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# Leptospirosis in the Azores: the Rodent Connection

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**ABSTRACT:** The Azores are Portuguese islands in the North Atlantic Ocean. The culture is very agrarian with a large cattle industry. Unfortunately, there is a chronic leptospirosis problem within the people, livestock, companion animals, and wildlife of the Azores. Introduced rodents play a significant role as maintenance hosts of this disease. We review the situation and make recommendations for reducing the occurrence and hazard of leptospirosis in the Azores. Areas addressed include the need for a better understanding of the epidemiology of the disease and the role of rodents, development of an effective rodent control program, improvements in farm practices and animal husbandry, and improvements in the Azores infrastructure to effectively reduce the leptospirosis hazard.

**KEY WORDS:** Azores, disease, house mouse, leptospirosis, livestock, *Mus musculus*, rat, *Rattus norvegicus*, *Rattus rattus*, wildlife disease

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## INTRODUCTION

The U.S. government maintains a military refueling base in the Portuguese Azores. It also has a cooperative agreement with the autonomous regional government of the Azores to strengthen the economic and social development of the Azores. Through the Azores Cooperative Initiatives Program, a Technical Working Group has made several trips to the Azores to develop strategies to address matters of mutual concern, such as health and safety, education, and agriculture. One project area identified for further investigation involves the infectious bacterial disease, leptospirosis. In this paper, we discuss the occurrence of leptospirosis in the Azores and the involvement of free-ranging wildlife. We also discuss potential strategies to help alleviate this chronic disease problem.

## OVERVIEW OF LEPTOSPIROSIS

Leptospirosis (also called Weil's disease, after the person who first described the pathogenic organism in 1886) is an infectious disease of humans and animals caused by seven antigenically distinct members (serovars) of the spirochete bacterium *Leptospira interrogans*. The disease occurs worldwide and it is believed that most species of mammals can be infected by one or more serovars. Usually, one to a few species of animals are considered the maintenance hosts for each of the infectious serovars (Bolin 2000). In the U.S. and its territories, these species include cattle, horses, pigs, dogs, raccoons, skunks, opossums, muskrats, rats, and mice. Other countries may have several of the same maintenance hosts plus additional ones (e.g., mongoose in the Caribbean and on Fiji, possum and hedgehog in New Zealand, and European badger in Europe). Rodents are often implicated in the occurrence of leptospirosis and some rodent species maintain the disease within their populations, with no apparent illness, even at low

densities (Faine et al. 1999). Maintenance (reservoir) hosts have the characteristics of efficient transmission between animals, a relatively high (30-50%) incidence of infection, production of chronic rather than acute disease, and persistent infection in the kidneys (Bolin 2000). Diagnosis of infection in maintenance hosts is often difficult because of the relatively low antibody response and the presence of few *Leptospira* organisms in host tissues. Incidental (or accidental) hosts, on the other hand, often have relatively low susceptibility to infection but show acute symptoms and high pathogenicity, sporadic transmission within the host species, and only a short phase of kidney infection.

In livestock, leptospirosis can cause abortion, stillbirth, weakness among neonates, reduced milk production, and death. In humans, the disease can cause diarrhea, chills, vomiting, myalgia, kidney damage, and occasionally, death. Various antibiotics are used to treat infected humans, and the severity of the disease is generally much greater if not treated promptly. In some countries, vaccines are available for humans, dogs, and livestock. The pathogenic organism is easily killed by disinfectants, heat, desiccation, and pH conditions below 6 or above 8.

Transmission of leptospirosis can occur through direct contact with an infected animal or its urine, placental fluids, or milk. Infection can also occur through exposure to a contaminated environment, and particularly to water containing *Leptospira* organisms. Entry into the body can occur via abraded skin, mucous membranes, consumption of contaminated meat or water, and inhalation. Once the bacteria enter the body, there is an incubation period of about 10 days. The bacteria multiply and circulate throughout the blood system causing an antibody response that generally clears the organisms from the body except for certain sequestered sites (kidneys, eyes, urogenital tract, central nervous system)

where the infection can persist for a long period of time.

The occurrence of this disease is strongly influenced by climate, the indigenous fauna, and agricultural practices (Faine et al. 1999). The organism survives well (6 weeks or more) in warm, moist conditions, and hence the disease is endemic to many tropical countries. In temperate regions, occasional outbreaks (epidemics) of leptospirosis occur. The pathogenic organism survives well in warm, neutral or slightly basic waters, and so epidemics (such as the one in Nicaragua in 1995; Trevejo et al. 1998) often occur after flood events. Certain professions (slaughterhouse workers, banana cutters, rice and sugarcane harvesters, cattle farmers, sewer workers, field biologists) and activities (swimming, rafting, camping, hunting and fishing) also put persons at higher risk. Reviews of leptospirosis have been provided by Bolin (2000), Faine et al. (1999), and Leighton and Kuiken (2001).

