www.roavs.com EISSN: 2223-0343

RESEARCH OPINIONS IN ANIMAL & VETERINARY SCIENCES

Climatic factors and temporal variation in the presence of vesicular stomatitis in the State of Veracruz, Mexico

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Abstract

The objective of this study was to analyze the possible relationship between certain climatic variables and temporal variation in the presence of vesicular stomatitis (VS) in bovine in the State of Veracruz, Mexico, from January 1996 to December 2002. The information on VS outbreaks was obtained from the data base of the World Organization for Animal Health. Maximum and minimum temperatures and rainfall were considered as climatic variables; the information from these variables was obtained from the data base of 25, 31 and 40 weather stations, respectively. A multivariate analysis of multiple correlations was carried out and it was found that the variable which best explained the presence of VS outbreaks, was rainfall.

Keywords: vesicular stomatitis; outbreaks; temperature; rainfall

To cite this article: Muñoz-Melgarejo S, B Domínguez-Mancera, A Hernández-Beltrán, S Salazar-Lizán, P Cervantes-Acosta and D Romero-Salas, 2013. Climatic Factors and Temporal Variation In The Presence Of Vesicular Stomatitis in the State of Veracruz, Mexico. Res. Opin. Anim. Vet. Sci., 3(3), 86-91.

Introduction

Vesicular stomatitis (VS) is a disease caused by the vesicular stomatitis virus (VSV), member of the Vesiculovirus genus from the *Rhabdoviridae* family. Domestic animals and humans can be infected with the following viruses of this genus: VSV-New Jersey (VSV-NJ), VSV-Indiana (VSV-IN or VSV-IN1), Alagoas, Calchaqui, Chandipura, Cocal, Isfahan and Piry (Letchworth et al., 1999), although Cocal and Alagoas are considered subtypes of Indiana and are designated as VSV-IN2 and VSV-IN3, respectively (Rodriguez et al., 2000).

In the Americas, VS appears in the form of outbreaks in the Southwest of the United States and is endemic in Mexico, Central America and the North of South America (Rodriguez, 2002). In Mexico, the disease appears with different frequencies over the entire country, but in greater proportion in the South-southeast, especially in the states of Veracruz, Chiapas and Tabasco (Rodriguez et al., 2000).

VSV can infect different species, but the clinical disease has been observed in cattle, horses and pigs; very rarely has it been observed in llamas. Clinical manifestations include the formation of vesicles and ulcers in the nasal and oral mucosa (on both lingual and gingival surfaces), coronary pad and mammary gland (McCluskey et al., 2003b). The clinical signs of VS make it undistinguishable from foot-and-mouth disease, one of the most devastating diseases for livestock, and this is why it is so important for a differential diagnosis.

Transmission of VSV can occur by direct contact or through vectors, be they biological or mechanical; nevertheless, reservoirs or amplifying hosts have not been identified (McCuskey et al., 2003b). VSV has been isolated from hematophagous arthropods of the *Psychodidae, Simuliidae, Culicidae and Ceratopogonidae* families, which embrace sand flies (*Lutzomya shannoni*), black flies (*Simulim vittatum*) and mosquitoes, among others, but it has also been isolated from non hematophagous arthropods like common flies (*Musca domestica)* (Rodriguez, 2002).

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VS are the outcome of a complex interaction between host, agent, vector or vectors and environmental factors (Bridges et al., 1997). In tropical and sub-tropical zones, the clinical disease is more frequent during and at the end of the rainy season or at the beginning of the dry season, suggesting that the outbreaks respond to short or long term climatic variations (Letchworth et al., 1999).

It is estimated that the climatic change phenomena will have considerable effects upon diseases transmitted by arthropods and that will increase the availability of areas suitable for colonization by mosquitoes and cerathopogonides (Jonsson and Reid, 2000). Likewise, an effect on the vectorial capacity (capacity of a vector population to transmit an agent to a population of vertebrates) of arthropods is expected (Mellor and Wittmann, 2002), from which a modification of the spatial and temporal distribution, as well as in the incidence and prevalence of VS, could be inferred.

