https://doi.org/10.22319/rmcp.v16i4.6704

Technical note

Economic loss due to paralytic rabies in cattle and livestock species in Mexico in 2022

Raymundo Salvador Gudiño-Escandón [a]

María Luisa Méndez-Ojeda [a]

Selene Piscidia García-Sarabia [a]

César Gilberto Luna-Azuara [a]

Vicente Eliezer Vega Murillo [a]*

[a] Universidad Veracruzana. Facultad de Medicina Veterinaria y Zootecnia. Miguel Ángel de Quevedo s/n Esq. Yáñez. Col. Unidad Veracruzana. 91710. Veracruz, Veracruz, México.

*Corresponding author: vvega@uv.mx

Abstract:

To evaluate the economic loss due to paralytic rabies in cattle and livestock species (horses, sheep, goats, and beefalos) in Mexico in 2022, statistical data from the directorate of animal health campaigns' epidemiological surveillance, prevention, and control activities were examined. The analysis in the 26 affected states showed 598 notifications addressed, which represents 0.84 % of the 70,517 animals at risk in the farms with the presence of the disease. To control hematophagous bats, 2,585 capture operations were carried out; 740 were positive cases, and 1,845 were monitoring cases. Of the 37'816,193 animals in the 26 states, 4.11 % were vaccinated (positive and preventive cases), with an investment of MX $60'443,105, in 2.94 % of the farms. A total of 972 trainings were granted, with an average of 9 attendees. The investment was MX $30.00 for vaccine/animal and MX $6,880.45 per bat capture operation. The economic loss (live animal price) incurred due to death was MX $4'964,500 (cattle, horses, sheep, goats, and beefalos, MX $4'789,400, $157,500, $1,200, $1,200, and $15,200, respectively). It is critical to innovate in training to reduce economic losses by increasing vaccination and control measures.

Keywords: Economic loss, Hematophagous bat, Paralytic rabies.

Received: 30/05/2024

Accepted: 17/09/2025

Rabies is an infectious-contagious, acute, and fatal zoonosis that attacks the central nervous system, caused by a virus of the family Rhabdoviridae of the genus *Lyssavirus*; it is found in the saliva and secretions of infected animals and is inoculated from a bite, scratch with fangs, or lick on mucous membranes or skin to cattle, horses, sheep, goats, and pigs[(1)]. The rabies virus is distributed throughout the planet in more than 150 countries and affects both domestic and wild mammals, including humans[(2)]. It is essential to consider that the one-health approach in this disease involves implementing control strategies according to the affected region, where they must consider from conducting an anti-rabies campaign to the way to analyze epidemiological and biomolecular data of the virus[(3)].

The main transmitter of rabies to cattle and livestock species is the hematophagous bat of the genus *Desmodus rotundus*, or as it is commonly called, the Vampire bat[(4)]. It is the main reservoir and transmitter of the disease to animals of livestock species, which is reflected in a decrease in dairy and meat production. Hematophagous bats inhabit tropical and subtropical regions from northern Mexico to southern Chile and northern Argentina[(5)]. Attacks by *Desmodus rotundus* on livestock are becoming more frequent, even in regions that for decades had been considered free of this disease[(6)]. It is important to consider that climate change will affect the distribution of *Desmodus rotundus* bats in Mexico[(7)]. Bovine paralytic rabies, better known as Derriengue, is responsible for a large number of deaths of cattle, generating economic losses and a reduction in the economy of producers due to the lack of application of the vaccine against this disease, since vampire bites cause indirect losses in milk and meat production, putting the producers' assets at risk. The direct economic losses from the death of rabid animals can be eradicated in a large percentage through the vaccination of susceptible populations and the training and equipping of vampire control brigades, which should be considered an investment. The purpose of this work was to analyze and quantify the economic loss due to paralytic rabies in cattle and livestock species in Mexico in 2022.

The search for information and data collection was carried out through different national government agencies and the Official Mexican Standards. In addition, statistical information was collected from the directorate of animal health campaigns, specifically from the national campaign for the prevention and control of rabies in cattle and livestock species and from the epidemiological surveillance activities for prevention and control (SIVE) in 2022. These served as a basis for analyzing and quantifying the investment made in vaccination and bat

capture, as well as the economic loss due to death (according to the prices set per kilo for animals destined for slaughter)[8].

