

# RABIES IN LATIN AMERICA



**ANDRES VELASCO-VILLA**



# OUTLINE

- Etiology:

- Lyssavirus diversity
  - RABV diversity.
  - Ecological complexity
  - Detection network and typing



- Dog-maintained rabies:

- History
  - Public health impact.
  - Ecological impact
  - Host shifts



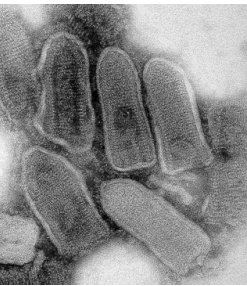
- Bat-maintained rabies:

- History
  - Public health impact.
  - Ecological impact
  - Host shifts



# THE DISEASE

- Rabies:
  - Acute progressive viral encephalomyelitis which can affect all mammals
    - Caused by all members of the *Lyssavirus* genus family Rhabdoviridae.
    - It is an ss-RNA virus order Mononegavirales
    - Fatality rate, one of the highest for infectious diseases
    - Distributed worldwide, with exception of the Antarctica
    - Nearly 70, 000 cases a year most transmitted by dogs to children in Asia and Africa



# LYSSAVIRUS DIVERSITY

Geographical distribution	Lyssavirus species	Bat species most commonly associated with lyssavirus infection	Common name	Transmission from bats implicated in human fatalities
The Americas	Rabies virus (RABV)	<i>Eptesicus fuscus</i>	Big brown bat	Yes
		<i>Tadarida brasiliensis</i>	Mexican/Brazilian free-tail bat	Yes
		<i>Lasiurus noctivagus</i>	Silver-haired bat	Yes
		<i>Perimyotis subflavus</i>	Tri-coloured bat	Yes
		<i>Desmodus rotundus</i>	Vampire bat	Yes
Africa	Lagos Bat Virus (LBV)	<i>Eidolon helvum</i>	Straw coloured fruit bat	No
		<i>Rousettus aegyptiacus</i>	Egyptian fruit bat	No
		<i>Epomorphus wahlbergi</i>	Wahlberg's epauletted fruit bat	No
	Shimoni Bat Virus (SHIBV)	<i>Hipposideros commersoni</i>	Commerson's leaf-nosed bat	No
	Duvenhage virus (DUVV)	<i>Mimiopterus sp?</i>	Undefined	Yes
Eurasia	European Bat Lyssavirus type 1 (EBLV-1)	<i>Eptesicus serotinus</i>	Serotine bat	Yes
	European Bat Lyssavirus type 2 (EBLV-2)	<i>Myotis daubentonii</i>	Daubenton's bat	Yes
	Bokeloh Bat Lyssavirus (BBLV)	<i>Myotis nattereri</i>	Natterer's bat	No
	Aravan virus (ARAV)	<i>Myotis blythi</i>	Lesser mouse-eared bat	No
	Irkut Virus (IRKV)	<i>Murina leucogaster</i>	Greater tube-nosed bat	Yes
	Khujand Virus (KHUV)	<i>Myotis mystacinus</i>	Whiskered bat	No
	West Caucasian Bat Virus (WCBV)	<i>Mimiopterus schreibersii</i>	Common bent-winged bat	No
	Lleida Bat Lyssavirus (LLEBV) *	<i>Mimiopterus schreibersii</i>	Common bent-winged bat	No
Australasia	Australian Bat Lyssavirus (ABLV)	<i>Pteropus alecto</i>	Black flying fox and related sp.	Yes
		<i>Saccolaimus flaviventris</i>	Yellow-bellied sheath-tailed bat	Yes
Sri Lanka	Gannoruwa Bat Lyssavirus (GBLV)	<i>Pteropus medius</i>	Indian flying fox	No



# RABIES VIRUS ECOLOGICAL COMPLEXITY

## Rabies reservoir hosts

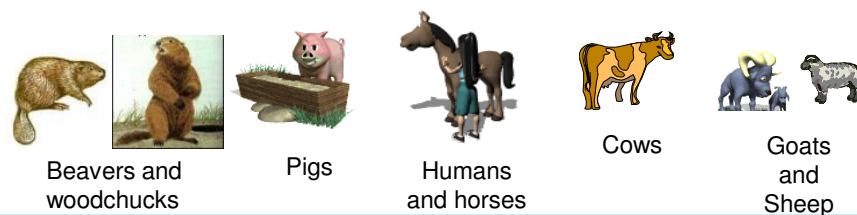


## Vectors



## Susceptible species

### Dead end hosts



Colored bullet shaped rods represent rabies virus variants specifically associated with a particular host



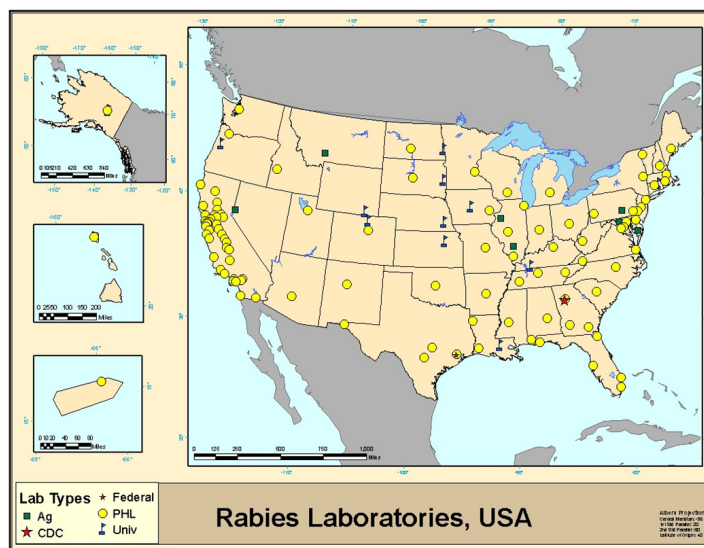


# DETECTION AND TYPING OF RABV DIVERSITY



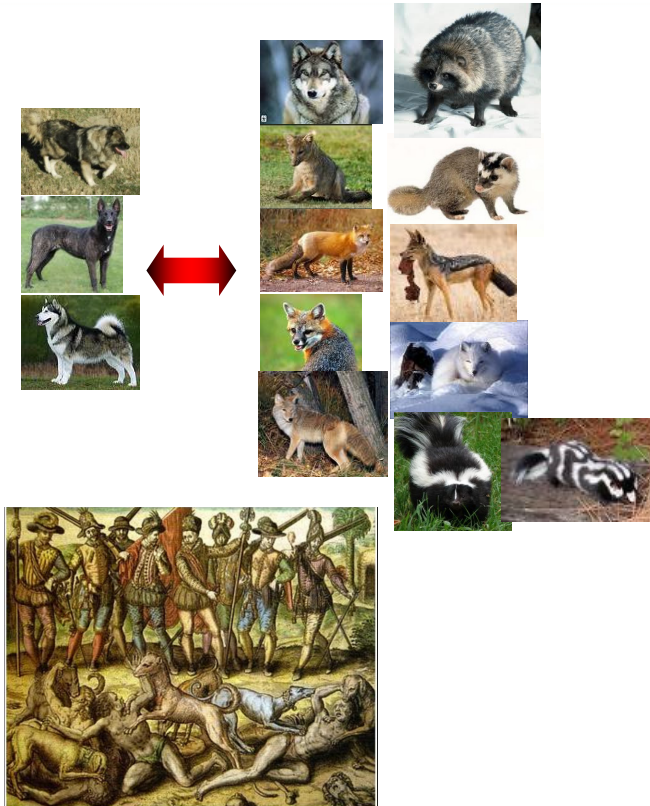
# DETECTION NETWORK IN THE USA AND LATIN AMERICA

