OBSERVATIONS ON THE EPIZOOTIOLOGY OF VAMPIRE BAT RABIES[1]

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Field studies indicate that rabies virus behaves similarly in vampire bat populations to other infectious agents in other hosts. In the work reported here, virus was isolated from vampires only during and shortly before outbreaks in cattle. Rabies antibody appeared infrequently in vampire sera taken before bovine outbreaks; during outbreaks low antibody rates were detected, and after outbreaks higher antibody rates were found.

Introduction

After the dog, one of the more important hosts and vectors of rabies virus in the Americas is *Desmodus rotundus,* the common vampire bat. This vampire species is found from Mexico to northern Argentina; it is regularly abundant wherever domestic stock are available and where there is an adequate distribution of suitable roosting sites such as caves, mines, hollow trees, large open wells, etc. Bovine losses from vampire-transmitted rabies have been estimated at between 500,000 and 1,000,000 head per year (*1,2*). As more land is opened up for cattle raising, future increases in cattle populations may result in even greater losses. Human mortality from vampire-transmitted rabies remains low because the bats do not often prey on man; nevertheless, as of a few years ago a total of about 150 human deaths had been reported (*3*).

Rabies virus is probably transmitted between vampire bats in their roosts, by either bite or aerosol (*4,5*). Neutralizing antibody found in the sera of vampire bats from which virus could not be isolated (*7*) indicates that some bats apparently survive exposure to rabies virus (*6*).

What normally call attention to the presence of a rabies epizootic among vampire bats are paralytic rabies cases in cattle. Though other domestic animals, wild animals, and man are also attacked, cattle are the vampires' preferred source of blood (*8*). For this reason the course of a rabies epizootic in vampire bats is usually followed through observations of bovine rabies (*9*). Such a procedure runs the risk of confusing vampire-transmitted rabies with rabies transmitted by other animals such as dogs, foxes, or skunks (*10*). Usually, however, inquiry about rabies in other local animals and a sampling of the local vampire bat population is sufficient to establish the source of virus in a bovine rabies epizootic.

No meaningful pattern in the epizootiology of vampire bat rabies emerged until the description published in 1969 by López, *et al.* (*9*). Through detailed examination of voluminous data obtained in northern Argentina, these authors showed how vampire-transmitted bovine rabies entered the country from the north on several occasions at different points,

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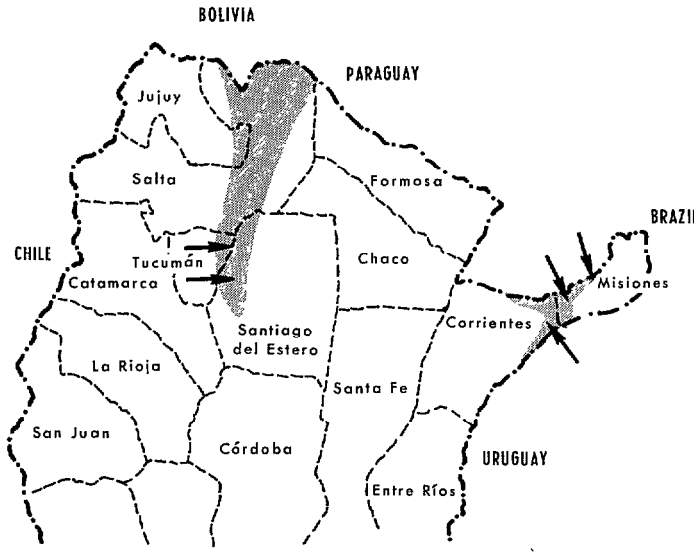

FIGURE 1–*A map of northern Argentina showing regions where two widely separated epizootics of vampire-transmitted bovine rabies occurred (shaded sectors). Arrows show where vampire bats were captured in the course of the work reported here.*

and afterwards spread slowly southward. Using an outbreak originating in the Province of Salta on the Bolivian border in 1959, they traced this southward progress. The estimated average distance travelled annually was about 40 kilometers. This pattern of rabies virus movement through vampire bat populations has been called a migrating epizootic (*10*).

In 1972, Delpietro, *et al.* (*7*) described different patterns of rabies neutralizing antibody and rabies virus in vampire bat sera from areas which they classified as "epizootic," "recession," and "rabies-free." They obtained rabies virus from eight of 33 bats examined in the "epizootic" sector but found rabies neutralizing antibodies in only one. On the other hand, they discovered antibody in 24 per cent of the sera from the "recession" sector, but found no virus. In the "rabies free" sector neither antibody nor virus was found.

