

# "Human and Armadillo Leprosy"

An Interpretive Summary

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- 1 in 6 armadillos found in Texas and Louisiana coastal marshes harbor leprosy
- The disease may be completely absent among animals in better drained areas
- Leprosy has evolved among armadillos by natural means and is likely present among armadillos in similar environments in other countries
- Human and armadillo leprosy infections show similar environmental tendencies in their geographical distribution
- Some cases of human disease probably result from zoonotic transmission from armadillos, but the real risk for leprosy infection through contact with armadillos seems to be extremely low. At this time, most people in the U.S. still appear to acquire their disease mainly through contact with infected family members

Wild armadillos (*Dasypus novemcinctus*) are highly endemic natural hosts of leprosy. This sylvan infection was first identified in 1975 but its origins, range and risks have been unclear. The following is an interpretive summary of our studies addressing those issues.

Armadillos are not native to the U.S. but began slowly expanding their range north from Mexico around 1880. Today they are found from Argentina to Colorado and southeast to the Florida panhandle. They are present on many Caribbean islands and several pairs were accidentally introduced into the state of Florida beginning around 1925. These animals established a second U.S. population, which now ranges as far north as the Carolinas, and merged with the main group around Appalachicola, Florida in 1985.

Earlier investigators detected leprosy in armadillos by examining histopathological sections of their ear tissues for acid fast bacilli in dermal nerves. Using this test, between 2-5% of the animals in Texas and Louisiana appear to be infected; but little evidence for armadillo leprosy is found elsewhere. Outside the U.S., only 2 leprosy infected armadillos have been found in Argentina and 1 in Mexico.

This ostensible restriction lead some early scientists to speculate that armadillos might have acquired leprosy only after expanding their range to the U.S., perhaps through contact with untreated human cases here; or through some inadvertent environmental contamination of the population on the part of leprosy researchers.



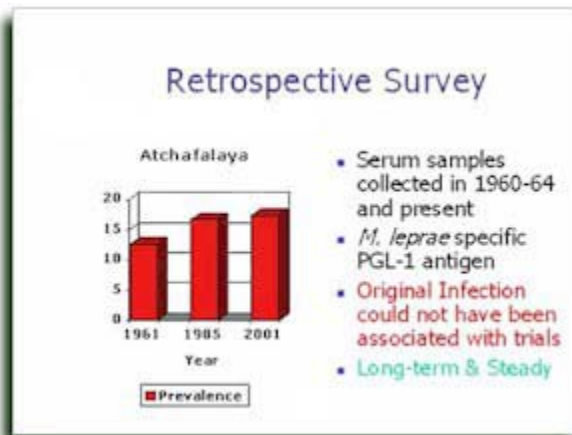
Histopathological examination of ear tissues is really one of the least sensitive methods to detect armadillo leprosy. Our studies have shown that *M. leprae* disseminate to ear tissues only shortly before an armadillo succumbs to leprosy. Serology is much more sensitive. We use an ELISA for IgM antibodies to the phenolic glycolipid-1 (*PGL-1*) antigen of *M. leprae*. These antibodies arise in a third the time required for *M. leprae* to become manifest in ear tissues and are detectable at an average bacteriological index (*BI*) of only 0.2 (about 1 bacterium in 500 microscopic fields). In screening, though, we commonly use a sensitivity that corresponds to a 1.0 *BI*. There appears to be a marked increase

in IgM to PGL-1 at this level of infection and nearly all (98%) of the experimentally infected animals that reach it eventually die from complications due to leprosy. Thus, surveys for PGL-1 IgM antibodies in armadillos are somewhat different than serological surveys for other disease agents. We mainly identify established active infections.

To determine if armadillo leprosy originated through natural or accidental means, we examined sera taken from wild armadillos in years predating the animal's use in leprosy research. These samples were collected in 1960-1964 as part of a survey for leptospire in Louisiana wildlife. They were stored frozen at Louisiana State University for 25 years prior to our study. We found that 14% of these sera had antibodies to PGL-1. Therefore, leprosy must have evolved in armadillos by natural means and could not have been the result of accidental experimental contamination by

researchers who only started using armadillos in 1968. To better understand just when armadillos became infected and what impact they have on man, we launched a more extensive investigation.