- Decentralized Laboratory network
  - Sample extraction
  - Rabies diagnosis
  - Rabies virus typing



# DOG-MAINTAINED RABIES IN LATIN AMERICA: AN IMPORTED PROBLEM

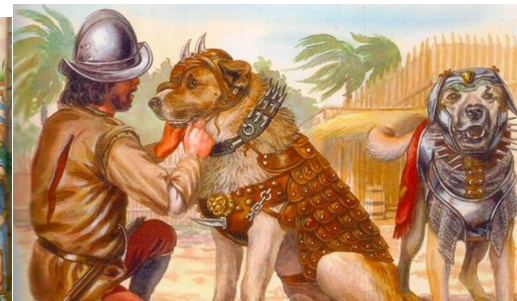
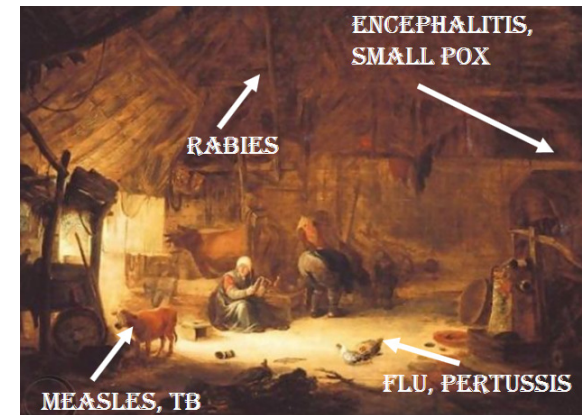
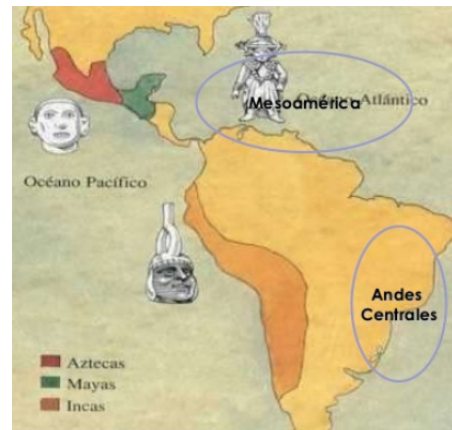
- Recognized since very first human civilizations in the Old World (Origins in the Old World)
  - Epizootic and Epidemic.
  - Does not respect natural barriers
  - Recurrent host shifts into sympatric wildlife (red foxes, raccoon-dogs, ferret-badgers)
- Imported to the Western Hemisphere by European colonizers
  - Epizootic and Epidemic.
  - Does not respect natural barriers
  - Recurrent host shifts into sympatric wildlife (gray foxes, crab-eating foxes, skunks)



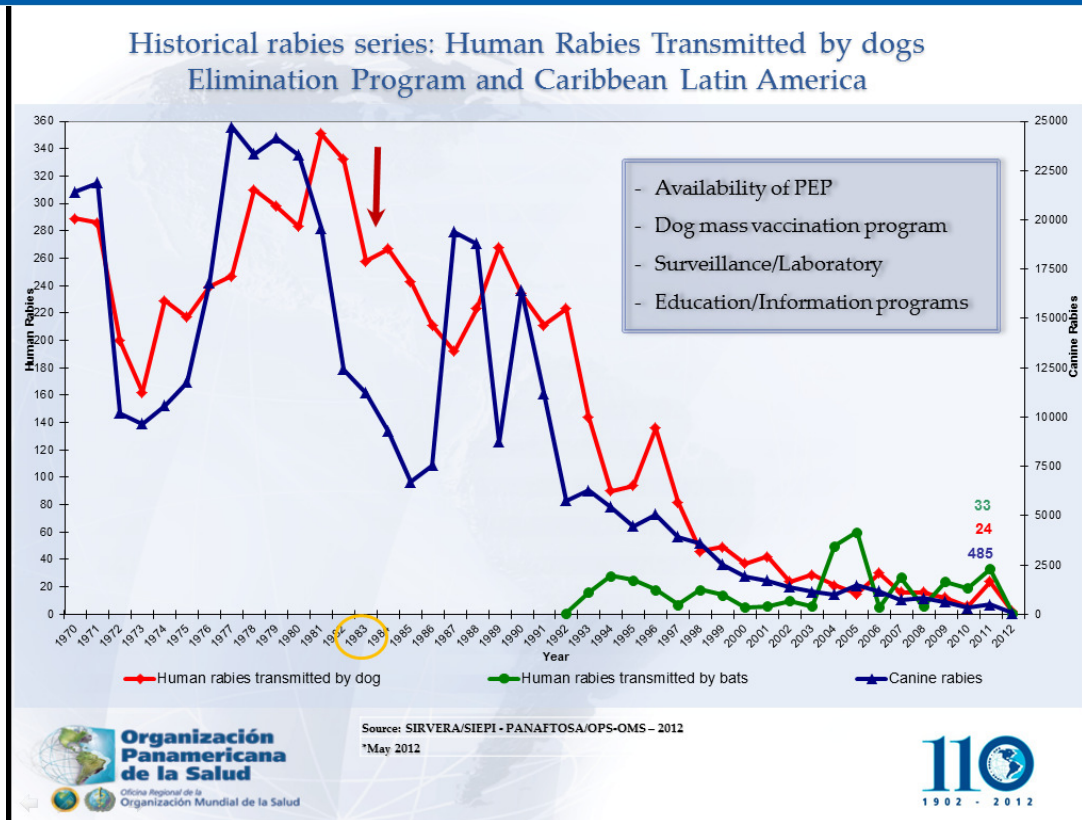


# HISTORY OF THE IMPORTATION OF DOG-MAINTAINED RABIES IN LATIN AMERICA

- Imported by European colonizers
  - Domesticated dogs arrived with first humans 15-18 thousand year ago.
  - No historic records on rabies-maintained and transmitted by dogs
  - Dog populations under control in pre-Colombian Times
  - European colonizers arrived 1492
  - Stray dog populations exploded
  - Trans-Atlantic travel time decreased (8 weeks to 3 days)
  - Likelihood of imported infected animals increased
  - First dog rabies epizootics occurred in 1709, 1776, 1803, 1806, 1835 at Mexico, Greater Antilles, Peru, Argentina and Chile, respectively

