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Observations of Sylvatic Rabies in Northern Argentina during Outbreaks of Paralytic Cattle Rabies Transmitted by Vampire Bats (*Desmodus rotundus*)

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ABSTRACT: During rabies outbreaks in cattle (paralytic rabies) in Argentina associated with the common vampire bat *Desmodus rotundus*, rabies was observed in marsh deer (*Blastocerus dichotomus*), red brocket deer (*Mazama americana*), capybara (*Hydrochoerus hydrochaeris*), savanna fox (*Cerdocyon thous*), and great fruit-eating bat (*Artibeus lituratus*). Rabies could constitute a threat to the survival of marsh deer in places where they live in small groups, and infection of both great fruit-eating bats and savanna fox represent a risk for humans; both species exhibit aggressiveness and fury when infected.

Key words: Capybara, clinical signs, conservation *Desmodus rotundus*, fruit-eating bat, human health, marsh deer, rabies transmission, red brocket deer, savannah fox, vampire bat.

The common vampire bat (*Desmodus rotundus*) is abundant in most of the tropical and subtropical cattle-raising ecosystems from Mexico to Northern Argentina. These bats primarily feed on cattle, horses, and swine and to lesser extent on poultry, wildlife, and humans (Crespo et al., 1961; Greenhall, 1970; Greenhall et al., 1983). Infected *Desmodus* can transmit rabies to its prey during feeding and to other vampire bats (and other species) by defensive or aggressive bites (De Verteuil and Urich, 1936; Johnson, 1948).

Rabies transmitted by *Desmodus*, usually called "paralytic rabies," kills hundreds of thousands of cattle every year and has recently caused an increased number of human cases (World Health Organization, 1984, 1992, 2004; Da Rosa et al., 2006). Paralytic rabies occurs in epidemic form, and more than 50% of vampire bats can die during an outbreak (Delpietro and Russo, 1996). Reports of rabies in wild species during outbreaks of paralytic rabies are few. The vampire variant of the rabies virus has been isolated from the great fruit-eating bat (*Artibeus lituratus*) and the savanna fox (*Cerdocyon thous*; Delpietro et al., 1997). In this article we report the epidemiology and clinical signs observed with those cases, as well as of other cases of rabies in wild animals observed during outbreaks of paralytic rabies in northern Argentina; in these additional cases virus was not typed.

Observations were made between 1969 and 2006 within the area of reported paralytic rabies in Argentina (Delpietro and Russo, 1996). This comprises the territory located north of parallel 29°S and to the east of meridian 66°W, with an area of approximately 550,000 km^2, including the Provinces of Misiones, Formosa and Chaco, and part of the Provinces of Jujuy, Salta, Tucumán, Catamarca, Santiago del Estero, Santa Fe, and Corrientes (Fig. 1). Wild animals that were paralyzed, or with clinical signs compatible with rabies, such as difficulty walking, opisthotonos, pedaling of posterior limbs, aggressiveness, and fury were found in the vicinity of cattle-raising areas. Samples of brain (and also salivary glands, interscapular fat, and lung in bats) were obtained from dead and euthanized animals. Diagnostic tests included direct immunofluorescence and suckling mouse intracerebral inoculation (Dean and Abelseth, 1973; Kaplan, 1973). Inoculated mice were observed for 30 days, and brains from those showing symptoms were harvested and tested by immunoflu-

