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# Vampire bat reservoir and main transmitter of rabies, a public health problem in Mexico

## El murciélago hematófago reservorio y principal transmisor de rabia, un problema de salud pública en México

*E. Abigail Amador Martínez* [a]

**Abstract:**

Rabies is considered a re-emerging disease due to increased contact with the reservoir. The vampire bat *Desmodus rotundus* is the reservoir and main transmitter of this disease. Alterations in the natural environment have caused imbalances of impact on the ecology, influencing the movement of the reservoir from natural areas to rural and urban environments, where there are human settlements and the presence of domestic animals. The objective of this work has been to present the most relevant aspects about the role of the vampire bat as a natural reservoir and main transmitter of rabies in the region in order to raise awareness in the population about the risk this is to public health. Attacks by vampire bat *Desmodus rotundus* on livestock species are becoming more frequent, even in regions that for decades had been considered free from rabies. This represents a public health problem, because these cases can generate contacts between infected animals and people.

***Keywords:***

*Desmodus rotundus, rabies, public health*

**Resumen:**

La rabia es considerada como una enfermedad reemergente debido a un incremento del contacto con el reservorio. El murciélago hematófago *Desmodus rotundus* es el reservorio y principal transmisor de esta enfermedad. Las alteraciones en el medio ambiente natural han causado desequilibrios de impacto en la ecología influenciando el movimiento del reservorio desde áreas naturales hacia ambientes rurales y urbanos, donde existen asentamientos humanos y presencia de animales domésticos. El objetivo de este trabajo ha sido el presentar los aspectos más relevantes sobre el papel del murciélago hematófago como reservorio natural y principal transmisor de la rabia en la región, con la finalidad de concientizar a la población del riesgo que representa para la salud pública. Los ataques por *Desmodus rotundus* a especies ganaderas son cada vez más frecuentes, incluso en regiones que por décadas se habían considerado libres de rabia. Esto representa un problema de Salud Pública, porque estos casos pueden generar contactos entre los animales infectados y las personas.

***Palabras Clave**:*

*Desmodus rotundus, rabia, salud pública*

## INTRODUCTION

The World Health Organization defines rabies as a viral infectious disease, deadly in almost every case once the clinical symptoms appear.[1] This disease affects both, domestic and wild animals, it also can infect humans by contact with saliva through bites or scratch from infected animals.[1] It is an encephalomyelitis of acute and progressive course produced by a *lyssavirus* belonging to the family *Rhabdoviridae* of the order of Mononegavirales.[2]

Rabies is a zoonotic disease widely spread, unattended and reported below its actual level, with a rate of lethality in people and animals that is around 100% once it has presented clinical signs.[1] Despite the advances in scientific methods and control tools, rabies remains a threat to human and animal populations.[3] Rabies virus is present all over the world, except in the Antarctic.[1,3] Some countries have established control and awareness protocols and have achieved to eradicate this disease, but nevertheless at developing countries, rabies keeps being endemic and main reservoirs and transmitters are wild animals.[3] Rabies is considered as one of the most important zoonotic diseases in the world.[4] In last years, rabies transmitted by wild animals has become more relevant, turning in a serious problem to public health.[3] Considered as a new challenge because control strategies in wild animals are quite different from those in

[a] Autor de Correspondencia: Médico Veterinario Zootecnista Email: emvzabigail@hotmail.com

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domestic animals.[4] Many species are vulnerable to rabies virus and they can be divided in two groups: the first one belongs to reservoirs or animals which maintain virus and spread it effectively. These animals are mainly predators such as dogs, foxes, wolves, coyotes, raccoons, mongoose, skunks, and vampire bats (*Desmodus rotundus)* who live in Latin America [5]; the second one corresponds to animals that may be infected with rabies virus but don't spread it as effectively as reservoirs. These animals could be bovines, equines, ovine, goats, porcine and also human beings, species that are considered as incidental hosts, because once they are infected it is less probably that they spread the virus to other vulnerable animals, because they usually do not attack as reservoirs do.[5, 6] The rabies virus is maintained in different epidemiological cycles that can be connected in the ecosystem, some authors divide them into urban and rural, terrestrial and aerial wild animal. In the urban cycle, dogs and cats are the main participants, and the domestic canines are considered as reservoirs of the virus.[6] In the rural cycle, transmission occurs in cattle and livestock species when attacked and bitten by infected wild animals. This cycle presents a serious problem of impact on public health, because these cases can generate contacts between infected animals and people, especially livestock and veterinarians, since it is possible to isolate the virus from samples of saliva and salivary glands of infected cattle.[6, 7]