During our own study of various aspects of vampire bat ecology in Argentina, populations were sampled for rabies virus and rabies neutralizing antibody. By chance, different populations were sampled before, during, and at varying intervals after outbreaks of bovine rabies. These opportunistic observations, while not perfectly satisfactory, have provided the useful information presented here on the epizootiology of vampire bat rabies.

Materials and Methods

During 1971 and 1972 vampire bat populations were sampled in the provinces of Corrientes, Santiago del Estero, and Tucumán in connection with study of two widely separated outbreaks of bovine rabies (see Figure 1). The bats were captured with Japanese nylon mist nets, bled by cardiac puncture, and sacrificed. When inadequate amounts of blood were obtained, the blood was diluted with normal saline and the dilutions were recorded for later calculation of antibody titers. The blood or blood-diluent mixtures were centrifuged, and the serum was separated and stored on dry ice.

PHOTO 1–*Setting a Japanese nylon mist net to capture bats.*

PHOTO 2–*A group of vampires* (Desmodus rotundus) *hanging from the wires of a cage.*

Sacrificed bats were labeled, placed in plastic bags, and frozen with dry ice.

Serum samples and bat carcasses were then transported to the laboratory of the Pan American Zoonoses Center at Ramos Mejía. The serum was tested by a standard procedure (*11*) for serum neutralizing antibody; titers of 1:5 or greater were considered positive. The bat carcasses were thawed; brain, salivary gland, and brown fat tissues were removed, ground with standard diluent (*7*), and inoculated into the brains of newborn mice for virus isolation. The brains of mice dying after the fourth day of observation were tested for rabies by immunofluorescence, using equipment, reagents, and methods described elsewhere (*12*).

Results

A total of 1,024 vampire bat sera were tested for antibody; of these, 57 yielded titers of 1:5 or more and were therefore considered positive. Table 1 classifies 877 of these sera according to the location of captured bats, the time between capture and the occurrence of a rabies outbreak in local cattle, and the presence or absence of neutralizing antibody.

The other 147 vampire sera tested do not appear at the top of the table because the time of local bovine rabies outbreaks could not be determined with sufficient accuracy. It is known, however, that in every case the most recent outbreak had occurred from 6 months to 4 years before the bats were bled. The results obtained with these 147 sera, shown in the lower part of Table 1, indicate that 13 sera (9 per cent) were positive for rabies neutralizing antibody.

All of the 1,024 bats tested for antibody were also tested for rabies virus, but no virus was detected.

Besides these bats captured with mist nets, 83 vampire bats were captured in the Province of Santiago del Estero during fumigation of their roosts. When tested for rabies virus, 11 were found to have the virus in one or more tissues (the tests were conducted on brains, salivary glands, and intrascapular fat). Two of the 11 positive bats were part of a sample of 33 specimens killed when their refuge was fumigated during part of a planned control effort (*13*). At the time there was no indication of rabies in the vicinity, but later the same month bovine rabies was reported in the area. The other nine positive bats were part of a sample of 50 specimens exterminated in roosts located in an area which was experiencing an epizootic of bovine rabies (*13*).

Discussion

Examination of the results in Table 1 and other data (*7*) show that, with one exception, neutralizing antibody has not appeared frequently in vampire serum samples obtained before the occurrence of rabies outbreaks in local cattle. The one exception (the Piedrabuena samples listed in Table 1) may illustrate problems inherent in depending on cattle rabies as an indicator of vampire rabies. A low but slightly higher overall percentage of samples containing rabies neutralizing antibody were obtained from bats captured during bovine rabies outbreaks, and varying but generally higher percentages of samples with antibody were obtained from bats captured one to seven months after bovine outbreaks.

The only virus isolated in the course of this study was obtained from bats captured just before or at the same time as bovine rabies cases occurred.

These results agree with and supplement those of Delpietro, *et al.* (*7*). Together with the epidemiologic information published by López, *et al.* (*19*), they point to a rabies virus epizootiology in vampire bats similar to that of many infectious agents in other hosts. It appears that on entering a vampire bat population, rabies virus successfully infects much of it, possibly killing some individuals (*3*) and causing immunization of others. Upon removal of

TABLE 1—*Rabies neutralizing antibody in vampire sera, grouped according to the capture site and the time between capture and occurrence of a local bovine rabies outbreak.*