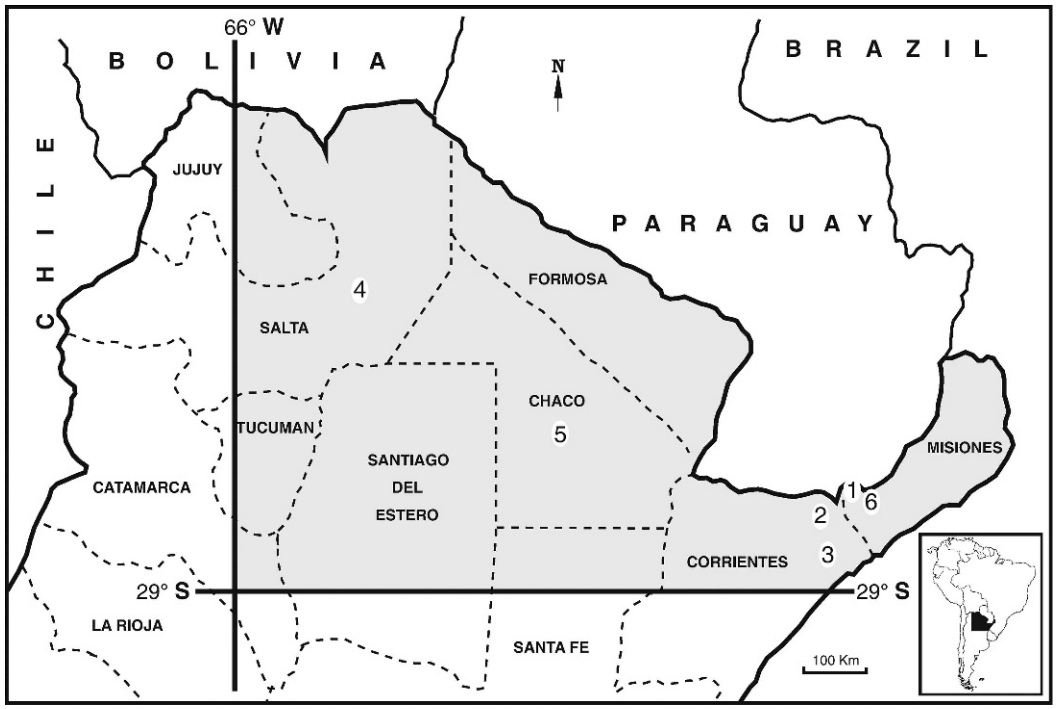

FIGURE 1. Rabies of wild species observed during outbreaks of rabies transmitted by the common vampire bat (paralytic rabies) in Argentina between 1969 and 2006 (dark, dispersion area of the disease). 1 Great fruit-eating bat (*Artibeus lituratus*, City of Posadas, 27°22′S - 55°55′W, August 1969; 2 Marsh Deer (*Blastocerus dichotomus*), Locality of Paso Tirante, 27°37′S - 56°15′W, February 1978; 3 Capybara (*Hydrochoerus hydrochaeris*), Locality of Infrán Cué, 28°10′S - 56°07′W, March 1983; 4 Red Brocket Deer (*Mazama americana*), Locality of Las Lajitas, 24°59′S - 63°34′W, June 1986; 5 Savanna fox (*Cerdocyon thous*), Locality of Las Garcitas, 26°35′S - 59°51′W, July 1993; 6 Great fruit-eating bat (*Artibeus lituratus*), City of Candelaria, 27°29′S - 55°45′W, August 1995.

orescence. In cases observed after 1992, we also characterized the antigenic variant of the rabies virus isolated with the use of monoclonal antibodies to rabies-virus nucleoprotein (Wiktor and Koprowsky, 1978). For these analyses, brain impressions were tested by the indirect immunofluorescence test with a set of 19 monoclonal antibodies, kindly provided by the US/PHS/CDC (Delpietro et al., 1997).

Rabies was observed in five wildlife species, including marsh deer (*Blastocerus dichotomus*), red brocket deer (*Mazama americana*), capybara (*Hydrochoerus hydrochaeris*), savanna fox, and great fruit-eating bat. The initial marsh deer case was observed in February 1978 on the cattle ranch in the Locality of Paso Tirante, Department of Ituzaingó, Province of Corrientes, Argentina (27°37′S, 56°15′W; Fig. 1) where an outbreak of paralytic rabies was occurring in cattle and horses. A group of about 20 wild marsh deer utilized the ranch. A subadult deer was seen alone with difficulty walking and standing; when trying to escape the observer, the animal fell down several times before hiding in nearby tall grasses. Three days later it was found about 200 m from this place, prostrate, with generalized paralysis, opisthotonos, with constant pedaling of the posterior limbs (this produced marks on the ground), abundant salivation, and very difficult and slow micturition; similar signs are observed in rabid cattle (Baer, 1991). The animal was euthanized and rabies virus was isolated from brain. Fresh feeding bites of vampire

bats were seen on this deer and on another deer that died later with similar signs. Mortality due to rabies ceased in cattle in April 1978 (30 days after antirabies vaccination), but continued in the deer until July 1978. The mortality rate in the deer population was estimated to be about 50%. In 1990 (12 yr after the outbreak) the deer population was estimated to be between 12 and 15 animals.

The red brocket deer cases were observed in October 1971 during an outbreak of paralytic rabies in the Locality of Fracram, Departament San Pedro, Province of Misiones, about 26°43′S, 54°08′W, 499 m above mean sea level. Local farmers reported an adult red brocket deer that was prostrate and paralyzed with abundant salivation and another deer with difficulty walking and remaining upright. It was not possible to obtain material for diagnostic testing from these animals. In another case during June 1986 during an outbreak of paralytic rabies of cattle in the Locality of Las Lajitas, Department Anta, Province of Salta, Argentina (24°59′S, 63°34′W; Fig. 1), a subadult red brocket deer was observed prostrate with paralytic symptoms, opisthotonos, very slow micturition, abundant salivation, and with constant pedaling of posterior limbs (the marks in the ground indicated that this animal had remained in this condition for more than 24 hr). The animal was euthanized and fresh bites of vampire bats were observed around the ears; rabies virus was detected in brain. Affected cattle and vampire bats also were observed in this area at the time this deer was observed.

In March 1983, in the locality of Desiderio Sosa, Departament of Santo Tomé, Province of Corrientes, Argentina (28°10′S, 56°07′W; Fig. 1), during an outbreak of paralytic rabies in cattle, a capybara was seen that had difficulty running away, and was falling and dragging its hind legs. Two days later the animal was found dead, partially submerged in mud. Feeding bites of vampire bats were observed on the carcass and rabies virus was isolated from the brain. At that time rabies virus was also isolated from cattle and vampire bats inside this area, but was not reported in other domestic or wild species.

