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## HISTORICAL REVIEW

# The occurrence of rabies in pre-Columbian Central America: an historical search

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## SUMMARY

Rabies is considered one of the oldest infectious diseases known to humans. However, the first written reports on rabies cases in the Americas did not appear until the first decade of the 18th century from Mexico. In an attempt to clarify if the disease was already present in pre-Columbian times, we searched for evidence in the Maya and Aztec cultures. Other sources of information were early manuscripts written by the conquistadors and early explorers. We did not identify any unequivocal direct evidence that the disease rabies was known in pre-Columbian Central America but sufficient circumstantial evidence is available suggesting that (bat) rabies was already present in these early times.

**Key words:** Rabies (animal), rabies (human).

## INTRODUCTION

With the conquest of the New World by the Spanish conquistadors in the early 16th century, the Europeans also introduced Old World diseases including smallpox, measles and typhus [1]. For the majority of diseases there is little argument that they were emphatically introduced into the New World from the Old World. However, some of the diseases, for example malaria and yellow fever, are in dispute [2]. It remains also unknown if rabies already occurred in the Americas during pre-Columbian time. The first known written accounts on rabies cases in the New World originate from Mexico in the first

decade of the 18th century [3]. If factual, this would be remarkable. Not only does rabies occur on every inhabited continent; it is considered one of the oldest known infectious diseases to humans in the world. Early accounts from different parts of the Old World are abundant; the first text describing rabies in dogs and the fatal outcome in humans when bitten is the pre-Mosaic Eshmuna Code of Babylon in the 23rd century B.C.:

If a dog is mad and the authorities have brought the fact to the knowledge of its owner: if he does not keep it in, and it bites a man and causes his death, the owner shall pay two-thirds of a mine (40 shekels of silver), if it bites a slave and causes his death he shall pay 15 shekels of silver [4, 5].

Hence, we decided to have a more detailed appraisal of the historical information by examining sources

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used in existing documents on this topic. Furthermore, we searched for direct and indirect clues in documents on two cultures in Central America, the Maya and Aztecs. We assumed that Central America where these indigenous inhabitants originated was the first locality for contact with Europeans in the beginning of the 16th century. This would offer the best starting point for our historical research. During his fourth voyage to the New World in 1502, Columbus landed on the mainland of the Americas at Puerto Castilla, near present-day Trujillo, Honduras. The first indigenous people that he met were Maya or members of a related tribe [6].