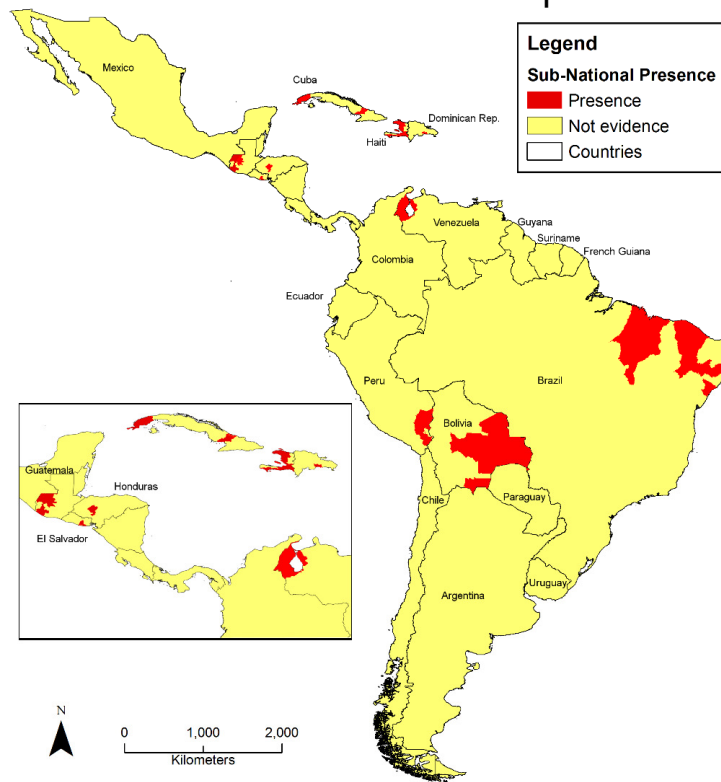


# FIGHTING THE PROBLEM AND DETECTION OF ALTERNATIVE SOURCES



# CURRENT PROGRESS ON THE ELIMINATION

Estimated areas of risk based on data on period 2010-2015

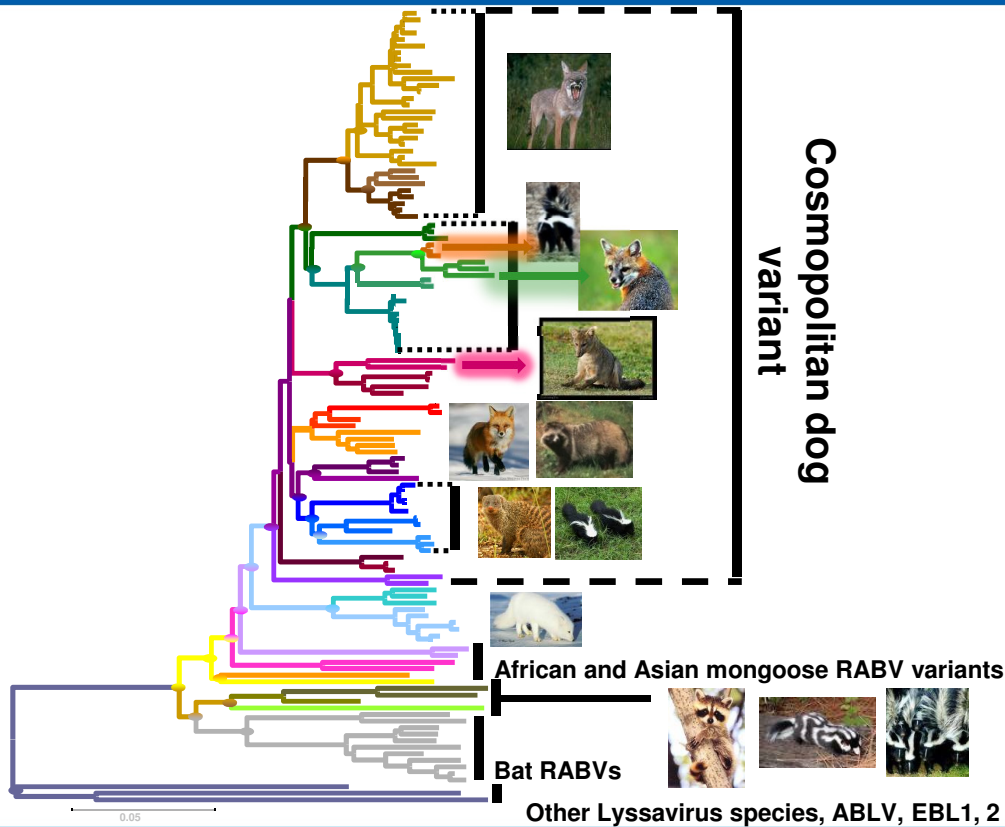


# THE COLLATERAL DAMAGE

- After dog-maintained rabies has been almost eliminated
  - RABV managed host-shifting into diverse terrestrial wildlife while epizootic
  - Recipient host population demographics and ecological drivers critical for the establishment.
  - Host shifts were not noted until dog-maintained rabies was significantly reduced
  - There is no a clear time-line as to when host-shifts could have occurred.
  - Contemporary detection of recurrent host shifts into sympatric wildlife (gray foxes, crab-eating foxes, skunks)



# DOG-MAINTAINED RABIES HOST-SHIFTS INTO TERRESTRIAL WILDLIFE



## Enzootic Rabies Elimination from Dogs and Reemergence in Wild Terrestrial Carnivores, United States

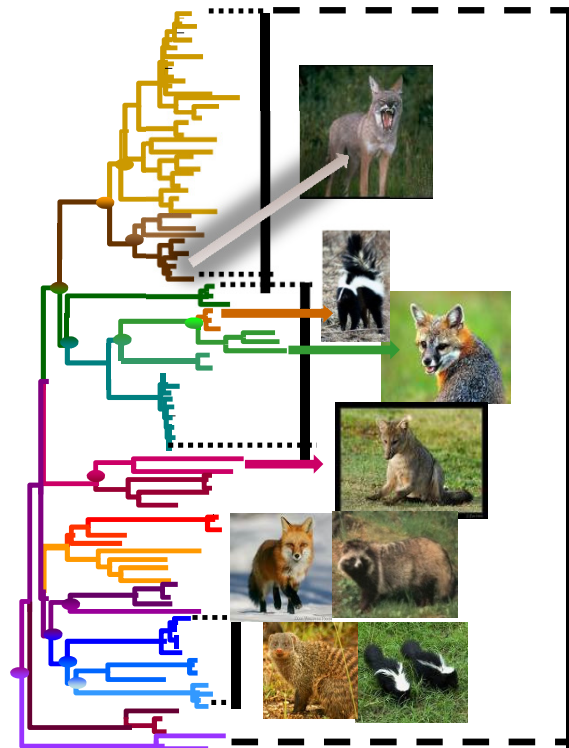
Andrés Velasco-Villa, Serena A. Reeder, Lillian A. Orciari, Pamela A. Yager, Richard Franka, Jesse D. Blanton, Letha Zuckero, Patrick Hunt, Ernest H. Oertli, Laura E. Robinson, and Charles E. Rupprecht