In Veracruz, where livestock is very important and considered a crucial factor in the constitution of complex ecological systems that define the unique biodiversity of the State (Hernández et al., 2006), VS is endemic and there are not available many epidemiological studies thereon. The objective of this study was to analyze the possible relationship between certain climatic variables and temporal variation in the presence of VS in bovine in the State of Veracruz, Mexico, from January 1996 to December 2002.

Materials and Methods

Study area

Veracruz State is located between the Sierra Madre Oriental and the Gulf of Mexico, at 17º 03' 18'' and 22º 27' 18'' North and 93º 36' 13'' and 98º 36' 00'' West coordinates. Since it is located in the Torrid Zone, the weather is hot all along the coast, but due to the varied relief of its topography, different climates can be found (INAFED, 2010).

Nevertheless, hot humid and hot sub humid climates comprehend a larger area, approximately 80% of Veracruz territory, and are distributed over the northern and southern Gulf coast plains, at a maximum altitude of 1000 meters above the sea level. The average annual temperature ranges from 22 to 26 ºC and the total annual rainfall varies from 2000 to more than 3500 mm. Likewise, among the types of vegetation thriving in the State, the most abundant are the evergreen tropical forest (a little more than 51000 km^2) and the deciduous tropical forest (INAFED, 2010).

Outbreaks of vesicular stomatitis

Until December 2004, member countries of the World Organization for Animal Health (OIE) presented monthly reports to said organization about the sanitary situation regarding the diseases in the so-called List A. These reports were processed in a database which can be consulted through the web Handistatus II (OIE, 2011a) interface. The number of monthly VS outbreaks that were notified as corresponding to the State of Veracruz, from January 1996 to December 2002, was used for the present work (OIE, 2011b). All outbreaks correspond to bovines.

The OIE (2011a) defines an outbreak as the occurrence of the disease in question in an agricultural establishment, breeding establishment or premises, including all buildings and all adjoining premises, where animals are present. Where it cannot be defined in this way, the outbreak shall be considered as occurring in the part of the territory in which, taking local conditions into account, it cannot be guaranteed that both susceptible and non-susceptible animals have had no direct contact with affected or suspected cases in that area.

Climatic variables

According to McCluskey et al. (2010a), the following climatic variables were considered: maximum temperature (MAXT), minimum temperature (MINT), daily rainfall (DRF) and monthly accumulated rainfall (MARF) in the State of Veracruz, from January 1996 until December 2002. A calculation of the monthly averages was carried out in the case of the first three variables.

The information of the climatic variables included was obtained thanks to a data base given by Juárez et al. (2008), who explains that the National Water Commission (NWC) compiles climatic data of Mexico and makes part of them available for the public domain through the CliCom data base (Computerized Climate).

Information from 25 weather stations was used for MAXT, from 31 stations for MINT and from 40 stations for rainfall. The selection of the weather stations was based on the period covered for data observation, the percentage of lost data and the quality of the available data according to Juárez et al. (2008) in his historical analysis of climatic variability in Veracruz (Fig. 1).

Table 1: Descriptive statistic of climatic variables and number of vesicular stomatitis outbreaks (1996-2002)

	MINT (ºC)	MAXT (ºC)	MARF (mm)	DRF (mm)	Outbreaks
Average	18.02	29.64	139.03	4.16	2.62
SD	2.65	3.06	111.69	3.43	4.05
SE	0.29	0.33	12.19	0.37	0.44

SD = Standard deviation, SE = Standard error; MINT = Minimum temperature, MAXT = Maximum temperature, MARF = Monthly accumulated rainfall, DRF = daily rainfall.

Statistical analysis

A descriptive statistic of the climatic variables and the number of VS outbreaks was carried out. Likewise, a multivariate analysis of multiple correlation, and one of cluster-type association (STATISCA program, v. 7.0 -StatSoft, 2004) in which the number of monthly VS outbreaks was considered as a dependent variable, and the MARF, monthly averages of MINT, MAXT and DRF for the 84 months comprehending the study period were considered as independent variables.

Results

The descriptive statistic of the climatic variables and the number of VS outbreaks for the study period are shown in Table 1. In Figure 2, the monthly distribution of the number of VS outbreaks for the study period can be seen.