The number of notifications addressed by state was analyzed using a generalized linear model with the GENMOD procedure of SAS (SAS 2023)[9], assuming a Poisson distribution of the counts, to observe the differences between the number by state.

The information on the activities of the National Epidemiological Surveillance System (SIVE, for its acronym in Spanish) was analyzed, according to the official reports of the National Service of Agrifood Health, Safety, and Quality. Table 1 shows that, of the 32 states of the Mexican Republic, 26 have the presence of the disease, with 598 notifications, 311 corresponded to cattle, 15 to horses, 1 to sheep, 1 to goats, 15 to hematophagous bats, 1 to beefalos, and 255 were negative, with a total of 70,517 animals in the affected farms.

Table 1: Number of notifications addressed by state and species, and number of animals per affected farm in 2022 in Mexico

State	Notifications	Cat	Hor	She	Goa	Other	Negat	AAF
Campeche	31	17	0	1	1	0	13	2,950
Colima	9	4	0	0	0	0	5	427
Chiapas	59	44	0	0	0	5 (HB)	10	22,208
Chihuahua	4	0	0	0	0	0	4	0
Durango	0	0	0	0	0	0	0	0
Guanajuato	7	4	1	0	0	0	2	75
Guerrero	39	21	0	0	0	1 (HB)	17	784
Hidalgo	39	23	0	0	0	1 (HB)	15	16,902
Jalisco	12	8	0	0	0	0	4	1,136
Edomex	7	1	0	0	0	0	6	250
Michoacán	8	3	1	0	0	0	4	222
Morelos	33	2	1	0	0	0	0	77
Nayarit	55	30	2	0	0	1 (HB)	22	4,846
Oaxaca	20	8	1	0	0	1 (BF)	10	299
Puebla	62	29	0	0	0	2 (HB)	32	2,610
Querétaro	15	8	0	0	0	0	7	577
Q. Roo	13	10	0	0	0	1 (HB)	1	2,246
SLP	37	21	0	0	0	2 (HB)	15	810
Sinaloa	0	0	0	0	0	0	0	0
Sonora	6	0	0	0	0	0	6	0
Tabasco	50	16	0	0	0	1 (HB)	33	3,855

Tamaulipas	15	9	2	0	0	0	4	738
Veracruz	73	33	5	0	0	1 (HB)	34	7,403
Yucatán	25	15	1	0	0	0	9	1,481
Zacatecas	6	4	0	0	0	0	2	621
Total	598	310	14	1	1	16	255	70,517

HB= hematophagous bat; BF= beefalo; Cat= cattle, Hor= horses; She= sheep; Goa= goats; Negat= negative; AAF= animals on affected farms; Edomex= State of Mexico; Q. Roo= Quintana Roo; SLP= San Luis Potosí. Source: prepared by the authors using data from SENASICA[7].

The states of Veracruz, Puebla, Chiapas, Nayarit, and Tabasco had more reports ($P<0.01$) than the other reported states. The states of Durango and Sinaloa did not present any notification of the presence of the disease. The states with the highest number of notifications in cattle were Chiapas, Veracruz, Nayarit, and Puebla ($P<0.05$), compared to the other states. The national campaign for the prevention and control of rabies in livestock species, within its epidemiological surveillance activity regarding the control of hematophagous bats in 2022, mentions that, for the control of this bat, 2,585 capture operations were carried out, resulting in 740 positive cases and 1,845 monitoring cases, with 21,543 hematophagous bats captured. Table 2 exhibits the information reported on the rabies vaccination conducted in 2022, showing that 1'106,283 preventive doses were applied in 19,934 farms, and 442,171 doses of vaccine were administered to positive cases in 9,536 farms. In the states of Chihuahua, Durango, Sinaloa, and Sonora, only preventive doses were applied. In the states of Tamaulipas, Guerrero, Tabasco, Chiapas, Veracruz, and Puebla, 65.49 % of doses of rabies vaccine were applied due to the presence of positive cases.