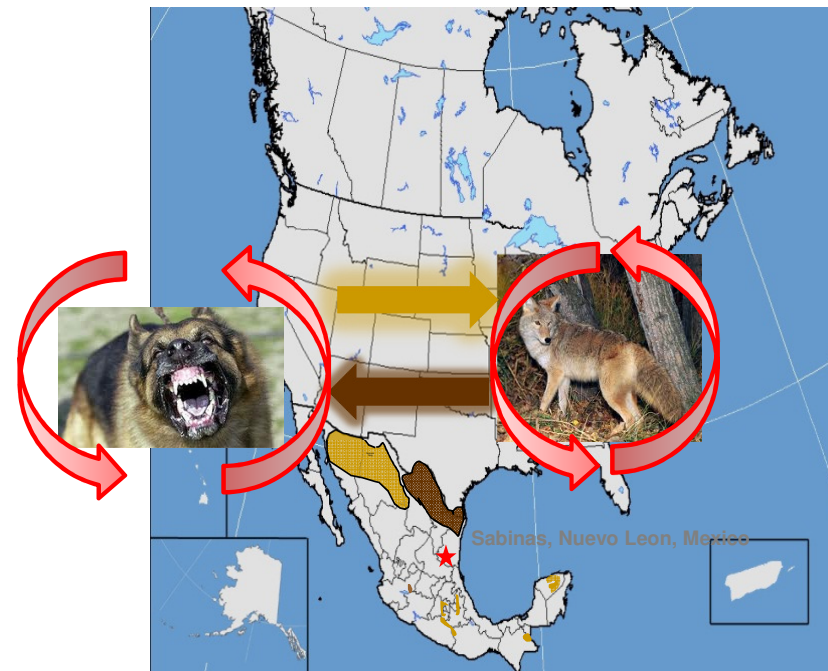


# DOG-COYOTE HOST-SHIFT

- First rabies epizootics in Coyotes reported across California, Nevada, Oregon Utah. USA 1910-1917
  - Texas coyote rabies epizootic first detected in 1988 expanded to Florida in 1994.
  - Eliminated from the USA through oral vaccination in 2007
  - Detected on the Mexico side in 2011



Cosmopolitan dog variant

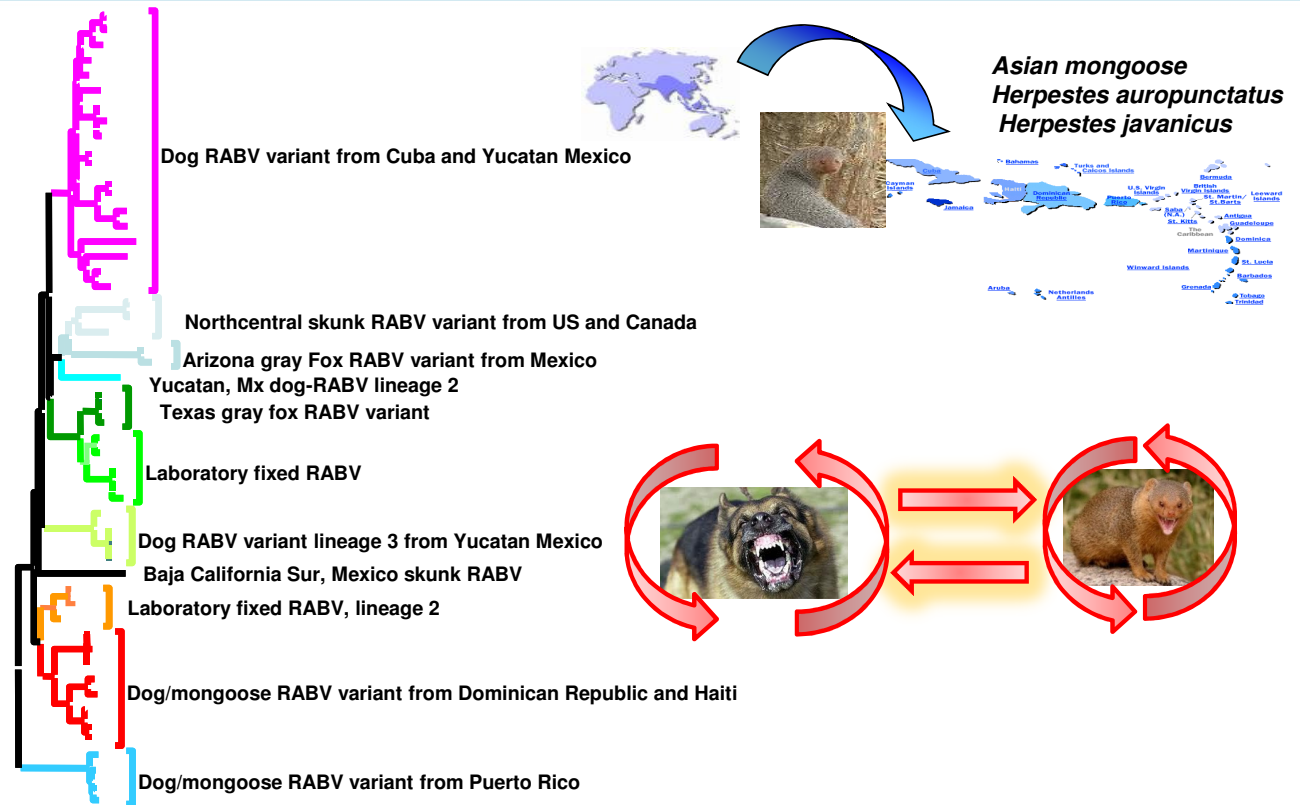


Is this RABV variant perpetuated by the dog or coyote population ???