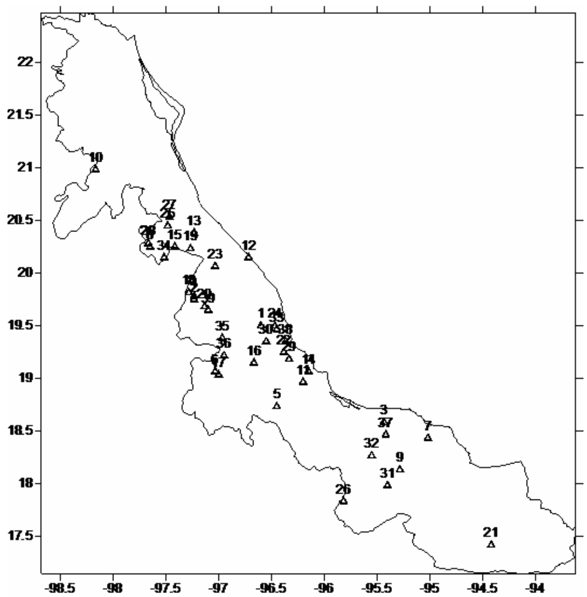

Fig. 1: Geographical location of the weather stations selected (taken from Juárez et al**., 2008).**

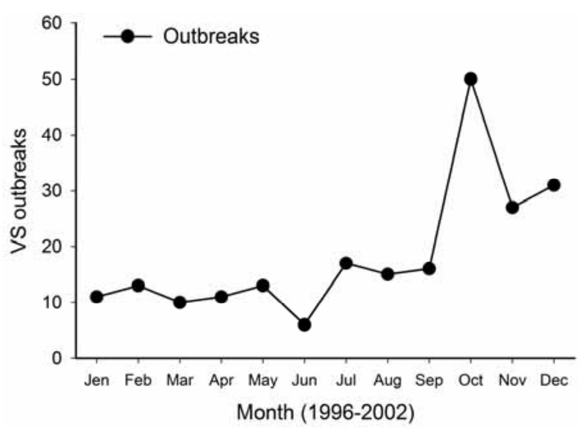

Fig. 2: Monthly outbreaks of vesicular stomatitis in the State of Veracruz (1996-2002).

Table 2: Correlation matrix of the climatic variables associated with the number of vesicular stomatitis outbreaks (1996-2002).

	Year	Month	MINT	MAXT	MARF	DRF
Month	-0.00					
MINT	0.04	0.22				
MAXT	0.13	-0.05	0.91			
MARF	-0.01	0.44	0.58	0.28		
DRF	0.01	0.44	0.59	0.30	0.99	
Outbreak	-0.01	0.29	-0.03	-0.16	0.12	0.12

MINT = Minimum temperature, MAXT = Maximum temperature, MARF = Monthly accumulated rainfall, DRF = daily rainfall.

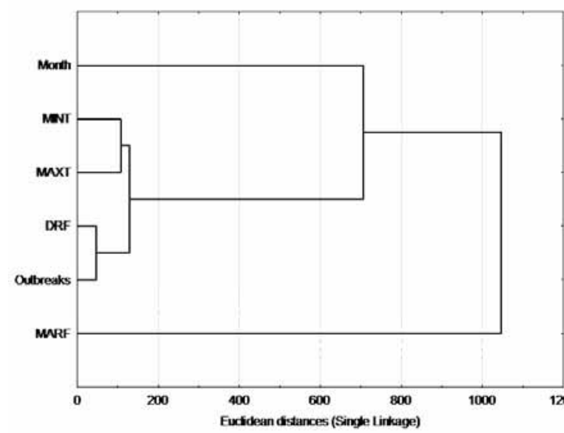

Fig. 3: Cluster analysis of climatic variables and number of vesicular stomatitis outbreaks. MINT = Minimum temperature, MAXT = Maximum temperature, DRF = daily rainfall, MARF = Monthly accumulated rainfall.

As can be seen in Table 2, by performing the multivariate analysis of the correlation matrix, an association between the number of VS outbreaks and the climatic variables temperature and rainfall were found. Besides, a cluster type analysis allowed a grouping of the variables with a higher degree of association (Fig. 3).