In July 1993, during an outbreak of paralytic rabies of cattle in a rural area in the vicinity of Las Garcitas, Department of Sargento Cabral, Province of Chaco, Argentina (26°35′S, 59°51′W; Fig. 1), a savanna fox was observed with difficulty walking, intense aggressiveness, and fury. The fox attempted to attack people, dogs, and any other moving objects; it was euthanized and the vampire variant of rabies virus was isolated from brain (Delpietro et al., 1997). In August 1969, in the suburbs of Posadas, Province of Misiones, Argentina (27°22′S, 55°55′W; Fig. 1), a great fruit-eating bat was found incapable of flying. It was euthanized and rabies virus was isolated from brain, salivary glands, interscapular fat, and lungs. At that time, rabies virus was also isolated from both cattle and vampire bats from rural areas near the city of Posadas. In another case during August 1995, in the suburbs of Candelaria, Province of Misiones, Argentina (27°29′S, 55°45′W; Fig. 1), a great fruit-eating bat was observed flying at dusk in circles and attacking a group of chickens; it also attacked a dog. This occurred intermittently for half an hour; then the bat fell to the ground, emitting loud vocalizations and beating its wings intensely. The bat died approximately 20 min later. During necropsy, pieces of chicken feathers were found in the mouth and stomach, and rabies virus was isolated from brain and salivary glands. The virus was typed as the vampire variant of rabies virus. Cattle and vampire bat cases were observed in the immediate area and nearby (3,000 m) rural areas.

Although the rabies viruses isolated from the marsh deer, the red brocket deer, and the capybara were not typed (at the time of submission this was not possible), there is epidemiologic evidence suggesting that these species were infected by vampire bats including: 1) the presence of vampire feeding bites on the sick animals, 2) the simultaneous occurrence of outbreaks of

paralytic rabies in cattle (with infected vampire bats) associated with these cases (De Verteuil and Urich 1936; Johnson, 1948; Delpietro et al., 1972, 1985; Smith and Baer, 1988); and 3) lack of reports of rabies in other possible rabies vectors (domestic or wild carnivores). The incubation period for rabies in these species is unknown, but infections were probably not related to the observed wounds inflicted by feeding vampire bats (made no more than 48 hr prior to observation). The abundance of fresh bites in these animals could be related to the inability of affected animals to defend themselves; this is also observed in infected cattle that are paralyzed (Delpietro and La Mata, 1989).

The isolation of the vampire bat variant of rabies virus from the great fruit-eating bat and the savanna fox may be related to aggressive or defensive bites by infected vampire bats rather than feeding; bite wounds were not seen on these species and they are not normal prey species utilized by vampire bats. The ranges of *Desmodus* and *Artibeus* overlap and the vampire bat variant of rabies virus has been previously reported in *Artibeus* in Brazil (Delpietro et al., 1997; Shoji et al., 2004; Kobayashi et al., 2005). On the other hand, the savanna fox is a predator of *Desmodus* (Delpietro et al., 1997) and could be infected by the defensive bite of rabid *Desmodus* (Delpietro et al., 1985). Rabies in other fox and carnivore species due to variants associated with bats have been reported from the USA (Smith 1988, 1989; Shankar et al., 2005; Leslie et al., 2006).

The clinical signs of rabies observed in the marsh deer, red brocket, and capybara were of paralytic rabies, similar to that manifested in rabid domestic livestock (Baer, 1991), whereas the intense fury and aggression observed in the great fruit-eating bat and in the savanna fox was similar to that observed in rabid vampire bats (Delpietro et al., 1985). In accordance with our observations, rabies transmitted by vampires to wild species was not frequent, considering that during the period of the study only six cases were verified from an area of 550,000 km^2 (Fig. 1), where the disease killed an average of 2,960 bovines per year (Delpietro and Russo, 1996). Nevertheless, these observations suggest the utility of increasing epidemiologic surveillance of wild species that live within the area of endemic rabies or in the surrounding region, because some of the observed cases have caused concern either from a conservation viewpoint or because of human health. In the marsh deer a high rate of mortality (50%) was observed, as well as a slow recuperation of the population. The latter could be related to inbreeding (De Oliveira et al., 2005), because these deer constitute an isolated group with little possibility of maintaining contact with other populations. These observations suggest that rabies transmitted by vampire bats could constitute a threat to the survival of marsh deer, especially in those places where reproductive success is normally limited, as occurs in some parts of Argentina (Mares et al., 1989; Dellafiore and Maciera, 1998) and Brazil (Schaller and Vasconcelos, 1978). It should be noted that the marsh deer is considered vulnerable throughout its distribution (Varela et al., 2002). From a human health perspective, rabies in marsh deer, red brocket deer, and capybara does not constitute a major risk. In contrast, rabies in great fruit-eating bats and savanna fox may represent a more immediate risk because of the aggressive behavior and fury they exhibit when infected.

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