# DOG-MONGOOSE HOST-SHIFT

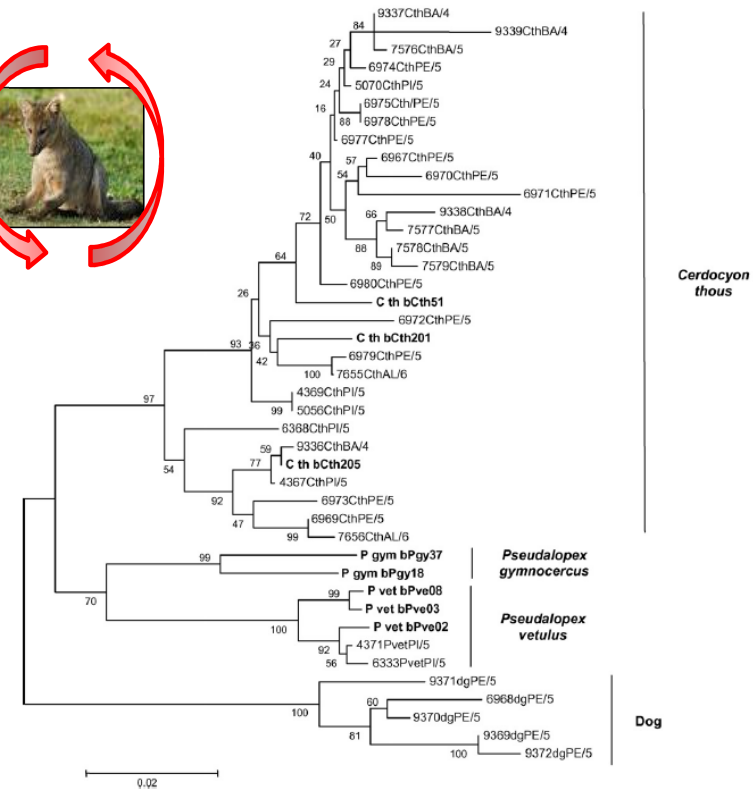
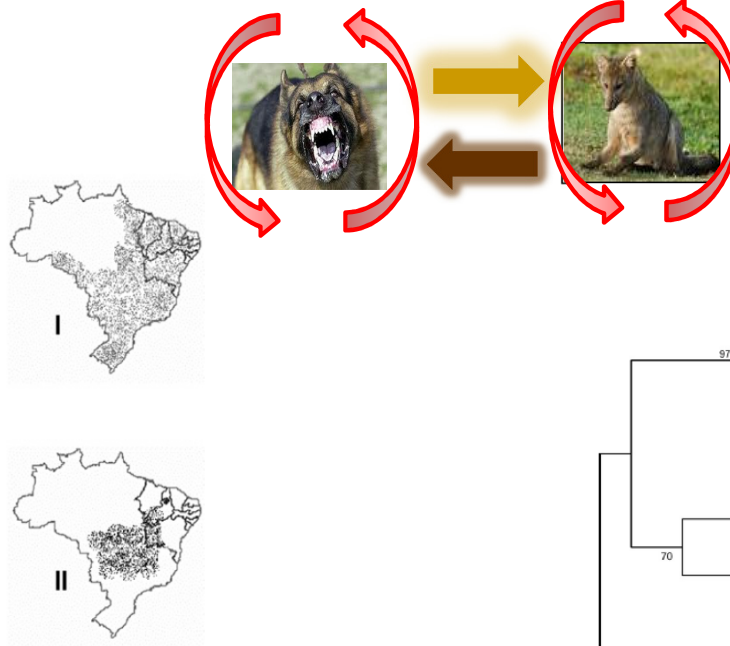
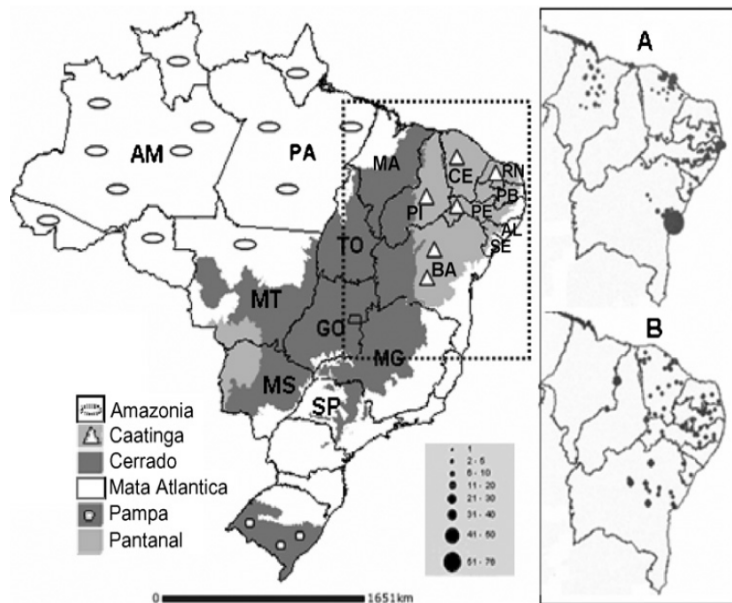
- Indian mongoose introduced in 1870

- Puerto Rico, Cuba, Grenada and Dominican Republic.
- Dog-maintained epizootic rabies in the region since 1776
- First mongoose rabies epizootics in the above countries 1950's