Re-emerging diseases are those previously known, controlled or treated effectively, but that come back and are constantly increasing and at a given moment.[8] Many of these diseases are due to the conditions that exist in a population favouring them to develop again and become a problem with an impact on public health.[9] The re-emergence of diseases depends on a multi-causal network of factors also called health determinants.[8] Environmental changes influenced by global warming and human activity have impacted ecology by altering the geographical distribution and populations of hundreds of wild animals that transmit risk pathogens to wild life, farm animals and also human beings.[8] That is the case of the vampire bat *Desmodus rotundus* that has adapted to different climates, heights and ecosystems that few decades ago where considered as natural barriers.[10]

Attacks from vampire bat *Desmodus rotundus* to farm animals are more and more frequent, even in regions where, for decades, have been considered disease free zones.[10, 11] This problem is getting worse, because farm animals favor the population growth and geographic distribution of this chiropter because they are their main food source.[11]

In recent decades, the rabies transmitted by the vampire bat assumes greater importance since it is the natural reservoir and main transmitter of this disease in Latin America, in about 68% of the registered cases.[7]

In Mexico, there have been reported positive cases of rabies in bovines and other farm animals, transmitted by *Desmodus rotundus*, in 25 states from the South of Sonora to Chiapas, and from Tamaulipas to Quintana Roo.[12] According to records from Epidemiologic Monitoring System of the National Service of Health, Safety and Agro-Food Quality, from January to December of 2018, there were reported 457 positive cases of which 21 of them happened in the State of Hidalgo,[12] occupying the tenth place with more cases reported in the Country.

Like in many other countries, in Mexico there is an important underreport of rabies cases because farm animals producers ignore the existence of this disease.[13]

Follow up and epidemiologic surveillance must be the main components of anti-rabies programs. It is crucial to report sickness cases that are considered of mandatory notification, so operative actions can be implemented to transfer data from a community level to national and international authorities. This way it could be known the efficiency rate of implemented programs and actions to repair deficiencies may be adopted. The objective of this review is to present the most relevant aspects of the role of vampire bat as a natural reservoir and the main transmitter of rabies, in order to raise the people's awareness about the risk it represents for public health.

## BACKGROUND

The possibility that vampire bats were transmitters of the rabies virus was initially considered at the beginning of the 20th century. The hypothesis arose as a result of an outbreak of rabies, (which happened in the state of Santa Catarina, Brazil), in which about 4000 cattle and 1000 horses and mules died. The situation produced great economic losses to the local population, the disease was known as *"peste das cadeiras"*.[14] Through information from producers in the region, it was learned about fatal cases of the disease on both banks of the Itajaí River, a place of difficult access for dogs, in addition to the presence of vampire bats that were feeding on livestock, which showed aggressive behaviour among their congeners.[14]

Two German veterinarians, Haupt and Rehaag, in 1995, when researching in the same region where Carini had diagnosed rabies in bovines, identified by optical microscopy the presence of Negri corpuscles, which are pathognomonic for rabies, in the central nervous system of a vampire bat that was feeding from a bovine, confirming Carini's hypothesis.[15]

After initiated the first investigations, the rabies virus began to be isolated from other species of bats of hematophagous habits. A specimen of *Diphilla ecaudata*, which was diagnosed as positive for rabies, was in the same shelter as five *Desmodus rotundus* specimens. Of these, two had paralysis and flight difficulties, another two died without clinical signs, one survived the infection and it apparently became a virus spreader.[16]

Tellez-Girón (1944) in Mexico showed that the disease, known as "renguera", was the same as the Brazilian "peste das cadeiras" and that it corresponded to the ancestral rabies, as Queiros Lima had described.[17]