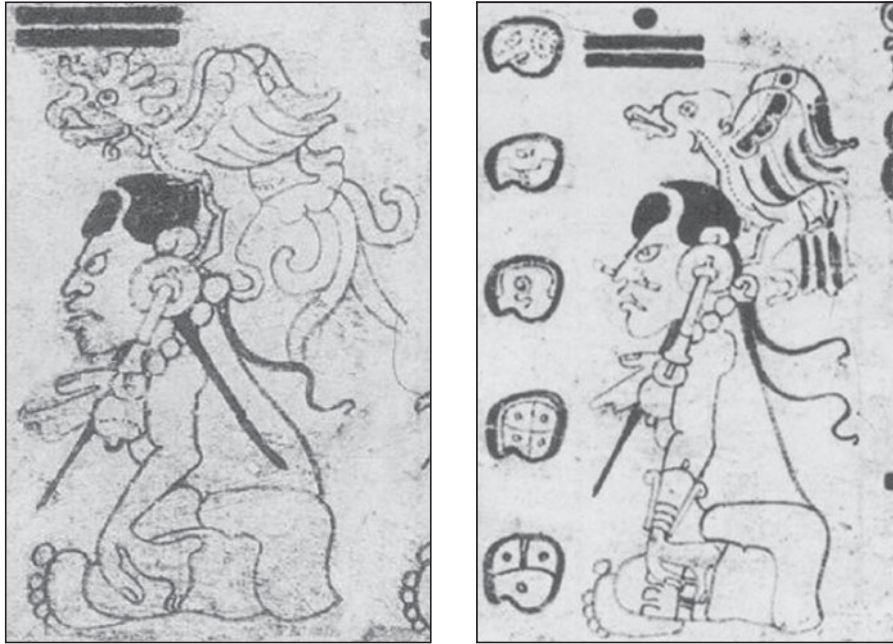
## MAYA AND VAMPIRES

The region inhabited by the Maya extended throughout the Central American region, including the present-day nations of Mexico (Southeastern), Belize, Guatemala and parts of Honduras and El Salvador. Nowadays, the rabies situation in this area is dog-mediated with an independent cycle of rabies in vampire bats in certain regions with the associated transmission to predominantly livestock but also other animals. Up until the mid-1980s, 95% of all cases reported involved dogs that were also responsible for the majority of human rabies cases [7]. In the 1990s, the Mexican government initiated nationwide mass dog vaccination campaigns. Since the inception of the vaccination of dogs against rabies, the rabies situation has changed markedly; dog- and consequently human rabies has almost disappeared and wildlife-mediated rabies, including vampire bat rabies, seems to be responsible for most cases in Mexico nowadays [7]. Unfortunately, in several other Central American countries dog-mediated rabies remains a serious problem. The two important present-day rabies reservoir species in Central America, vampire bats and dogs, were also familiar to the Maya. Both were often recognized in hieroglyphs or figures in several artistic forms, including stone sculptures, ceramics, murals and codices [8–10]. The importance of the bat for the Maya is best reflected in the fact that the fourth month of the Maya year was named after this animal (*Zotz/Zodz*) [11]. There were at least three spatially widely separated Maya clans who worshipped a bat deity [9]. In *Popul Vuh*, a Mayan sacred book containing myth-historical narratives, Camazotz is a bat-like figure that acts as the guardian of the underworld. It kills its victims by decapitation, rather than a bite which would be

expected if it was patterned on a blood-sucking vampire bat. Mostly, bats are shown with the prominent nose leaf distinguishing the New World leaf-nosed bat family Phyllostomatidae. Moreover, the hieroglyph for the month *Zotz* shows the head of the bat with the characteristic nasal appendage. Tozzer & Allen suspected that the Maya most likely used the largest and most abundant of the native bat species for artistic representation [8]. The largest representative of this family is also the largest bat in the Americas, i.e. the false vampire bat, *Vampyrum spectrum* [12].

The Maya was the only pre-Columbian civilization to develop a sophisticated writing system many centuries before the Spanish invaded their territories in the early 16th century. They wrote numerous books, called ‘codices’; unfortunately most of these were destroyed during the attempts to convert the Maya to Christianity. Only four of these codices are known to have (partially) survived to present times; the Madrid Codex, the Paris Codex, the Dresden Codex and the Grolier Codex of which the authenticity remains controversial. Drawings of bats are widespread on monuments and artefacts, but seem to appear in these codices only as sign for the fourth month [13]. Although in the Madrid Codex there appears a bat sign with another sign held in the mouth. Boot translates this sign as ‘man’, and relates this to the killer bats of the *Popul Vuh* [14]. The most complete codex is the 74-page long Dresden Codex. Historians claim that this document printed on fig-bark is the earliest known written book in the Americas and it was most likely written in the 13th century, although recent studies suggest that it is much younger and originates from the 15th century [15]. However, it is believed to be a copy of an original text written centuries earlier. A whole chapter of the Dresden Codex is dedicated to medical almanac. A seated goddess is shown in association with among others various birds and animals, e.g. a screech owl, quetzal, macaw, black vulture, turkey, monkey and dog (Fig. 1). Thompson claims that the goddess shown is ‘Ix Chel’, the moon goddess, a deity of disease (medical matters), floods and pregnancy [16]. The names of some of the animals listed above are also names of diseases or of kinds of fits and madness: *Ah coo akab* (screech owl) means also ‘the one who is mad at night’ [16].