Of the 37'816,193 animals (27'606,563 cattle, 4'235,252 horses, 4'153,124 sheep, and 1'821,254 goats)[10,11], which spend their productive life in states with the presence of paralytic rabies, the total number of vaccinated animals (positive and preventive cases) was 1'557,812, which represents 4.11 %, with an investment of MX $60'443,105. In turn, of the 1'006,756 farms in the 26 states[10], which are affected by this disease, 29,572 were vaccinated (preventive and positive cases), representing 2.94 % of the total. These data correspond to the vaccinated animals reported to SENASICA, and there is a lack of information on unreported vaccinations carried out by producers and technicians in the field; this allows to estimate the universe of animals and farms that require preventive vaccination and control of this disease. It was considered necessary not only to mention the number of vaccinated animals, but also the number of farms, to know indirectly the impact that the campaign is having on the people who are involved in working with animals; thus, a figure of 2.94 % of the vaccinated farms indicates a lack of vaccination awareness among the producers who own the farms.

Table 2: Number of doses by state applied in positive and preventive cases

	Positive cases		Preventive cases	
State	**Doses**	**NF**	**Doses**	**NF**
Campeche	12,410	159	9,657	240
Colima	11,321	165	140	1
Chiapas	45,302	339	109,483	1,453
Chihuahua	0	0	21,040	192
Durango	0	0	35,103	194
Guanajuato	15,605	993	21,799	1,279
Guerrero	56,300	1,276	30,600	575
Hidalgo	20,401	1,250	32,287	2,049
Jalisco	16,982	166	41,687	487
Edomex[2]	3,529	81	53,437	1,313
Michoacán	15	1	17,425	258
Morelos	5,700	178	3,800	113
Nayarit	8,387	207	19,113	529
Oaxaca	8,100	310	1,900	28
Puebla	32,611	1,411	75,358	2,029
Querétaro	12,651	581	43,292	1,955
Q. Roo[3]	12,935	259	441	17
SLP[4]	18,525	259	50,942	438
Sinaloa	0	0	210,055	2,463
Sonora	0	0	42,351	497
Tabasco	54,876	349	11,610	124
Tamaulipas	61,017	729	164,983	1,833
Veracruz	39,502	749	67,330	1,188
Yucatán	2,590	18	18,410	215
Zacatecas	3,412	56	24,040	464
Total	442,171	9,536	1’106,283	19,934

NF= number farms.

Source: prepared by the authors using data from SENASICA[7].

In 2022, leaflets and posters were made and distributed, and 972 talks and training courses were delivered to producers and technicians in the 26 states where this disease is present; these meetings were attended by 9,509 people, reflecting 9.5 attendees per training event. The impact of this training could not be measured directly with the data evaluated, but it did allow to observe that it is essential to seek innovative strategies in the training of the producers who own the farms, technicians, and people who are related to the campaign against paralytic rabies in the areas affected by paralytic rabies, since as mentioned, only

2.94 % of the farms in the affected states were vaccinated; this indirectly indicates that only this percentage of producers is aware of the importance of vaccination for the prevention of this disease, and therefore the training and dissemination carried out by the campaign is insufficient.

Table 3 presents the information on the economic loss due to the death of cattle and livestock species. Of the 329 animals reported in the epidemiological surveillance, 311 are cattle, which means 94.58 %; 15 are horses, 4.55 %; one sheep, one goat, and one beefalo, 0.29 % each. This results in a total loss of MX $4'964,000.

Table 3: Economic losses due to death caused by paralytic rabies in cattle and livestock species in Mexico in 2022

Category	Total number of animals	Average live weight (kg)	Average cost per kg ($)	Total kilograms	Economic loss ($)
Cattle	311	350	44	108,850	4'789,400
Horses	15	350	30	5,250	157,500
Sheep	1	30	40	30	1,200
Goats	1	30	40	30	1,200
Beefalos	1	400	38	400	15,200
Total					4'964,500

Source: prepared by the authors using data from SENASICA[7].

The investment for each capture conducted for the control of populations in the endemic zone was MX $6,880.45. Based on the above, the investment for vaccination and bat capture was calculated to develop the campaign against bovine paralytic rabies and domestic species with animals from affected farms. On the other hand, the investment in pesos for the vaccination of the 70,517 animals in the endemic zone was MX $2'115,510, and for the 2,581 bat captures, it was MX $17'785,963.25.

On the other hand, the investment for vaccination activities per animal in the population at risk in 2022 is presented in Table 4, with a total of MX $30.00. The most significant investment corresponds to the price of the vaccine dose (live modified attenuated virus), followed by labor, fuel, cooler, coolant, syringes, and needles. The travel expenses and the expenses due to the work carried out per animal with the vaccination were included to have a real figure of the investment. These data reflect that the investment made in preventing animals is minimal compared to what is lost due to their death.