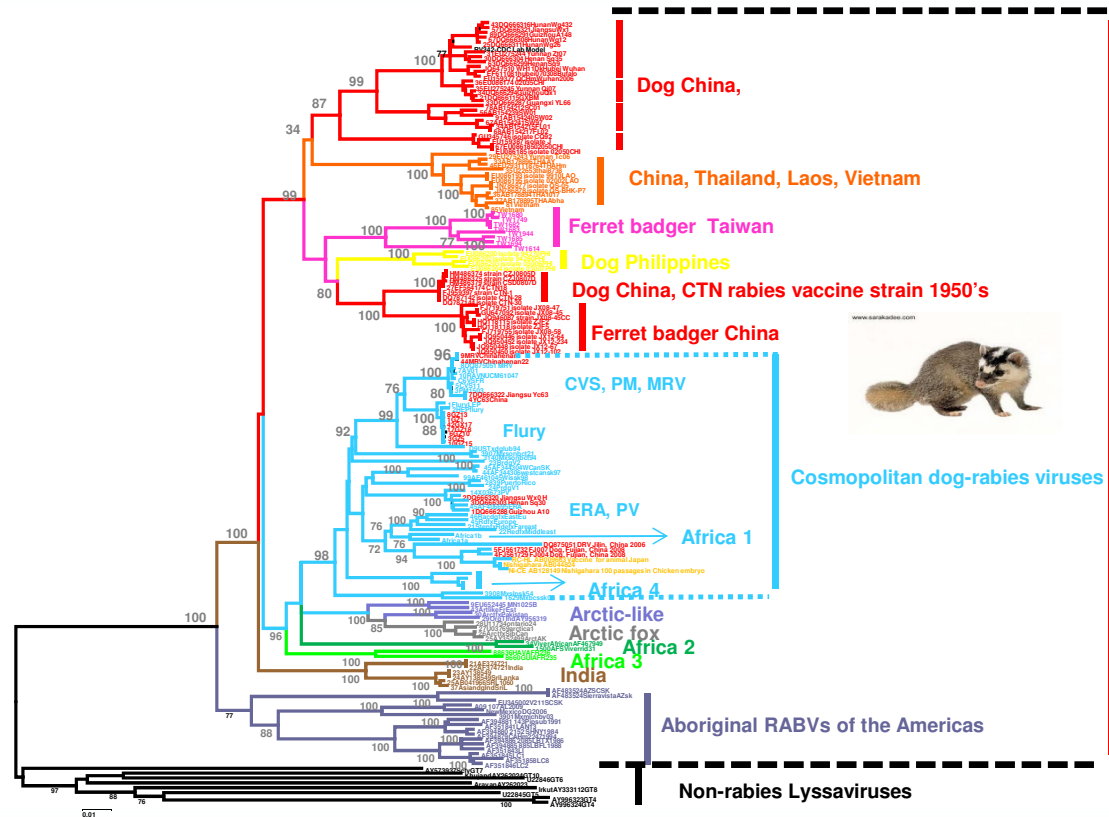


# DOG-CRAB-EATING FOX HOST-SHIFT

*Cerdocyon thous*



# DOG-FERRET-BADGER HOST-SHIFT



Rabies virus, genotype 1  
Rabies species



Cosmopolitan dog-rabies viruses



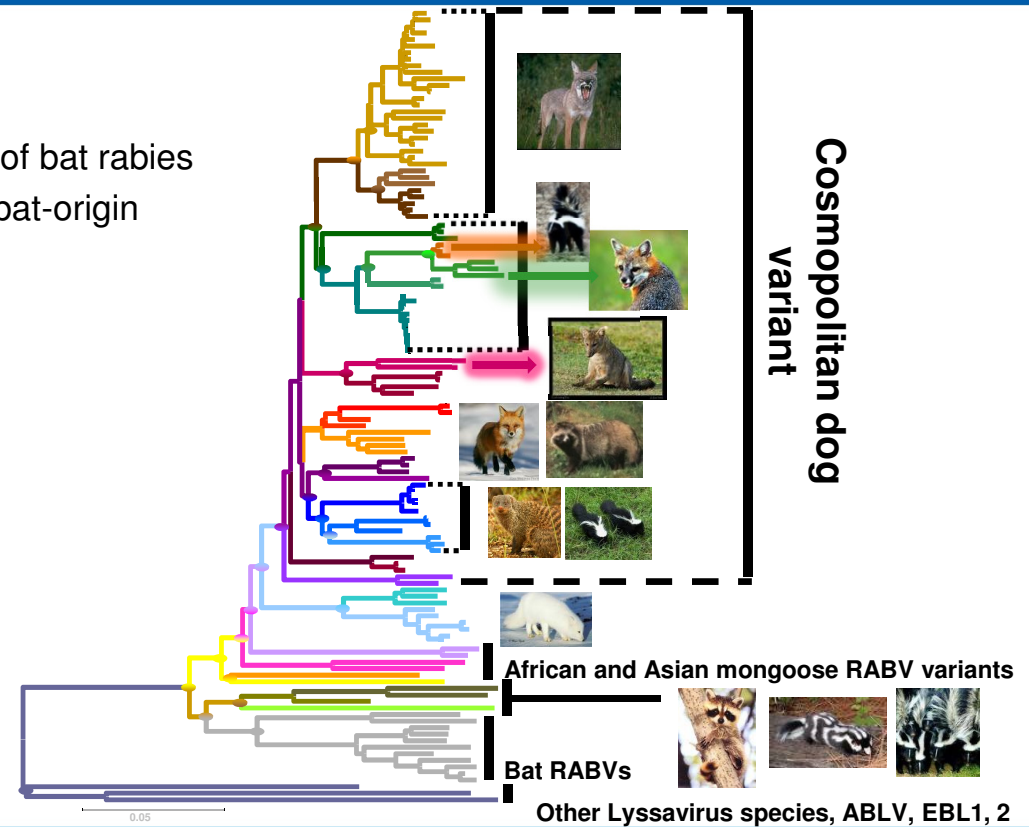
# BAT-MAINTAINED RABIES





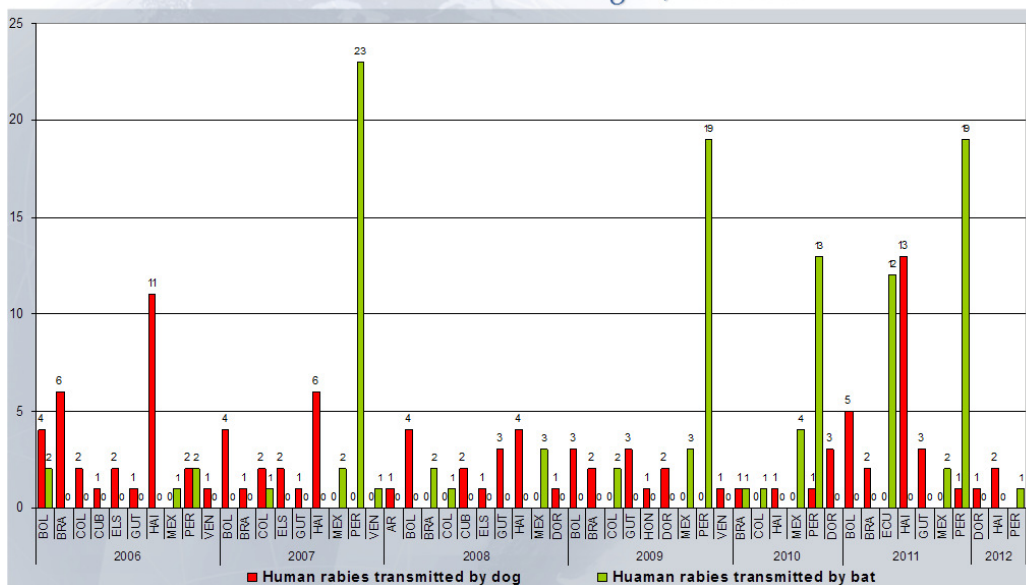
# BAT-MAINTAINED RABIES FROM PRE-COLOMBIAN TIMES UNTIL PRESENT

- Autochthonous
  - Historic evidence since 1516 .
  - In the 1950's terrestrial wildlife was the primary source of bat rabies
  - Terrestrial reservoir hosts whose RABV seem to be of bat-origin



# MOST NOTORIOUS BAT RABIES EPIZOOTIC

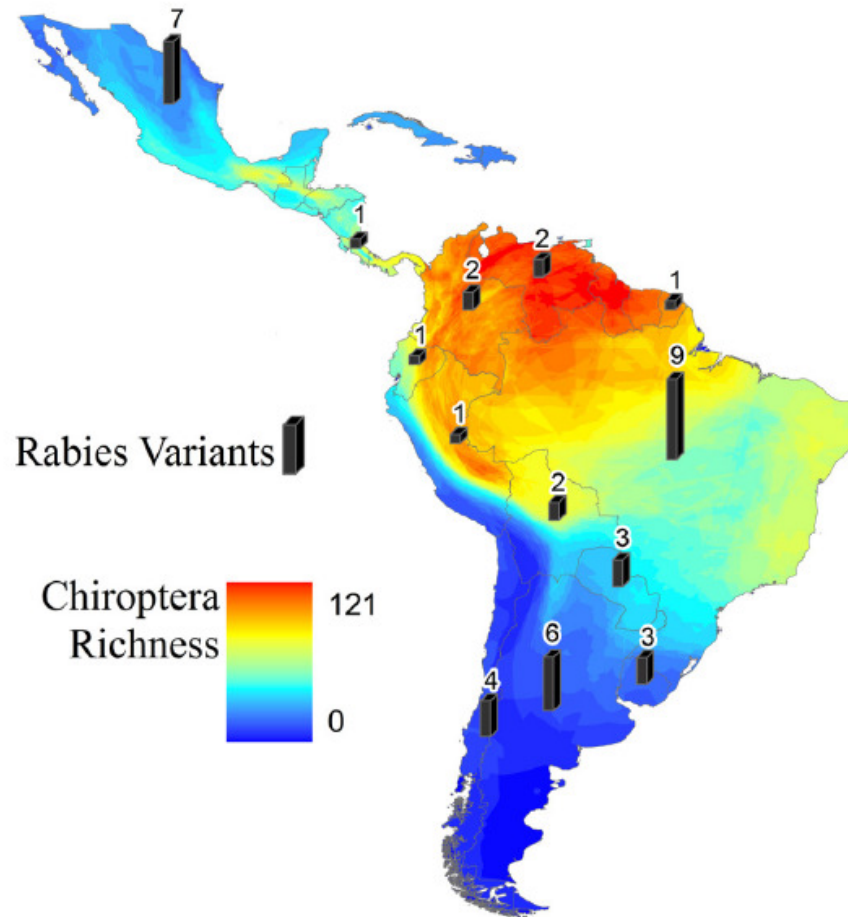
Human rabies transmitted by dogs and bats, at country level, by year in Latin America and Caribbean Region, 2006-2012\*