The Maya believed that mental diseases were caused by spirits taking animal forms at night [17]. Although a dog (*pek*) is shown together with the Moon goddess, this animal was apparently not associated with a form of madness since *pek* is also the



**Fig. 1.** Two images of the Dresden Codex showing the seated moon goddess together with two birds representing some kind of illness (source: Sächsische Landesbibliothek – Staats- und Universitätsbibliothek, Dresden; <http://77digital.slub-dresden.de/id28074827/16>).

name for more than one type of skin infection [18]. Unfortunately, the goddess is not shown together with a (vampire) bat, which would be an interesting observation from a perspective for evidence of the presence of rabies. It seems that certain categories of diseases were controlled by distinct deities. So, the fact that rabies or a rabies-like disease is not explicitly described in the Dresden Codex is not evidence that the disease was not known about; it could have been the ‘responsibility’ of another deity not described in this particular Codex.

Another source is the ‘The Ritual of the Bacabs’. This manuscript contains more than 40 curative incantations in the Mayan language and it is assumed that it was recorded in the late 18th century [19]. However, it is considered that the information this manuscript contains is much older. A search of this manuscript revealed the word ‘coil’ in one of the chants that had been translated as ‘rabid’.

CAN TIPTE TU NAK UNIC LAE; HACH UTZ LAE

Zam tun bacin in chucech  
 Cen a na, cen a yum  
 Cech Zacal Can Tiptte be chee  
 Cech Chacal Can Tiptte be chee  
 Max bin ve chee cech ocic kin be chee ahic cabe chee  
 Cech u *coil* al be chec, u *coil* chab be chee

FOR SNAKE INTESTINAL PAINS IN A PERSON'S STOMACH; VERY GOOD

Shortly therefore I seize you  
 I who am your mother, I who am your father

Oh you White Snake intestinal pains  
 Oh you Red Snake intestinal pains  
 Oh who are you at sunset, oh at dawn  
 Oh are you the *rabid* child, the *rabid* creation

If this chant originates from pre-Columbian times, it would indicate that rabies was known. However, it can not be excluded that the meaning of the word ‘coil’ has been interpreted by the translator as ‘rabid’ but could just as well been replaced by the term ‘mad’ or ‘furious’. There are medical texts that come from at least the 18th century in which the word ‘*co(o)il*’ is applied specifically to rabies: U Chibal can ua cooil pek – The bite of a snake or a mad dog [18]. Unfortunately it is difficult to date these texts precisely in order to be able to say with certainty when the usage of ‘coil’ pertaining to rabies began in the Yucatecan Mayan language. In examining the old Yucatecan Mayan dictionaries the first time that the term ‘rabies’ referring to the disease is listed is in *Diccionario de la Lengua Maya* (1877) by Juan Pío Pérez (1798–1859) with the following entry: ‘coil-pek: perro con rabia (dog with rabies)’. Older Spanish–Maya or Maya–Spanish vocabularies from the 16th and 17th centuries do not contain a specific word for the disease rabies. We therefore must conclude that the term ‘coil’ in ‘The Ritual of the Bacabs’ has the meaning of ‘mad’ or ‘furious’, and does not have the meaning of being infected with rabies.

## AZTECS AND DOGS

When the Spanish conquistadors set out to conquer the New World, the cultural peak of the Maya was already over. In fact, many Mayan cities in the Yucatan area were already deserted. Another regional power had established itself to the North in nowadays Central Mexico; the Aztecs. The distribution map of the vampire bat and the areas inhabited by the Aztecs showed no or only limited overlap. Hence, it seems more logical to identify clues associated with dog-transmitted rabies than for rabies in bats in pre-Columbian Aztec culture. Actually, the earliest Meso-American remains of domestic dogs were from the Tehuacan valley in Central Mexico [20]. The dog was very abundant in this region and was also partially used as a food source. Fray Diego Duran mentioned that at the time of the conquest hundreds of dogs were for sale at the market of Acolman near the pyramids of Teotihuacan in Central Mexico [21]. The Aztecs did not have a written language as the Maya did but shortly after the conquest of their empire by the Spanish, books and other documents appeared describing the daily life of Aztecs. These books were sometimes written by Spanish, but also by indigenous people educated by the Spanish. Aztecs were renowned for their medical skills; Spanish soldiers who accompanied Cortez in his conquest of Mexico are known to have preferred Aztec physicians to their own practitioners. The first herbal and medical text known to have been written in the New World was actually written in Nahuatl, the Aztec language, by Martin de la Cruz, an Aztec physician at the College of Santa Cruz, in Tlatelolco [22]. The Latin translated version known as the Codex de la Cruz – Badiano was sent to Spain in 1552 and it contains pre-Hispanic remedies for many ailments. Unfortunately, there is not one recipe that clearly indicates a remedy against rabies. This is in contrast to Viesca, who mentioned that the pre-Hispanic Nahua (Aztec) used the meat of buzzards, in broth, with all its feathers, as a remedy for rabies [23]. Interestingly, the previously mentioned Mayan recipe against the bite of a rabid dog also describes the use of feathers and blood of a turkey-like bird [18].