Table 4: Investment per animal for vaccination activities ($)

Inputs	Price of input per unit	Total, per animal
Rabies (dose)	18	18
Syringes	5	1
Needles	1	1
Cooler	80	2
Coolant	30	1
Fuel (liters)	22	2
Labor	10	5
Total		30

Source: prepared by the authors using data from SENASICA[7].

The economic loss of a producer with bovine paralytic rabies problems with a prevalence of 6 % was evaluated. The cattle population at risk was 50 animals in the LPU; this number when multiplied by 350 kg (live weight) at a price of MX $44.00 resulted in a total of MX $770,000, and the loss due to the death of 3 animals (prevalence of 6 %), when multiplied by 350 kg average (live weight) and by the MX $44.00 of the average national price of cattle, resulted in MX $46,200.

The information on the epidemiological surveillance, prevention, and control activities of 2022 was obtained from the platform of the directorate of the national campaign for the prevention and control of rabies in cattle and livestock species. Based on this, the analysis of the 598 notifications addressed was carried out, representing 0.84 % of the 70,517 animals existing in the affected farms; likewise, the 740 capture operations were analyzed, accounting for 28.62 % of positive cases of the total. This indicates that there is a lot of work to be done, as the number of cases that are not reported to SENASICA must be added to this figure. In line with this, some authors[12,13] mention that many cases occurring in rural areas are not registered or notified to the bovine paralytic rabies campaign, due to the lack of knowledge of the disease on the part of producers.

In reference to this, the data analyzed about the vaccination reported in the epidemiological surveillance allowed to determine that the vaccination is underreported, which, together with misdiagnoses and lack of coordination among all the sectors involved, gives rise to an underestimation of the magnitude of the presence, incidence, and economic impact of this disease. According to data from SENASICA[14], it can be seen that, in 2022, Veracruz was the state with the highest number of notifications of paralytic rabies, and ranked fifth in vaccine application in positive cases and in preventive vaccination, which means only 0.87 % and 1.5 % of its livestock inventory, respectively. Since Veracruz is the state with the highest number of cattle in the country, it indicates that there must be a greater number of unreported positive cases, and that there is a lack of vaccination. In line with this, it is

mentioned that, in Veracruz, despite reporting more intensive vaccination, the number of detected outbreaks was on the rise[14]. On the other hand, Sinaloa was the state with the highest preventive vaccination rate, at 13.55 %, and no notification of positive cases. This indicates that more work must be done on preventive vaccination to reduce cases of paralytic rabies in the country.

Regarding the training conducted in 2022 across the 26 states where this disease is present, it is necessary to redouble efforts to increase the number of attendees, with greater dissemination through the various media currently in use. In 2006, there were 19 states with the presence of bovine paralytic rabies[15]; by 2022, this number increased to 26 affected states, allowing to estimate the growth and presence of the disease at the national level, which causes substantial economic losses[7]. In this regard, SENASICA[14] points out that losses due to the death of animals with bovine paralytic rabies from 2015 to November 2020 amounted to MX $30.27 million, reaching its maximum level in 2018 with 7.02 million. In relation to the economic loss due to bovine paralytic rabies in the endemic area of the 26 states affected by this disease, there is once again a lack of information on dead animals and affected farms that are not reported to SENASICA; it is essential to mention that the numbers can increase considering the value of the animal (registered cattle) and the potential of its production (meat or milk), as well as investment in food and veterinary care. Some authors mention that it is difficult to estimate the impact of *Desmodus rotundus* on the livestock industry due to the lack of accurate reports[16,17]. The investment for vaccination activities for head cattle in 2022 was MX $30.00, a figure that represents an expense equivalent to 0.25 % of the MX $15,200 of loss due to the death of an animal. The investment cost for labor to carry out the vaccination was calculated based on a herd of 50 animals and a salary of MX $250. Likewise, the other prices were those that each of the items had at that time[8]. On the other hand, when analyzing the case of a producer with problems of bovine paralytic rabies with a prevalence of 6 %, it is observed that the death of three animals represented MX $46,200 against MX $1,500 for investment in vaccination. The investment in vaccination is minimal compared to the economic losses due to animal deaths. Another measure to control this disease is to use vampiricides, with due caution, in accordance with the product's indications so as not to affect ecosystems[18]. The scheduling and application of a health program must involve consultation with the veterinarian, who adapts the vaccination plan to the needs of the herd and the area.