In 1997 in Brazil, two strains of rabies isolated from a frugivorous bat (*Artibeus lituratus*) were examined with

monoclonal antibodies for the first time and were found to correspond to variants of hematophagous bats.[18]

Another study carried out by Aguilar-Setién et al., 2005, wanted to evaluate the excretion of the virus in a hematophagous bat using a dose ($10^6$MIC$_{LD50}$) of an isolated virus of a hematophagous bat rabies. Decreased appetite, decay, dehydration and death were observed. The infected bats were sampled before and after the appearance of the clinical signs. It was not possible to detect the presence of the virus in the samples of clinically ill animals. However, it was possible to make viral isolation in cell culture of three bats that survived the infection on day 6 and 21. All three remained healthy and had neutralizing antibodies at the end of the experiment.[19]

In 2004, for the first time in the history of the Regional Program for the Elimination of Rabies coordinated by the Pan American Health Organization, the number of human cases transmitted by wild animals was higher than those of rabies transmitted by dogs. In 2005, this trend was clearly manifested when 51 cases of human rabies transmitted by bats were reported, compared to 11 cases of rabies transmitted by dogs.[20]

As of 2006 in Mexico, 22 cases of human rabies transmitted by wild animals have been reported, of which 17 cases were transmitted by vampire bat.[21]

In the year 2008, Velasco-Villa and collaborators reported the isolation of a new variant of rabies virus isolated in a human from Oaxaca.[22] This case turned out to be related to a previous one in 2005 of the same state of the Mexican Republic. Although the source of infection was a terrestrial carnivore whose identity could not be accurately established, the molecular and phylogenetic characterization of this virus suggested that its origin was related to insectivorous bats. The phylogenetic reconstruction of these virus groups them with the rabies viruses isolated in *T. brasilensis mexicana*, (95% identity percentage), however, they segregate in an independent lineage.[22]

## DESMODUS ROTUNDUS RESERVOIR AND MAIN TRANSMITTER OF RABIES VIRUS

Bats are mammals, mainly because they are haired animals and feed their offspring with milk, they belong to the Chiroptera's order. To modern English bat word is influenced by latin "blatta": moth, nocturnal insect; in Spanish the name *murciélago* is influenced by "muris" (mus): "mur", mouse; "caecus": blind, "ala": wing which makes reference to its flying ability.[23]

In Mexico, there are about 138 bat species, only three species of them belong to hematophagous group, proceeding each one of them from the *Desmodontinae* sub-family, *Phyllostomidae* family.[24] These three genders of bats are: *Desmodus rotundus* or bald legs vampire; *Diaemus youngi* or white end wings vampire and *Diphylla ecaudata* or furry legs vampire; this bats behavior is unique also their anatomic structure makes easier its eating habits.[24]

*Desmodus rotundus* bat is half size, its length goes from 75 to 93 mm (0.3 inch); when young, their back is pale grey or blackish grey haired, when they become adults its back becomes dark brown, light brown or reddish; white ventral, dense short and soft hair, short and thin face with a rudimentary external nose, big eyeballs, tiny and pointed ears, a bulky lower lip in "V". Its interfemoral membrane is short haired; long toes with three pads, wide and long wings, not tailed short calcaneus, its upper limbs bones are strong with borders enhanced to attach muscles; round skull, big blade shaped upper front and canine teeth and lower bi-lobed tiny front teeth and a diastema at half jaw (Fig.1). Average weight in not active adults without food goes from 27 to 33 g (1oz).[25]

*Desmodus rotundus* is the species with the greatest abundance and distribution, as well as natural reservoirs of the rabies virus, and since they feed exclusively on vertebrates' blood, especially cattle, they are considered one of the most important transmitters of rabies in Latin America.[23, 24]

It occupies a wide variety of habitats, such as caves, fissures of rocks and hollows of trunks and tree branches, as well as artificial shelters, such as mines, irrigation canals, sewers, chimneys, abandoned houses, basements, roofs, wells and drains.[25, 26] This shows that they are very adaptable opportunists, who take advantage of the changes caused by human beings in natural environments.[26]

