caves were dynamited in Brazil (Walker, 2001).

Even nowadays, the reduction of the bat population is often presented as the method of choice and is ongoing (Massad et al., 2001). The number of vaccinated cattle per year in Brazil increased from 17 916 061 in 1999 to 23 979 090 in 2001. The number of 2722 cases in cattle in 1999 increased to 6088 in 2000 and decreased to 2194 in 2001 (OIE, 2003). The total

number of the cattle population in Brazil was 164.6 millions in 1999 (Ministerio da Agricultura do Brasil, 2003).

In 2001, Brazilian authorities reported rabies in 157 wild animals without mentioning the species (OIE, 2003). The existence of multiple independent transmission cycles involving different bat species has been discussed (Favoretto et al., 2002).

Rabies virus in bats, rabies transmission and Public Health aspects

The rabies transmitted by the vampire bat is caused by the genotype 1, the classic rabies virus (King et al., 1990). The transmission of the virus between the bats occurs by bite (Tuttle, 1990). Healthy bats do not excrete infectious virus in their saliva, an asymptomatic salivary carrier state is therefore improbable (Brass, 1994).

In a study carried out in 1994, antigenic variants of 288 samples containing rabies virus from 17 Latin American countries and the Caribbean were tested with monoclonal antibodies. The four samples originating from vampire bats contained antigenic variant 3, which was also found in nine of 19 samples submitted from cases of human rabies and in 28 from 63 samples from rabies cases in cattle (Diaz et al., 1994). The incidence of cases is not elevated, but the bat-associated antigenic variants are frequently found in rabies-positive samples. In the diagnosis, the strain-specific reverse transcriptase-polymerase chain reaction (PCR) and restriction fragment length polymorphism analysis allow the discrimination between dog-related and bat-related rabies viruses (Ito et al., 2003). A hemi-nested PCR is in use for the detection of Brazilian rabies isolates from haematophagous bats and herbivores (Soares et al., 2002).

Delpietro and Nader (1989) investigated the epidemiology of rabies outbreaks in herbivores transmitted by vampire bats in Argentina, in the tropical zones close to the border with Brazil, between 1964 and 1987. They report that the maximal duration of rabies outbreaks in cattle was 18 months, showing a high initial mortality among the herbivores, which diminished and stopped suddenly, followed by a rabies-free period of 4 years or more. The high initial mortality in rabid bats and the slow renewal of the bat population explain these patterns. The appearance of rabies in a vampire bat population does only occur if a significant percentage of the bat population is infected. A part of this population die of rabies, another part does not get infected. As the number of susceptible bats decrease, the outbreak is spread to a fully sensible neighbour population. The fact that the risk for humans and animals depends on the infection states of the bat population is mainly neglected by the public opinion and only recently mentioned as an important feature (Goncalves et al., 2002).

Cases of human rabies transmitted by bats were increasing in Brazil between 1980 and 1990 (15.1%) (Schneider et al., 1996a).

Most of the outbreaks occurred in small villages of the Amazon's region. The National Centre for Epidemiology of the Brazilian Ministry of Health conducted a cross-sectional survey, in the 160-habitant village of Mina Nova, in the Amazonian region of Brazil. A total of 129 people were interviewed, 23.33% had been attacked by a vampire bat in the year precedent to the survey and received prophylactic treatment. None of the 12 captured bats tested rabies-positive.

The risk calculation presuming the presence of the disease in the local bat population defined 0.96 cases per 100 area residents, therefore there were 1.54 cases of bat-transmitted rabies per year (Schneider et al., 1996b).

Twenty-six humans bitten by bats were followed in a 5-month study in the rural area of Honorópolis, Goiás, Brazil. No case of rabies infection occurred (Batista da Costa et al., 1993). All patients were bitten at night, most of them into their toes. The outbreaks in the Amazon region took place in mining communities, where most of the people sleep in temporary housing, easily accessible for bats.

In eight outbreaks of human rabies in the Amazonian region of Brazil and Peru, the common feature was that there were man-induced environmental modifications in bat-habitats, changing former wildlife areas into peri-urban areas (Schneider et al., 2001). Many of the villages in which bats feed on people are gold-searchers' settlements with precarious housing conditions, permitting bats to enter, or former rain forest areas in which the rain forest was devastated and livestock introduced. The accessibility to post-exposure treatment is not guaranteed in remote areas and needs also the awareness of people.

In the urban areas, the situation is different, but even there the invasion of former rural areas transformed into suburbs increases the risk for people to get in contact with *D. rotundus*.