Locality	Months before (-) or after (+) Outbreak	Presence of Neutralizing antibody No. positive/tested	% positive
Specimens Bled Prior to Outbreak			
Retiro, Santiago del Estero	23(-)	0/7	0
Las Cejas, Santiago del Estero	8(-)	1/92	1
San Felix, Santiago del Estero	8(-)	0/98	0
San Ramon, Santiago del Estero	8(-)	0/6	0
Timbo Viejo, Tucuman	8(-)	0/6	0
El Naranjo, Tucuman	8(-)	0/139	0
Tala Pozo, Tucuman	7(-)	3/40	8
Arenales, Santiago del Estero	7(-)	0/43	0
San Felix, Santiago del Estero	5(-)	0/6	0
Piedrabuena, Tucuman	5(-)	16/110	15
Bobadal, Santiago del Estero	4(-)	0/16	0
El Rincon, Santiago del Estero	2(-)	1/65	2
El Azul, Santiago del Estero	2(-)	0/66	0
	Subtotal:	21/694	3.1)
Specimens Bled during Outbreak			
Siete Arboles, Santiago del Estero	0	1/31	3
San Pedro, Santiago del Estero	0	2/14	14
San Jose, Tucuman	0	0/18	0
Ita Ibaté, Corrientes	0	2/13	15
	Subtotal:	5/76	6.6)
Specimens Bled after Outbreak			
San Vicente, Santiago del Estero	1(+)	1/32	3
San Antonio, Santiago del Estero	2(+)	5/21	24
San Miguel, Santiago del Estero	4(+)	1/6	17
Las Lajas, Santiago del Estero	5(+)	3/23	13
Virasoro, Corrientes	5(+)	7/12	58
Las Lajas ,Santiago del Estero	7(+)	1/13	8
	Subtotal:	8/107	16.8
Specimens Bled from 6 months to 4 years after Outbreak (exact interval unknown)			
Teyu Cuaré ,San Ignacio, Misiones		2/7	29
Almafuerte, Misiones		2/8	25
Santa Ana, Misiones		2/11	18
Candelaria, Misiones		0/60	0
Rincon Chico, San Carlos, Misiones		7/61	11
	Subtotal:	13/147	8.9

sufficient susceptibles in these ways the epizootic presumably subsides or moves on to neighboring populations.

Such findings are not surprising and in fact serve to explain bovine rabies phenomena seen throughout the range of the vampire bat. Periodic outbreaks occur because time is needed to build up a sufficient density of susceptibles in the bat population to reach or exceed the required threshold of contagion.

Most vampire bat populations are in contact, indirectly, with most other vampire populations. That is, each population has its own refuges but regularly visits neighboring roosts, thereby forming a connecting network. Banded individuals have been found within a 5-kilometer radius of the refuges where they were first captured (*14*), and recaptures at even greater distances have occurred (*15, 16*). There is thus a ready explanation for the passage of rabies virus through a series of vampire bat populations in chain-like fashion.

SUMMARY

Vampire bat populations were opportunely sampled before, during, and at varying intervals after outbreaks of bovine rabies. The captured bats were examined for rabies neutralizing antibody and virus. In all, sera from 1,024 vampire bats were tested for antibody, and tissues from these bats plus 83 others were tested for virus.

Neutralizing antibody only rarely appeared in vampire serum samples taken before bovine rabies outbreaks, and only low percentages of samples positive for rabies antibody were obtained from bats captured during bovine outbreaks. In contrast, varying percentages of positive samples (including some high percentages) were taken from bats captured at various intervals after bovine outbreaks.

Only eleven rabies virus isolations were obtained in the course of this study. In each case the virus came from a bat captured just before or during a bovine outbreak.

The authors suggest that rabies virus behaves in vampire populations the way diverse infectious agents typically behave in other hosts. That is, the virus infects many individuals; some die and other s survive to demonstrate their exposure through the appearance of antibody. The disease disappears from the bat population in time and does not return until a sufficient number of susceptible bats have re-entered the population.

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WHO RECEIVES MILLION-DOLLAR VOLUNTARY CONTRIBUTION

On 15 August the Japan Shipbuilding Industry Foundation made a contribution to the World Health Organization of 300 million yen (US$1,016,949). This sum, the largest voluntary contribution from a non-governmental source ever received by WHO, was donated in support of WHO's programs for control of leprosy and global eradication of smallpox.

Mr. Ryoichi Sasakawa, President of the Japan Shipbuilding Industry Foundation and the Sasakawa Memorial Health Foundation, presented the check to Dr. Francisco J. Dy, WHO Regional Director for the Western Pacific. The ceremony took place at the Japanese Ministry for Health and Public Welfare in the presence of the Minister, Mr. Masami Tanaka.

Mr. Sasakawa said: "Because of my belief in the brotherhood and sisterhood of mankind, I and my Foundation wish to do everything possible to combat two of the most dreaded diseases, smallpox and leprosy." (*Source:* World Health Organization Press Release WHO/28, 15 August 1975.)