*Figure 1. Desmodus rotundus vampire bat Hidalgo, Mexico.*

The vampire bat is not very abundant in natural tropical forests, however, when these are cut down and become paddocks, the affected area becomes favorable for them, because the introduced cattle serve as food. These chiroptera prefer to live and take refuge in places with temperatures between 21 and 25 ° C, with few or no wind drafts and a minimum relative humidity of 45%. However, they can leave their shelters to feed themselves even when the cold or heat conditions are extreme.[23-26]

Vampire bats usually go out to find their food in complete darkness, which depends on the phases of the moon. The highest

activity is between midnight and 1:00 am, but they can search for their prey between 8:00 pm and 4:00 am, with a total of 7 to 8 hours of daily activity. In addition to the search for food, the movements of bats from one area to another are due to the need of young males to form or integrate to other colonies when they are rejected and expelled by dominant individuals who enjoy a good social status defined in the refuge.[24]

The size of their colonies varies greatly depending on the place, type, size, characteristics and conditions of the refuge.[25] Colonies of 10 to 15 individuals can be gathered, but in general they are made up of about 100. The colonies are usually composed of adults. In these colonies the bats form compact groups, where they interact with their congeners in activities of individual and social grooming, during which they clean themselves and lick each other, they help in the care of the young. Adult males compete and fight constantly to have access to females or to shelters with females. It is frequent to observe adult males with cut off ears, or with wounds and blood on the face and forearms that indicate that there was a fight.[22, 24]

They feed on blood from different vertebrates, particularly cattle.[24] When bats attack their prey they approach carefully, walking on their thumbs and hind legs, with the body and the head lifted. At other times they land on the back of their prey. To bite choose very vascularized areas, such as the back of the neck, the edge of the ears or the side, the edge of the hooves and the base of the tail.[24] Once the bat has chosen the site where it will bite, it moistens it with its saliva in a radius of 10 to 15 mm; then recharge the lower mandible against the skin of the prey, so that a small ridge forms and bites with the incisors quickly. Saliva has a substance that acts as an anesthetic.[26] The wound reaches the dermis, which is why blood emanates in abundance, in addition to the fact that the vampire keeps it fresh because during the ingestion of the blood it continuously hits the wound area with the tongue and introduces a desmokinase anticoagulant that it possesses in the saliva. The feeding lasts up to 25 minutes, but the vampires actively lick the blood for 13 minutes. In free life, the bat ingests about 15 ml of blood, which represents half of its body weight.[24]

## GEOGRAPHICAL DISTRIBUTION

Its distribution has spread along the coast of the Gulf of Mexico from Northern Tamaulipas and along the Pacific coast through Southern Sonora to the southern border of the country, and from there to northern Argentina and the southern region of Chile.[10, 27] However, the frequent increase in livestock and the alteration of tropical vegetation has favored its distribution, adapting to altitudes ranging from three meters, present in the coasts of Campeche and Yucatan, up to 2,420 meters above sea level in the mountains of the State of Hidalgo reaching up to 3,680 meters above sea level in South American countries such as Peru.[29]

The pathogenesis of rabies virus in bats is little known, it is known that these animals when infected, can harbor the virus for longer periods than other species in their saliva and remain infective before presenting clinical signs.[30] They are considered bats suspected of being infected, those that are found during the day in unusual places and with difficulty of flight or neurological signs. All suspect animals must be sent for diagnosis and identification. In the case of *Desmodus rotundus* the main signs that appear are: habit of eating during the day, hyperexcitability, aggressiveness, lack of coordination, muscle spasms, paralysis and death.[30]

## EVOLUTION OF THE *LYSSAVIRUS* AND ITS RELATIONSHIP WITH BATS

RNA viruses are considered to be rapidly evolving. Through the analysis of the glycoprotein gene of the different lyssaviruses, it was observed that this protein has a great diversity, showing only 54% of conserved amino acids.[28, 30]

This study shows that the bat lyssaviruses exist much earlier than the carnivorous lyssaviruses, and that a successful host change took place, moreover it dates from that change between 888 and 1459 years.[30, 31]

Currently, the transmission of rabies virus from bats to terrestrial mammals continues to occur, a phenomenon that epidemiologists call "*spillover*" or "*spill*" and that can give rise to emerging diseases. When the virus gains sufficient adaptation to a new host, the "*host switching*" phenomenon appears.[31] The host switching of bat rabies virus to terrestrial carnivores are important to understand the evolution and emergence of this disease, the implications in Public Health, particularly in areas where terrestrial rabies has been eliminated.[31]