We surveyed armadillos at locations across the south-central U.S. and in Argentina and Grenada. By the end of the field studies we had sampled more than 1400 armadillos and evaluated their population characteristics in many sites. Antibody prevalence rates in Louisiana averaged 15%. Leprosy is a slow chronic disease which manifests itself mainly in adult armadillos. In repeat observations in one site where armadillos were originally sampled in



• Serum samples collected in 1960-64 and present

• *M. leprae* specific PGL-1 antigen

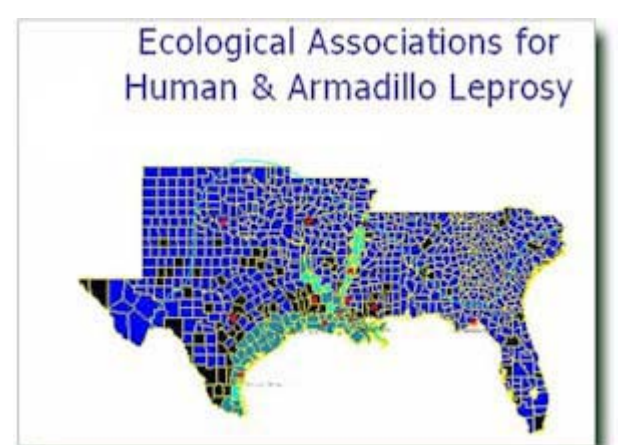
• Original Infection could not have been associated with trials

• Long-term & Steady



remote sensing environments

remote sensing environments

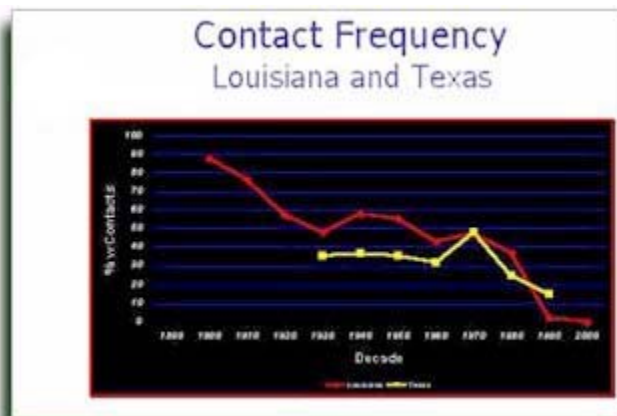


1960-64, we found that prevalence rates fluctuate significantly in different seasons. These changes are caused by certain behavioral characteristics of armadillos. Rates are lowest in the spring when adult females sequester themselves during parturition and nurturing of their newborns, but they return to higher levels in the summer. This behavior temporarily removes a large proportion of the affected individuals from the population and influences the detectable rate of disease.

It seems likely that since the age structure of animal populations change in different habitats, age structure differences between armadillo groups in different locations may have erroneously contributed to many earlier speculations about geographic trends or clusters in armadillo leprosy. We used the progesterone concentration in plasmas obtained from animals during different seasons to confirm these changes in age structure, and developed this technique as a means for age correcting prevalence rates observed in different locations. We found that the real prevalence of leprosy remains constant within armadillo groups during different seasons. It had not changed significantly in this particular location for more than 30 years. Over a similar environmental area extending from north Louisiana to southern Texas, 30% of the adult armadillos have leprosy. Long term steady maintenance of a high rate of disease over a large geographic area suggests that armadillos have harbored *M. leprae* for several generations. They are well adapted natural hosts. To determine the actual extent of the infection, we examined armadillos from the ends of their range in Florida, Mississippi, Oklahoma and outside the U.S. in Argentina and Grenada. We found evidence for armadillo leprosy everywhere except for among the animals in Oklahoma and those arising from Florida.

Hence, armadillo leprosy is actually quite widespread. It is unlikely to have originated from some hypothetical U.S. nidus within recent history and can be viewed as an indigenous infection of armadillos. Leprosy was unknown in the new world prior to the immigration of European settlers. Armadillos may have acquired the disease from man but they probably first encountered *M. leprae* many years ago in any number of more highly endemic foci than the U.S. If so, they could have repeated the event many times over the years and might even be continuing to share *M. leprae* with man in some regions today. Under such circumstances one would expect to find a wide distribution to the infection, but with higher prevalence rates in areas conducive to leprosy transmission or susceptibility.