Source: SIRVERA/SIEPI - PANAFOTSA/OPS-OMS - 2012  
\*May 2012

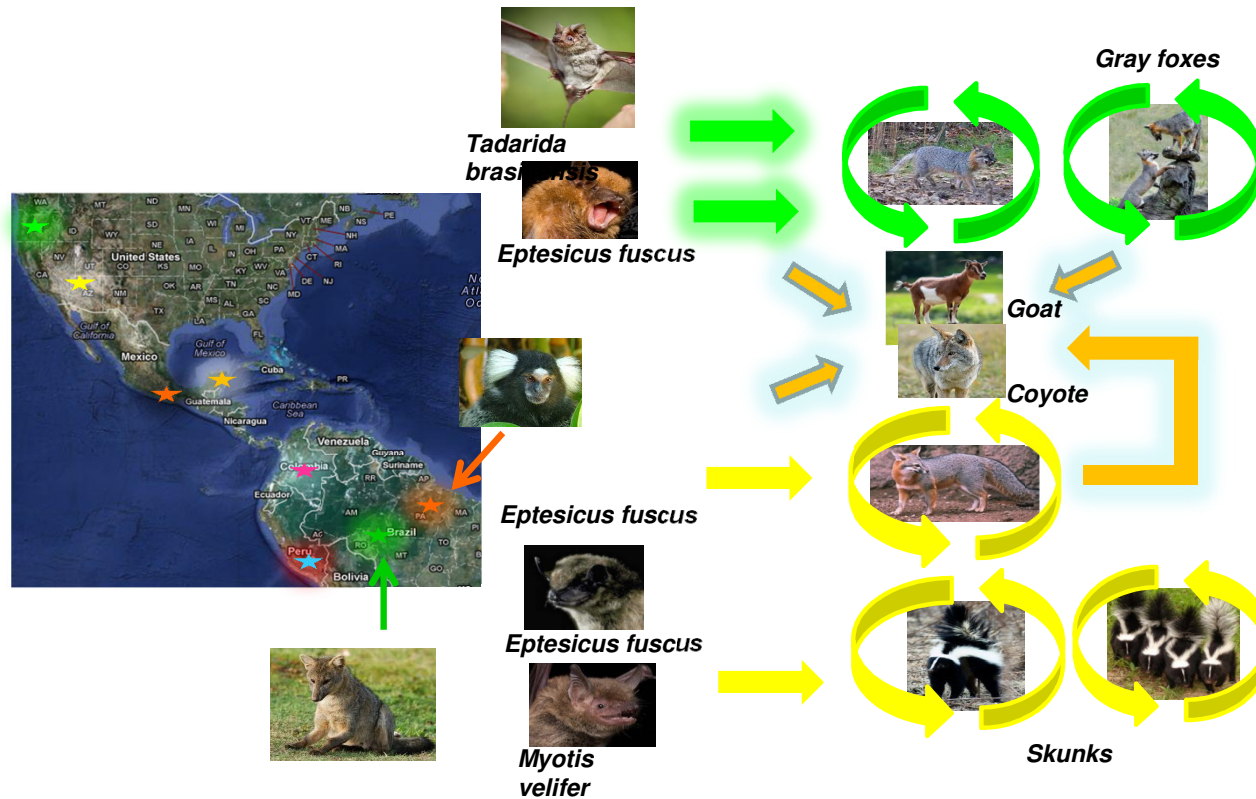


# RABV DIVERSITY IN RELATION WITH BAT DIVERSITY





# RABIES HOST-SHIFTS FROM BATS TO MESO-CARNIVORES

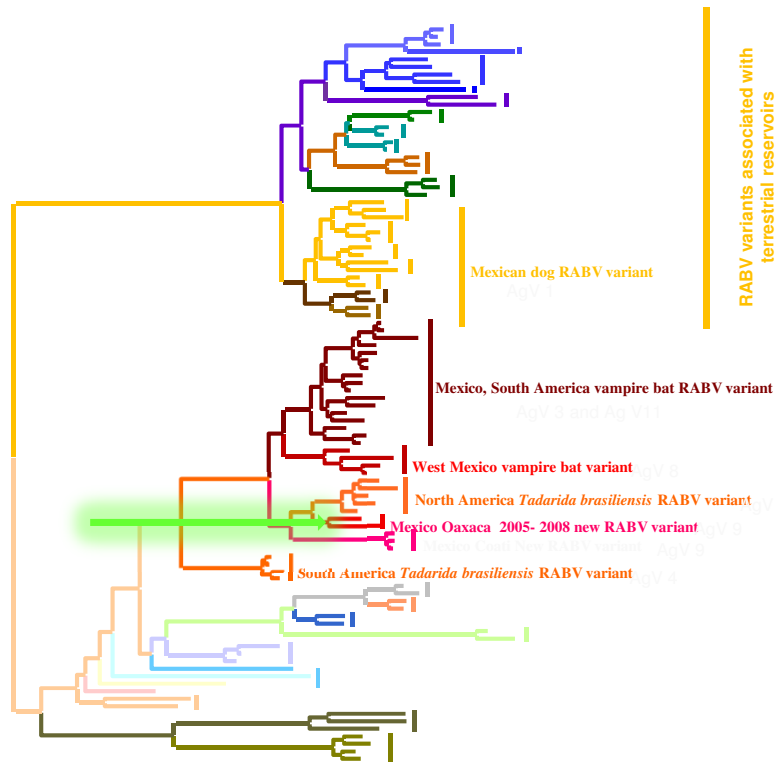


Stars on the left map indicate approximate geographic location of other potential independent events of host shifts throughout the Americas. Events of AZ and OR are the only ones indicated on the right in light green and Yellow, respectively