## THE RABIES VIRUS

The rabies virus belongs to the order of Mononegavirales, within this order it is grouped in the family *Rhabdoviridae*, and is of the genus *lyssavirus*, electron microscopy defines its shape as a bullet, measures 180 nm in length and approximately 75 nm in diameter, has an outer shell of 8 nm with 5 nm spicules that encompass a central ribonucleocapsid of dense appearance and helical structure.[28,32]

The rabies virus has 12,000 ribonucleotides. It is composed biochemically by 74% of proteins, 20% of lipids, 3% of carbohydrates and 3%, RNA. The genome of the virus is composed of helical RNA, of a single chain of negative polarity, with RNA-dependent polymerase (nucleoprotein).[33] The genome is transcribed from the 3'-end to the 5'-end in a short RNA and in five messenger RNAs that successively code for 5 structural proteins: a surface glycoprotein (G), an inner membrane protein or matrix (M), three nuclear proteins ribonucleoprotein (RNP), nucleoprotein (N) and phosphoprotein (P) and an RNA-dependent RNA polymerase (L). The five proteins are produced from transcribed monoistronic messenger RNAs of the corresponding structural genes.[34]

Protein N encapsulates and protects the virus genome from degradation by forming a nucleocapsid (or ribonucleoprotein), resistant to RNase enzymes, which serves as a template for both replication and transcription. The ribonucleoprotein, before being associated with RNA, is associated with the phosphoprotein (P) which maintains it in a soluble form.[34, 35] The phosphoprotein (P), together with the polymerase (L), constitute the components of the activities of the RNA polymerase dependent which consists of the transcription and the replication.[34] These two activities are developed by different complexes of the polymerase, the L- (P) 3 complex, in the transcriptase activity, or N-P-L in the replicase. The complexes of transcriptase and replicase are also associated with cellular proteins, which are necessary for the activity. The assembly of the viral polymerase within the virions is essential, since the viral genome, which is RNA negative, cannot be used as RNAm, and the host cells do not have the appropriate enzymes to catalyze transcription.[30, 34]

The protein of the Matrix (M) is the smallest protein acting as a bridge between the parts of the spicules of the glycoprotein that cross the membrane and the nucleocapsid.[34] Among the functions of the M protein are participation in the assembly of the virus and its exit from the cell, as well as down regulation of transcription. Finally, the L protein directs the transcription and replication of viral RNA. The mutation rate of the genomes of RNA viruses is between one thousand and one million times greater than that of the genomes of DNA viruses, largely due to the fact that RNA polymerases lack the intrinsic mechanisms of "correcting tests" that have DNA polymerases. However, despite the great potential for random mutation, rabies virus isolates generally have high levels of conservation, indicating the existence of strong selective pressures.[31, 35]

The G protein is a type I glycoprotein, with a large extracellular domain that forms the trimeric spicules that protrude from the membrane and play an essential role in the pathogenesis, since it is responsible for the binding of the virus in the host cells and also collaborates in the assembly of virions; a transmembrane domain and a cytoplasmic domain. Together with the M protein, it is involved in the formation of the viral envelope and in the production of virions. G protein is also a target of T lymphocytes and virus neutralizing antibodies.[35]

## CLASSIFICATION OF THE RABIES VIRUS

Based on its genetic and antigenic properties, the genus *lyssavirus* is classified into seven genotypes (Table1).