Rainfall was the variable that best explained the presence of VS outbreaks, particularly DRF. When the number of outbreaks was compared with the Month variable, its correlation was high (0.29) due to the differences in temperature and precipitation between the months of the year. Therefore, the outbreaks of VS were present in a higher proportion during those months in which these variables were above the average.

In Figures 4 and 5 it is possible to appreciate the association with the different climatic variables graphically, considering the interaction between temperature (maximum and minimum) and rainfall (monthly accumulated and daily) with the number of VS outbreaks during the study period.

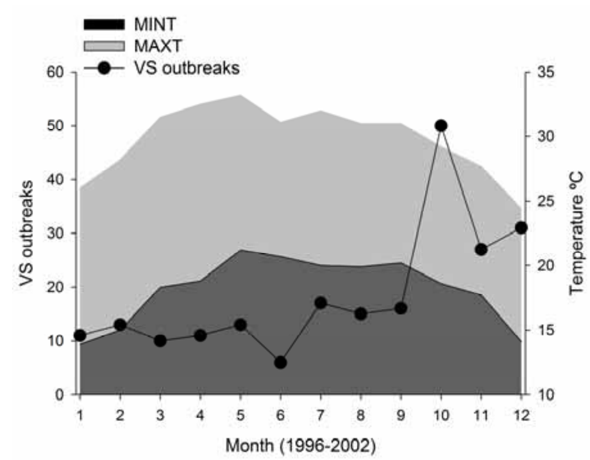

Fig. 4: Behavior of vesicular stomatitis outbreaks during the year in the study period, in relation to the minimum (MINT) and maximum temperatures (MAXT).

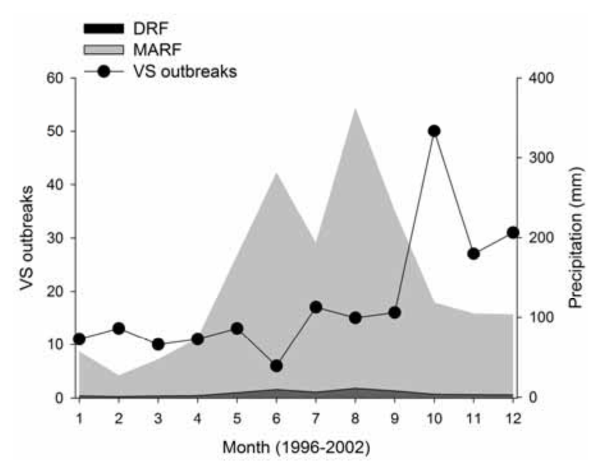

Fig. 5: Behavior of vesicular stomatitis outbreaks during the year in the study period, in relation to daily (DRF) and monthly accumulated rainfall (MARF).

Discussion

To date, there are questions concerning the natural history of VS and it is common to have knowledge of reports, sometimes anecdotic, about the association of VS outbreaks with certain climatic patterns. Several authors agree that the weather influences the frequency and time in which the disease is present (Atwill et al., 1993; Vanleeuwen et al., 1995; Rodríguez et al., 1996; Letchworth et al., 1999; Arboleda et al., 2001; Arboleda and Trujillo, 2002; McCluskey et al., 2003a; Adell et al., 2010; Arroyo et al., 2011).

The State of Veracruz is considered an endemic zone of VS, since most of its territory offers favorable conditions for the permanence and propagation of the agent. The OIE data base (2011b) allowed the observation that in all the years considered for the study, VS outbreaks were present in the State. This coincides with what Mason et al. (1978) reported in an epidemiological analysis of VS, with the data accumulated over a period of 27 years from 1949 to 1975.

Nevertheless, there is a lack of information to confirm whether, as Atwill et al. (1993) indicate, at least two cycles of transmission for VSV-NJ and one more cycle for VSV-IN are present in Veracruz, probably depending on different species of vectors and reservoirs of the virus. In the case of VSV-NJ, the scenario of the two cycles could be presumed, since according to data of the OIE (2011b), this serotype is predominant in the State as in the rest of Mexico, as noted by Mason et al. (1978), Adell et al. (2010) and Arroyo et al. (2011).