Another important document on Aztec beliefs and customs and the natural history of Central America was written by Bernardino de Sahagun, a Franciscan friar who arrived in Tenochtitlan in 1529, 8 years after the conquest. He learned Nahuatl and interviewed the surviving Aztec priesthood. His findings were

recorded in the invaluable work entitled ‘Historia General de las cosas de Nueva España’; better known as the Florentine Codex. In these manuscripts there seems no mention of a rabies(-like) disease. In the special volume on the Mexican fauna there is also no special chapter or paragraph dedicated to (vampire) bats although specific chapters and paragraphs are devoted to animals like opossum and scarlet macaw. Although, the Aztecs also associated the bat with the cult of death and human sacrifice, it must be concluded that (vampire) bats did not have such a prominent role in the Aztec culture as the dog. In the late 16th century the monumental work of the Francisco Hernandez, ‘Historia de los animales de la Nueva España’ appeared. In this work, there is no explicit report of rabies, although the author was a physician and must have had experience with this disease, because dog-mediated rabies was widespread in Spain around 1500 [24].

Except for the reference in form of a recipe written down by Viesca, there is no drawing or written evidence that (dog) rabies was known to the Aztecs at the time of the conquest. The recipe described by Viesca implies that the pre-Columbian Aztecs were familiar with the disease rabies [23]. The Aztecs did not have a written language and consequently this recipe must have been orally transmitted from generation to generation before it was finally recorded in post-Columbian times. In the first comprehensive dictionary published in the New World ‘Vocabulario en lengua castellana y mexicana’ (1571) by the Franciscan priest Alonso de Molina, already several words in the Nahuatl language associated with rabies are listed (the Spanish word for ‘rabies’ in the 16th century was not ‘rabia’ but ‘rauiā’); *rauiā* (ytzcuintlaelilocayotl), *rauioso* (ytzcuintlaelililoc), *rauiar* (itzcuintlaelililoc). These Nahuatl terms are based on the two words *Itzcuintli* (dog) and *Tlaelililoc* (bad, roguish, deformed). In the Siméon Dictionary (1885) these same words in the Nahuatl language associated with rabies are listed and described in more detail: *Itzcuintlaelililoc* (dogs with hydrophobia, rabid, dangerous), *Itzcuintlaelilocayotl* (hydrophobia, rabies), *Itzcuintlaelillocati* or *Oitzcuintlaelililocat* (to have hydrophobia, rabid).

## EARLY COLONISTS AND EXPLORERS

A problem with rabies is that it is a disease without clear distinct symptoms that does not show any resemblance to clinical signs induced by other diseases;