*Table 1. Classification and distribution of lyssavirus*

| Name | Genotype | Serotype | Geographical distribution | Vector/ reservoir |
|---|---|---|---|---|
| Lyssavirus | 1 | 1 | Cosmopolitan; except in Australia, Japan, Antarctica, Scandinavia | Carnivores around the world Bats of America |
| Lagos bat-virus | 2 | 2 | Nigeria, Senegal, Zimbabwe, Central African Republic, South Africa | Frugivorous bats (Megachiroptera) |
| Mokola virus | 3 | 3 | Nigeria, Cameroon, Zimbabwe, Central African Rep. | Cats, dogs, shrews, rodents. |
| Duvenhage virus | 4 | 4 | South Africa, Zimbabwe | Insectivorous bats |
| European Bat Lyssavirus 1 | 5 | | France, Poland, Denmark, Germany | Insectivorous bats |
| European Bat Lyssavirus 2 | 6 | | France, Spain, Denmark, Germany | Insectivorous bats Myotis spp. |
| Lyssa virus 2 | 7 | | Australia | Australian bats |

***Source:*** *own elaboration from International Committee on Taxonomy of Viruses 2019.*[10,34,36]

Genotype 1 corresponds to the classic rabies virus itself, which includes laboratory reference strains, vaccine strains, and viruses isolated from rabid wild or domestic animals throughout the world.[36] It is very important from the epidemiological point of view since it has been shown that there are several reservoirs for this genotype, whose variants remain in nature in independent cycles.[36]

In Mexico, 9 out of the 11 variants of genotype 1 have been reported, these variants are: V1 (dog), V3, V5 and V11 (hematophagous bat), V4 and V9 (insectivore bat *Tadarida brasilensis*), V7 (Arizona fox), V8 and V10 (skunk).[37] Using a panel of eight monoclonal antibodies developed for the characterization of the rabies virus from many parts of Latin America, Velasco-Villa et al. (2006) identified a number of variant antigens (AV) circulating in Mexico these are, AV3 and AV11 (hematophagous bat). Antigenic variant 3 (AV3) and AV11 showed an overlap in the distribution along the east coast of Mexico. The AV11 has a continuous distribution over the tropical and subtropical regions along the Gulf of Mexico, as well as in part of the states of Chiapas and Oaxaca within the plains of the Isthmus of Tehuantepec, while AV3 from Tamaulipas to Yucatan throughout the region adjacent to the Gulf of Mexico and the Mexican Caribbean.[36, 37]

An atypical antigenic variant, which sometimes represents a standard antigen identical to the central skunk of Southern United States AV8, was found circulating within the subtropical and tropical zone of the central western region of Mexico.[36, 37] Antigenic variants (AV9) associated with insectivorous bats such as *Tadarida brasiliensis* and *Lasiurus cinereus* were found dispersed from central to Northern Mexico.[37]

## PATHOGENESIS OF THE RABIES VIRUS

The severity, location and number of bites influences the transmission of the virus, having associated bites in the head or neck with shorter incubation periods and higher mortality rates.[33] Once the virus is inoculated, it binds to the cell receptors. It subsequently infects the neurons through the motor plates or sensory fibers and spreads to reach the central nervous system (CNS), where rapid replication of the virus begins. It is then when the clinical signs of the disease manifest themselves. Later the virus is transported from the CNS, through the peripheral nerves, to multiple locations, among which the salivary glands stand out for their importance in the transmission. With the spread of the virus through saliva, its infection cycle would be completed. [33]

The incubation period usually varies from two weeks to 6 years (being 2 to 3 months the average), depending on the amount of virus in the saliva, the distance from the site of inoculation to the brain.[33]

## DIAGNOSIS OF THE RABIES VIRUS

Rabies is an important zoonosis for which diagnostic techniques have had to be standardized internationally.[41] In Mexico, the National Center for Preventive Programs and Disease Control, the General Directorate of Epidemiology and the Institute of Epidemiological Diagnosis and Reference "Dr. Manuel Martínez Báez", maintain the epidemiological surveillance of rabies through the implementation of different strategies, among which the direct immunofluorescence (DIF) technique, which is the gold technique used for the diagnosis of the virus throughout the country, stand out.[40] Its principle is based on the detection by means of direct immunofluorescence epitopes of the N protein of the rabies virus through immunoenzymatic interactions through the mixture of monoclonal antibodies and fluorescein.[40]

The identification of the agent is carried out in a tissue imprint of the system central nervous system (CNS), including Amon's horn, cerebellum, and medulla oblongata.[41] A simple negative test on the fresh material does not eliminate the possibility of infection, the inoculation test should be performed on the lactating mouse simultaneously, in order to carry out viral replication.[41] This test consists of inoculating probable infected nervous tissue in lactating or 3 to 4 week old mice intracerebrally and then keep them under observation for 28 days, to determine the presence of the disease. Any mouse that dies between 5 and 28 days will have a DIF.[41]