In a study in the Metropolitan Region of São Paulo, bats belonging to 24 bat species were collected. The insectivorous bats (Molossidae and Vespertilionidae) represented 76.1% of the total amount of captured bats. From the haematophagous species, only *D. rotundus* was found (Da Silva et al., 1997).

In a total of 289 bats examined in the São Paulo district between 1988 and 1992 two insectivorous bats (0.69%) tested positive (Almeida et al., 1994). The authors warn to take indiscriminate predatory actions against these bats because of their importance in the ecological balance of the insect population in cities.

Sera of wild animals totalling 547 in the São Paulo city were tested for neutralizing anti-rabies antibodies. A prevalence of neutralizing antibodies of 14% has been found (Almeida et al., 2001).

With the increasing number of cases of bat-transmitted human rabies in Brazil, in areas with a rapid destruction of the natural ecosystems like former rain forest areas transformed into gold-searcher villages or rural areas into suburban centres, the polemic about bats as a danger for humans grows. The increasing invasion of former wildlife dominated areas by humans and their livestock is not considered in the public discussion. Media in Brazil present bats as dangerous transmitters of rabies without any differentiation or information on prevention. In the past, bats have always been a target for myths and superstition in a negative sense. 'Dracula', associated with death and horror, is one of the most well-known figures related to vampire bats.

Bat rabies control: current policy and future perspective

The livestock breeders claim that *D. rotundus* prefer to feed on livestock because of its easier accessibility compared with wild animals. The loss has initiated direct actions, such as capturing bats and poisoning them, destroying roosts and caves with explosives. Enormous quantities of bats were and are killed in government-supported programmes in Brazil. These actions

are regarded by farmers and local and national authorities as necessary 'control measures' against the 'plague' of bats and the danger of rabies transmission. These attempts to 'reduce' *D. rotundus* bat population endanger other bat species, which are extremely important for ecological balance and diversity, like the insectivorous Molossidae family species in the urban and suburban areas (reducing insects), the Stenodermatinae family (dispersing seeds), and the Glossophaginae family (pollinating plants) in rural areas. A sustainable effect in reducing paralytic rabies in livestock has not been achieved. The ineffective and unecological bat-killing policy should be replaced by a different approach.

An effective control measure, the vaccination of livestock against rabies, is only carried out for a part of the animals. The knowledge of epidemiological features is still deficient and needs further research. Therefore, the implantation of an epidemiological surveillance system, gathering information about bat population aspects, migratory movements of bats, bat-transmitted rabies, is needed. To encourage livestock breeders to vaccinate their livestock against rabies, further research should be carried out to combine the rabies vaccine with other necessary vaccines. The development of long-acting 'Vampire-repellent' effect substances, to keep vampire bats away from livestock, would be advantageous. The research on an oral immunization of bats which could be applied to identify risk areas should be continued and intensified (Aguilar-Setien et al., 1998, 2002). The feasibility of an oral immunization will not only depend on official Veterinary service capacity, but also on awareness and willingness of farmers. The cost-effectiveness plays an important role. The risk areas need to be identified and constantly monitored, the size and structure of Brazil will not permit to cover the whole territory with oral immunization programmes.

Livestock in risk areas should be vaccinated, 'bat-safe' housing campaigns for humans and awareness campaigns in risk areas should be initiated, including information about the important functions of bats, avoiding the 'Dracula' stereotype. Alternatives to the traditional livestock production, such as multiple species production systems and adding wildlife use to traditional production systems should be developed for former wildlife areas (Uhart and Milano, 2002).

Western Europe could serve as an example for the ineffectiveness of reducing animal populations to control rabies, and the benefit of changing these strategies. In Europe in the 60s and 70s, millions of foxes' dens were put under gas, poisoning red foxes, Europe's principal wildlife vector for rabies. There were no satisfactory results in reducing rabies. With a growing conscience for ecological features, efforts were made to develop other control strategies. The oral rabies immunization by baits, distributed by field workers and helicopters, has been the method of choice. In the European Union, a surveillance system passing national borders and collecting data from each participating country was implanted, and annual meetings are held. Rabies is decreasing in the participating countries (Schlueter, 1997).

In 1999, the Advisory Committee on Immunization Practices of the Centre for Disease Control and Prevention in the USA made the following statement: 'It is neither feasible nor desirable to control rabies in bats by programmes to reduce bat populations'. (Center for Disease Control and Prevention, Rabies prevention, USA, 1999).

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