Rainfall was the variable which best explained the presence of VS outbreaks; especially DRF, as can be seen in Figure 5. These results agree with what was observed in New Mexico, USA (McCluskey et al., 2003a), Colombia (Arboleda and Trujillo, 2002) and Costa Rica (Atwill et al., 1993), where the altitude above sea level was also considered as a relevant environmental element.

In Mexico, the VS outbreaks have been associated with rain (Mason et al., 1978; Hernandez et al., 1992). It has been seen in Colombia that rain is an important environmental triggering factor for VS epidemics, because the outbreaks appear in dry periods following the rainy season (Arboleda and Trujillo, 2002). This observation is consistent with Figure 2, where more VS outbreaks can be appreciated in October, November and December, less rainy months following those with a greater rainfall (July, August and September), and coincides with the reports from Arroyo et al. (2011).

High levels of rainfall can favor an increase in the number of reservoirs and/or amplifying hosts, necessary for VS outbreaks. Several disease-transmitting vectors have highly water-dependent biological cycles, black flies for instance. The rain provides reproduction sites for these vectors and creates environmental conditions which favor a longer life cycle. Consequently, the increase in rainfall would multiply the available sites for reproduction and, therefore, the amount of available vectors (McCluskey et al., 2003a).

Regarding the temperature, the vectorial competition among arthropods of the *Culicoides* genus, for some serotypes of orbovirus, increases linearly with heat. Likewise, arthropods must survive long enough to feed and, therefore, transmit the agent, a situation which is less likely to occur with temperatures ranging from 27 to 30ºC (Mellor and Wittmann, 2002). It has been seen that the female of *Culicoides variipennis sonorensis* feeds every other day at 30ºC and every 14 days at 13ºC (Whittmann and Baylis, 2000).

Juárez et al. (2008) highlighted the possible existence of an increase in the maximum temperatures and monthly accumulated rainfall upon analyzing the temperature behavior and rainfall during 43 years (1940-2002) in the State of Veracruz. It can be inferred that the ideal conditions for the maintenance, and even for an increase in the population of arthropods transmitting VSV in the State, among which the *Culicoides* genus and *Culex nigripalpus* (Hernández et al., 1992) stand out, will persist.

Weather the predictions about climatic change are fulfilled, the afore mentioned condition may be aggravated or at least become erratic, since a modification in the global patterns of temperature, rainfall and climatic variability is indicated for the coming decades due to the effect of a sustained accumulation of greenhouse gases in the troposphere (McMichael and Beaglehole, 2000).

The hypothesis that the warming that has occurred during the last decades has caused variations in the distribution of vectors is supported by different studies, which show that: vectors die or do not develop adequately under certain thresholds of temperature, and that the rates of reproduction, population growth and feeding of the vectors increase as the temperature increases (Harvell et al., 2002).

It is also pertinent to point out that this work took the information offered by the OIE and the NWC as a basis; therefore, it is difficult, almost impossible, to validate said information. It is also necessary to consider the possibility of entering errors when creating the database, referred by Thrusfield (2005) as "manual or keyboard errors", caused by the insertion, suppression, substitution or transposition of characters.

Furthermore, the prevailing problem of sub-notification of animal diseases in our country must be highlighted. Even though in Mexico VS is a disease which requires immediate and mandatory notification, the actuality is that producers do not inform of its presence, perhaps because they want to avoid all the trouble that quarantine would imply, or because they have become accustomed to "living" with the disease. Neither is it clear to what extent the veterinarians contribute to sub-notification.

In conclusion, the climatic variable which best explained the presence of VS outbreaks was rainfall, particularly DRF; yet the variable must not be considered individually, but as part of a complex process and that it contributes to the appearance of the disease, confirming the concept of interaction and the multifactorial nature of VS.

Acknowledgments

Dr. Sergio Francisco Juárez Cerillo, researcher of the School of Statistics and Informatics, Xalapa, University of Veracruz. LCA. Carolina Andrea Ochoa Martínez, group of Applied Climatology, School of Electronic Instrumentation and Atmospheric Sciences, Xalapa, University of Veracruz

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