therefore no pathognomonic symptoms as a unique identifier of rabies are available. So, if the disease occurred in Central America but was not very common in relation to other diseases it may have gone unnoticed or misdiagnosed. However, c. 1500 (dog) rabies was rampant in Spain and the conquistadors and early explorers would have been cautious with respect to rabies. Therefore, the travel journals and related documents of these early explorers form a potential reference source. In 1552, Francisco Lopez de Gomara mentioned that rabies was not present in the New World [25], but he had never visited the Americas himself and his work has been criticized for being full of inaccuracies. In 'Historia General de las Antillas' by Jean Baptiste Du Tertre (1688) a disease affecting the dogs in present-day Haiti is described that according to the author resembled rabies. However, this diagnosis has been questioned by others [25]. The absence of rabies was also noticed by the early medical colonists of New Spain. Juan de Cardenas dedicated a whole chapter on why animals in the New World never get rabies, predominantly as a result of certain prevailing climatic conditions [26]. Interestingly, in several papers this statement was erroneously claimed to be made by the viceroy of Mexico, Don Louis de Velasco [25, 27]. The first written accounts on rabies from the New World date from early 18th century, almost 200 years after the Spanish entered the mainland of the New World. Unfortunately, there is no consensus on who reported the first cases from Mexico. One source mentions that Reverend Lucio Marmolejo reported a case in 1709 [28], others claim that Fray José Gil Ramirez wrote about rabid dogs and foxes from Mexico in 1709 [29]. Actually, Fray Ramirez was involved in a dispute if rabies in humans was a punishment of God; the minutes of this argument have been written down in the Ramo Inquisition papers; Archivo General de la Nacion. Ramo Inquisicion, Galeria, 743(3), 444–459 (2 April 1709) and 742(21), 546–554 (22 August 1709). Based on these documents, Tellez Giron concluded that rabies was present already in 1709 but may have been earlier [30]. It is probable that the above described religious dispute supports the account that after a priest reported rabies to his superiors in 1703, he was subsequently admonished by his superiors in Spain who dismissed the notion that rabies was a problem in the New World [31]. In 1712, Juan de Esteyneffer dedicated a chapter on dog rabies and another on human rabies in his book 'Florilegio medicinal de todas las enfermedades' published in

Mexico [25]. So, when rabies was reported for the first time remains debatable but we can safely state that dog rabies was present in Mexico during the first decade of 18th century. A simple explanation on the origin of these early rabies cases could be the introduction of rabies-infected dogs or other animals from the Old World [32, 33]. The average time to cross the Atlantic Ocean during the 16th and 17th centuries was approximately 5 weeks; much shorter than the upper limit of the rabies incubation period.

Other researchers have suggested that rabies was already present during colonization in the 16th century [32, 34]. According to Koprowski the first indirect description of rabies in the Americas was in the book *De Rebus Oceanicis et de Orbi Novi Decades Octo* by Petrus Martyr D'Anghera (1516–1525) and quotes:

In several places bats not much smaller than turtle doves used to fly at them in the early evening with brutal fury and with their venomous bites brought those injured to madness ... [and] ... They say that large bats, not smaller than turtle doves, come in from the marshes on the river and attack our men with deadly bite [35].

As observed with the old texts from the Maya, translation is often also a matter of interpretation. If we compare these two quotes with the translation from MacNutt the terms 'madness' and 'deadly' are replaced by the more harmless descriptions 'desperate' and 'painful', respectively:

and in many places bats as large as pigeons flew about the Spaniards as soon as twilight fell biting them so cruelly that the men, rendered desperate, were obliged to give way before them as though they had been harpies ... [and] ... In the night-time bats swarmed from the marshes formed by this river, and these animals, which are as big as pigeons, tormented the Spaniards with their painful bites [36].

However, in the continuing section, also in the translation of MacNutt, it is stated that people did die as a result of these bites:

when asked by me concerning the danger of such bites, told me that one night, when he slept uncovered because of the heat he had been bitten by one of these animals on the heel, but that the wound had not been more dangerous than one made by any other non-poisonous creature. Other people claim that the bite is mortal, but may be cured by being washed immediately with seawater [36].

Molina Solis mentioned that during the conquest of Yucatan led by Francisco Montejo in 1527 the soldiers and their pack animals were also attacked by bats, sucking their blood while sleeping [37]. This can only apply to vampire bats, but there is no mentioning

of a fatal outcome of these bite wounds. However, a more 'promising' reference can be located in De Oviedo dated 1526:

Many Christians have died till they learned the simple but effective treatment against bat bites from the natives. The treatment was to cauterize the wound with a piece of hot ember or to wash it thoroughly with warm water [38].