It is concluded that investing in vaccination and innovative training on paralytic rabies in cattle and livestock species, as well as in the control of the vampire, is profitable due to the economic losses incurred, as this is associated with the risks of animal death and the prevention of this zoonosis.

Acknowledgements and conflict of interest

We are grateful to and acknowledge SENASICA for having the updated data on the platform of the directorate of animal health campaigns of the national campaign for the prevention and control of rabies in cattle and livestock species, from where the data of the epidemiological surveillance, prevention, and control activities of 2022 could be obtained to write this scientific note.

Literature cited:

1. SENASICA. Servicio Nacional de Sanidad, Inocuidad y Calidad Agroalimentaria. NOM-067-ZOO-2007 Campaña nacional para la prevención y control de la rabia en bovinos y especies ganaderas. México. 2011.

2. Romero-Almaraz ML, Aguilar-Setién A, Sánchez-Hernández C. Murciélagos benéficos y vampiros: características, importancia, rabia, control y conservación. México: AGT Editor SA; 2006.

3. Sánchez MP, Díaz-Sánchez OA, Sanmiguel RA, Ramírez AA, Escobar L. Rabia en las Américas, varios desafíos y Una Sola Salud: artículo de revisión. Rev Inv Vet Perú 2019;30(4):1361-1381.

4. Zarza H, Martínez-Meyer E, Suzán G, Ceballos G. Geographic distribution of *Desmodus rotundus* in Mexico under current and future climate change scenarios: Implications for bovine paralytic rabies infection. Vet Méx OA 2017;4(3):1-16.

5. Bárcenas-Reyes I, Loza-Rubio E, Zendejas-Martínez H, Luna-Soria H, Cantó-Alarcón GJ, Milián-Suazo F. Comportamiento epidemiológico de la rabia paralítica bovina en la región central de México, 2001–2013. Rev Panam Salud Publica 2015;38(5):396–402.

6. Mistry S, Moreno-Valdez A. Climate change and bats: Vampire bats offer clues to the future. BATS 2008;26(2):8-11.

7. SENASICA. Servicio Nacional de Sanidad, Inocuidad y Calidad Agroalimentaria. Prevención y control de la rabia en bovinos y especies ganaderas. México. 2021.

8. Gudiño ERS. Potencial del extensionismo pecuario. con la aplicación del MIRB (Manejo integral de la reproducción bovina) en el ganado Veracruzano. XLIII Congreso Nacional de Buiatría. Boca del Río, Veracruz. 2019:44-69.

9. SAS. SAS/STAT User's Guide (Release 15.3). Cary NC, USA: SAS Inst Inc. 2023.

10. PGN. Padrón Ganadero Nacional. Inventario de bovinos estatal del padrón ganadero nacional. México. 2019.

11. INEGI. Geostatistical Framework. Sociodemographic panorama of Mexico. National Institute of Statistic and Geography. Aguascalientes, México. 2020.

12. Lee DN, Papes M, Van Den Bussche RA. Present and potential future distribution of common vampire bats in the Americas and the associated risk to cattle. PLoS One 2012;7(8).

13. Ramírez-Romero R, González-Báez A, Nevárez-Garza AM, Rodríguez-Tovar LE. Informe de tres casos de rabia paralítica y babesiosis bovina en el municipio de Aldama, Tamaulipas. Vet Méx 2011;42(4):331–338.

14. SENASICA. Servicio Nacional de Sanidad, Inocuidad y Calidad Agroalimentaria. Panorama nacional de rabia paralitica bovina. México. 2022.

15. SENASICA. Servicio Nacional de Sanidad, Inocuidad y Calidad Agroalimentaria. Panorama nacional de rabia paralitica bovina, México. 2006.

16. Belotto A, Leanes LF, Schneider MC, Tamayo H, Correa E. Overview of rabies in the Americas. Virus Res 2005;111(1):5–12.

17. Kuzmin IV, Rupprecht CE. Bat rabies. In: Jackson AC, Wunner WH, editors. Rabies. 2ª ed. San Diego, USA: Academic Press; 2007:259–307.

18. García-Sarabia SP, Méndez-Ojeda ML, Vega-Murillo VE, Gudiño-Escandón RS. Reduction of hematophagous bat aggressions with the use of systemic vampiricide in a population of the state of Veracruz, Mexico. 32 World Buiatrics Congress. Cancún, México. 2024.