# HOST-SHIFTS AND PUBLIC HEALTH IMPACT



Free tailed bat



Bat-related RABV variants

## Identification of New Rabies Virus Variant in Mexican Immigrant

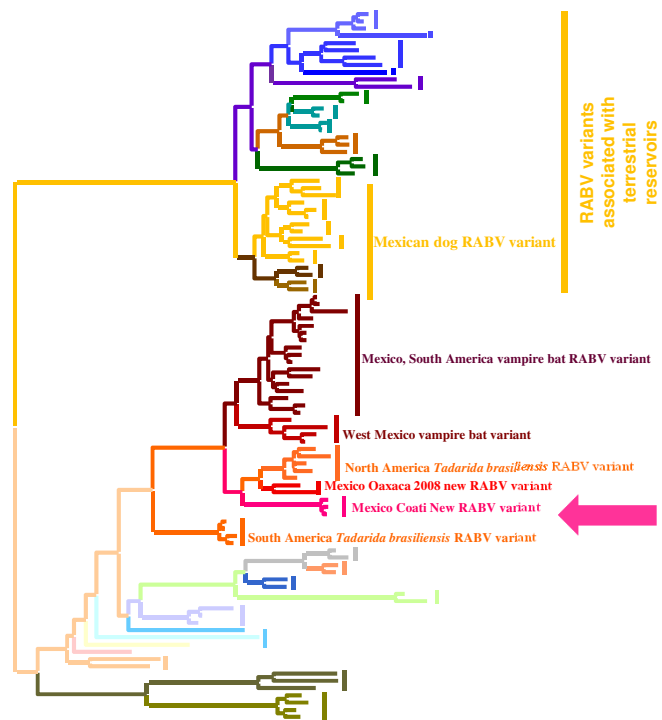
Andres Velasco-Villa, Sharon L. Messenger, Lillian A. Orciari, Michael Niezgod, Jesse D. Blanton, Chris Fukagawa, and Charles E. Rupprecht

A novel rabies virus was identified after death in a man who had immigrated from Oaxaca, Mexico, to California, USA. Despite the patient's history of exposure to domestic and wild carnivores, molecular and phylogenetic characterizations suggested that the virus originated from insectivorous bats. Enhanced surveillance is needed to elucidate likely reservoirs.

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# BAT RABV VARIANT IN COATI



Free tailed bat



?  
*Nasua narica*

*Epidemiol. Infect.* (2010), 138, 1586–1589. © Cambridge University Press 2010  
doi:10.1017/S0950268810000762

## SHORT REPORT New rabies virus variant found during an epizootic in white-nosed coatis from the Yucatan Peninsula

N. ARÉCHIGA-CEBALLOS<sup>1,2</sup>, A. VELASCO-VILLA<sup>3</sup>, M. SHI<sup>1,4</sup>,  
S. FLORES-CHÁVEZ<sup>5</sup>, B. BARRÓN<sup>2</sup>, E. CUEVAS-DOMÍNGUEZ<sup>5</sup>,  
A. GONZÁLEZ-ORIGEL<sup>6</sup> AND A. AGUILAR-SETIÉN<sup>1\*</sup>

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<sup>3</sup> Rabies Program, Pox & Rabies Branch, Division of Viral and Rickettsial Diseases, Centers for Disease Control and Prevention, Atlanta, GA, USA

<sup>4</sup> School of Biological Sciences, The University of Hong Kong, Hong Kong, China

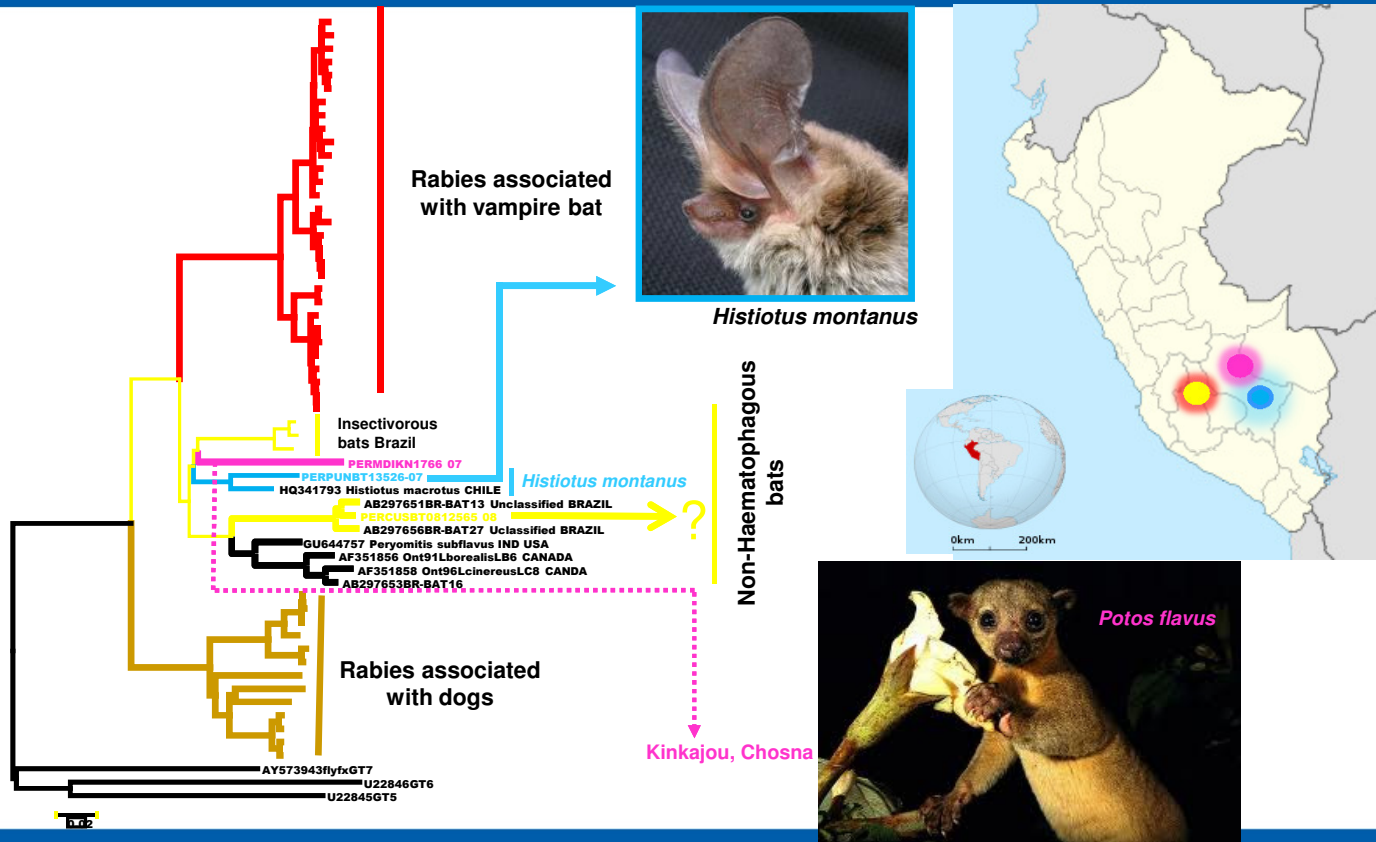
<sup>5</sup> Centro de Instrumentos, Centro Médico Nacional Siglo XXI, Instituto Mexicano del Seguro Social

<sup>6</sup> Dirección General de Vida Silvestre, Secretaría del Medio Ambiente y Recursos Naturales, México

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# BAT RABV VARIANT IN KINKAJOU



Areas colored in the map match colors in the phylogeny on the left