Significantly higher prevalence rates are found among armadillos in low lying poorly

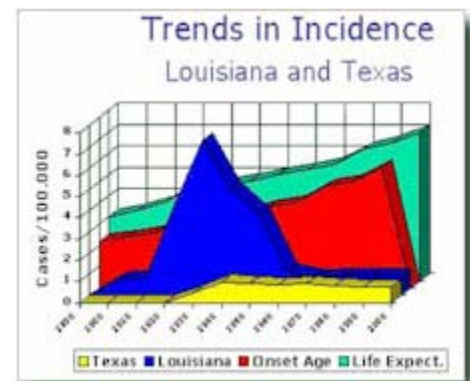


drained environments than in others. These environments are easily recognized using modern AVHRR satellite images and are seen to form a contiguous habitat system extending through Louisiana and coastal Texas. Antibody prevalence rates in the bottom-land hardwood alluvial and coastal habitats we examined in Louisiana and Texas range between 18-25%. But they were only 5-8% in rolling woodland areas of Louisiana and Mississippi, and fewer than 1%

(none detected) of the animals in drier regions of central Texas and Oklahoma appear to be infected. We do not know why an obligate intracellular parasite like *M. leprae* might have environmental tendencies in its disease distribution and hope our future studies will reveal this important information. Presently though, armadillos should be viewed as a large natural reservoir of *M. leprae*. Leprosy infected armadillos shed *M. leprae* to their environment and even casual association with armadillos can expose a person to *M. leprae*. The raw organ flesh or blood of infected armadillos contains large numbers of leprosy bacilli and contact with armadillos from some low lying environments in Louisiana and Texas may present some increased risk for human infection, although the disease remains very rare and all such risks would be really quite low.

The U.S. is not a leprosy endemic country. Most of our patients acquired their disease while abroad, but we do have 30-40 new indigenous cases each year among native-born citizens in Texas and Louisiana. This incidence is fewer than 1/100,000 and even if all of those cases were attributed to armadillos the absolute risk value for infection would be quite low. The disease is believed to be transmitted directly from man-to-man. The odds for family contacts of leprosy patients to develop leprosy are thought to be 3-10 times higher than for those of other people.

To help understand the impact that infected armadillos may have on man, we reviewed the historical incidence of leprosy in Louisiana and Texas since 1894. The data show a changing epidemiological profile. From the time, when armadillos fully populated the state (*Louisiana, 1957*) the incidence rate has remained low but constant. While leprosy was once a disease of families, it is now being acquired increasingly from other sources in the community. None of the Louisiana cases presenting in the last 14 years could recall ever having contact with another person who had leprosy, and, there has been marked geographic dispersion of the infection. The absolute odds for a person developing leprosy in Louisiana are very low but are 4 times higher for people in low lying poorly drained areas than in others. The timing and pattern of disease dispersion corresponds with the armadillo's migration and their present density in the state.



The impact of infected armadillos is difficult to discern. Surveillance data reported to the National Hansen's Disease Registry (*Baton Rouge, Louisiana*) shows that about a third of all leprosy patients acknowledge some sort of contact with armadillos. Patients presenting from Louisiana and Texas are significantly more likely (55%) to report contact with armadillos than patients presenting from other states. Certainly, the size of the armadillo reservoir alone suggests that these animals could contribute to some cases of human infection; but the incidence of leprosy in the US remains quite low and has not increased even in face of growing numbers of armadillos. Two case-control studies comparing the armadillo contact history reported by U.S. leprosy patients presenting from areas known to harbor either high or low rates of armadillo leprosy failed to show that direct contact with armadillos was an important risk factor for infection. A third case-control study found a higher risk for lepromatous

type leprosy among certain Mexican born leprosy patients in the United States who acknowledged some former exposure to armadillos in Mexico. However, the rate of leprosy infection among armadillos in Mexico has not been determined.

The majority of U.S. cases continue to be among immigrants and nationals who lived in endemic areas abroad, or who others have other family members with the disease. The role that armadillos might play in helping to perpetuate leprosy in this hemisphere merits consideration, but they may be of only secondary significance in the epidemiology of disease in this country. Really much more intriguing, are the apparent environmental trends seen in the geographical distribution of leprosy in man and armadillos. Leprosy occurs sporadically in all states. The disease was brought to the new world by European settlers and Africans being traded as slaves. In most places autochthonous transmission ceased after about a generation but it has persisted in coastal regions of Texas and Louisiana since at least 1768. Also recent arrivals to this country, armadillos expanded their range through the western Gulf States in the late 1950's and today the geographical distribution of leprosy in armadillos is very similar to the distribution seen for man.

What is it about these environments that so much favor leprosy? In addition to prospects of zoonotic transmission, these data might also suggest some mutually enhanced susceptibility to leprosy for both man and armadillos in certain environments, or the possibility for transmission of leprosy to both man and armadillos from third reservoirs in those environments. Armadillos are a unique parallel population, which supports autochthonous transmission of leprosy. A better understanding of factors which influence their susceptibility to leprosy or which can interrupt the transmission of *M. leprae* among armadillos could significantly benefit our ability to control leprosy in man.

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