Also Girolamo Benzone described in his 'La Historia del Mundo Nuovo' (1565) how he was bitten in his toes by bats while he was asleep in what is present-day Costa Rica [39]. From these early accounts, it is clear that people were bitten by (vampire) bats and that these wounds could be fatal. However, because there are no detailed descriptions of clinical symptoms, we cannot be certain that these deaths were a result of a rabies infection. Bats in these regions are known to transmit many different, sometimes fatal, diseases to humans. Furthermore, many animals bitten died as a result of a secondary infection. Humboldt (1850) had already described this:

Enormous bats suck their blood like vampires during their sleep, or attach themselves to their backs, causing festering wounds, in which mosquitoes, hippoboscuses and a host of other stinging insects, niche themselves [40].

Furthermore, since these early days, the death of horses and cattle that died after being bitten by vampire bats was often mistakenly attributed to loss of blood [41]. The many accounts of these early explorers do not give a conclusive answer; people were bitten by vampire bats, sometimes with fatal outcome, but no description is given on the clinical signs of such fatal cases.

## DISCUSSION

In this study we focused preliminary on Central America and we have not established any evidence that rabies occurred in pre-Columbian times in this part of the continent. However, the absence of any empirical evidence is not sufficient proof that rabies was not present, especially considering the enormous amount of manuscripts written during the first decades after the arrival of the conquistadors that were either destroyed or lost or have not been reviewed in this study. The fact that vampire bats can transmit rabies virus to cattle and humans has been known since the 1920s [42, 43]. However, only in the late 1940s it was shown that derriengue, a highly fatal paralytic disease of cattle that had been prevalent in the Pacific coast of Mexico for the previous 40 years,

was actually caused by rabies virus [44]. This clearly shows that although the disease rabies was present in cattle, it was not identified as such. Another example is rabies in insectivorous bats in America and Europe. The first cases were observed on both continents in the 1950s. Recent phylogenetic studies have clearly shown that rabies in insectivorous bats is much older than these first cases indicated [4, 45]. Hence, lyssaviruses must have been circulating undetected in American and European bat populations long before they were identified as such. Death as a result of a bite from a vampire bat was already known to the very first conquistadors. The fact that these bites of vampire bats were not linked to rabies could be due to possible different clinical manifestations induced by rabies virus variants associated with vampire bats (usually paralytics) instead of dog rabies variants (more furious) [41]. The early colonists, including physicians, may simply not have recognized the disease rabies transmitted by vampire bats as such just as with derriengue. Hence, based on the circumstantial evidence provided here we conclude that (vampire) bat rabies was already present in Central America in pre-Columbian times.

It is assumed that due to recent ecological changes, contact between bats and humans (and their pets and livestock) has increased in many areas explaining the increase in emerging zoonotic diseases caused by viruses like rabies with bats as reservoir species [46, 47]. This is exactly what occurred with rabies in Central America. Before the arrival of the Spanish in the early 16th century, vampire bats were relatively rare and rabies incidence in the vampire bat population was most likely also very low; comparable with the low incidence of bat lyssaviruses nowadays in Europe. Spillover infections from vampire bats to humans or dogs would have occurred sporadically and the link between death and the vampire bite would not have been made. It was only after the arrival of Spanish and their livestock that the vampire population was able to grow exponentially; livestock provided vampire bats with a new, sustainable and almost limitless food supply disrupting the ecological balance causing a substantial growth in numbers of vampires [48]. Subsequently, rabies cases transmitted from vampire bats to humans and their domesticated mammals increased. Sustained rabies spillover infection from bats to terrestrial mammals can occur, as has recently been shown for skunks in Arizona [49]. However, on most occasions these rare spillover infections from bats to terrestrial mammals are

dead-ends without epidemiological relevance [33, 50]. Therefore, the spread of terrestrial rabies in the New World was predominantly a result of the importation of rabies-infected animals from the Old World and subsequent sustained spillovers in local dog and terrestrial wildlife populations.

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George M. Baer (1936–2009) was unfortunately not able to witness the fruits of his enthusiastic support and contributions. He was not only a great rabies expert but also had extensive knowledge of the history of ‘his’ Mexico.

## DECLARATION OF INTEREST

The co-author, A. R. Fooks, is an associate editor of *Epidemiology and Infection*.

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