There are other diagnostic tests for rabies virus that also identify the type of variant to which they belong and this is achieved through the use of a panel of monoclonal antibodies, specific nucleic acid tests, or by the test of Retrotranscription of the Polymerase Chain Reaction (RT PCR) followed by the sequencing of deoxyribonucleic acid (DNA) from genomic areas. Such techniques can distinguish between wild viruses, vaccine strains, and possibly geographically identify distribution and behavior of virus variants.[40, 41]

In the human being, with clinical signs and symptoms, the presence of the rabies antigen will be determined by fluorescent antibodies in cornea imprint, neck skin biopsy in the transition area of the scalp, saliva samples for its inoculation in the mouse lactating or in neuroblastoma cells and will be processed according to the technical capacity and accreditation of the laboratory.[42]

## RABIES TRANSMITTED BY VAMPIRE BAT A PROBLEM OF IMPACT ON PUBLIC HEALTH

In Latin America, and particularly in Mexico, the incidence of rabies cases in domestic animals, especially in species such as dogs and cats, has declined.[1,3] However, the rabies transmitted by the vampire bat *Desmodus rotundus* to livestock species has had a significant increase.[4,21] Despite the anthropogenic activity, it has generated imbalances in the natural environment that have impacted the ecology of hundreds of wild animals, including vampire bat, influencing the movement of this chiropter to areas where it has never been before.[39,42] This is due to the increase in agriculture and livestock activity as they have extended to natural areas and introduced new livestock species that serve as a source of food for these hematophagous bat, favoring the adaptation and growth of their populations.[27, 41]

The paralytic rabies is the presentation of the disease in cattle, it constitutes a threat to health since the man can become infected with rabies when he is attacked and bitten by the vampire bat, or by direct contact with mucous membranes or recent skin wounds with material infection through the handling of infected domestic animals, since it is possible to isolate the saliva virus and salivary glands from infected cattle.[1, 3, 6]

It is important to mention that bats are not only reservoirs for the rabies virus but also a wide range of pathogens that can cause disease in people and domestic animals.[42]

## PREVENTION AND CONTROL OF RABIES TRANSMITTED BY VAMPIRE BAT IN MEXICO

In Mexico, the prevention and control of rabies transmitted by vampire bat *Desmodus rotundus* is carried out following the Official Mexican Standard NOM-067-ZOO-2017 National campaign for the prevention and control of rabies in cattle and livestock species. The strategic aspects of this campaign are based on the diagnosis of the disease, the training of operative and producer personnel, the anti-rabies vaccination of cattle and

the control of populations of the vampire bat *Desmodus rotundus*.[41] The rabies vaccination of livestock species is mandatory in the endemic area and in those places where clinical cases of the disease are confirmed by laboratory, actions are carried out in a focal and perifocal manner within a minimum radius of 10 kilometers from the initial focus. The anti-rabies vaccination scheme in cattle over one year of age is carried out annually and in cattle under one year old the first vaccine is given to the first month with the following reinforcements at three and six months respectively. In addition, vampire bat populations are controlled by designing strategies and a program of actions, considering and indicating the size of the area, natural barriers, the cattle population and livestock species, the incidence of bites, as well as the estimated population of vampire bats. Prior taxonomic identification of captured vampire bats, in pen or shelter by trained personnel, will proceed to topical treatment with oral anticoagulant-based vampiricide ointment.[41]

## CONCLUSION

Rabies is a re-emerging disease of great importance due to its lethality and impact on public health, therefore, it is recommended to make efforts aimed at limiting exposures either with the reservoir or with infected domestic animals. For this, it is necessary to work in health education in the endemic areas of the vampire bat *Desmodus rotundus* with the aim of introducing and implementing strategies to limit the spread of the rabies virus between wild and domestic animals, thus safeguarding human health.

The disease continues to be a serious public health problem due to the great variability of the virus, which makes the transmission and distribution of it more dependent on the reservoir and transmitter of the disease, than on the geographical region, making prevention and control quite complex.

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