### SITUATION IN THE AZORES

The Azores archipelago is a group of nine inhabited volcanic islands in the North Atlantic Ocean. Administered as an autonomous region within the Portuguese Republic, it is endowed with its own parliament and government. The islands comprise a land area of about 2,340 km<sup>2</sup> and are located about 1,500 km west of Lisbon and about 4,000 km east of New York City. The highest elevation occurs on the island of Pico (2,351 m at Mount Pico); elevations on the other islands do not exceed 1,130 m. The shorelines of most islands are craggy on the western and northern sides with gentler slopes on the eastern and southern sides. About 250,000 people inhabit the islands, with about 50% of the population located on the two large islands, Terceira (401 km<sup>2</sup>) and Sao Miguel (774 km<sup>2</sup>). The climate is characterized by low thermal amplitude and high precipitation and humidity. The mean annual temperature is 17.5°C, ranging between 10°C in winter and 25°C in summer. Average rainfall ranges from 752 mm on Sao Miguel to 2,386 mm on Terceira. A "cloud-zone forest" occurs at high elevations, saturating the air and soil with moisture.

Vegetation is luxuriant, covering essentially all land that is not paved or built upon. The native flora has been largely replaced by introduced plant species. Lower elevations are covered primarily with herbaceous plants (grasses, forbs) with relatively little coverage by woody species (trees, shrubs). Forest and shrub cover is extensive at higher elevations, where Japanese conifer (*Cryptomeria japonica*) and eucalyptus (*Eucalyptus* spp.) trees predominate.

The only native mammals on the Azores are two species of bats (*Myotis myotis* and *Nyctalus azoreum*) (Mathias et al. 1998). In addition to livestock, many species of mammals have been accidentally or purposefully introduced, including domestic dogs (*Canis familiaris*), domestic cats (*Felis catus*), black rats (*Rattus rattus*), brown rats (*Rattus norvegicus*), house mice (*Mus musculus*), European hedgehogs (*Erinaceus europaeus*), European rabbits (*Oryctolagus cuniculus*), least weasels (*Mustela nivalis*), and European ferrets (*Mustela furo*)

(Mathias et al. 1998). Also present on the Azores are many species of birds, both native and introduced, including birds of prey (hawks and owls).

The islands are very pastoral. Most towns are small and are located at low elevations (<250 m) along the perimeter of the islands where relatively fertile soils occur. The mild maritime climate supports an agrarian culture with a wide variety of crops (e.g., clover, corn, beans, chicory, bananas, pineapples, oranges, wine grapes, tobacco, and tea). Most rural and many urban families have small vegetable gardens. At higher elevations, cereal crop (e.g., wheat) production and pasture for livestock are predominant land uses. Although dairy farming is the major industry in the Azores, there are also fishing, wine production, manufacturing, and other small industries.

Most Azoreans are cattle farmers, although some sheep, pigs, goats, ducks, and chickens are also raised. There are about 200,000 cattle on the islands, 90% of which are dairy cattle. There are about 8,000 dairy farmers, but some 18,000 families raise cattle. Large Azorean dairies maintain about 100 cows, but most dairies have only 20 - 30 cows. Some 40,000 beef cattle are shipped to the European mainland each year and about 20,000 are slaughtered for island use. Many of the more modernized, intensive dairy operations in the Azores vaccinate their cattle against leptospirosis and other diseases. Cattle graze freely year-round on semi-permanent pastures divided into small paddocks by walls of volcanic rock. In many cases, a single, concrete livestock watering tank serves four paddocks by being located at the central junction.

A chronic leptospirosis problem has existed in the Azores for many years. Recently, an average of 14 human cases have occurred per year, with 1 - 2 being fatal (Joao Franca Gouveia, unpubl. data). Additionally, the rate of infection in cattle is typically 30 - 40% (e.g., Collares-Pereira 1991). As noted in the previous section, rodents are commonly involved in chronic leptospirosis situations. Unfortunately, although rodents occur on all nine islands in the Azores, their populations have received very little study (Mathias et al. 1998). A limited survey of small mammals and leptospirosis prevalence rates was conducted on 6 islands during 1993-95 (Collares-Pereira et al. 1997). The main species captured were house mice (157 from 5 islands), black rats (87 from all 6 islands), and brown rats (23 from 5 islands). The highest rates of leptospirosis prevalence among house mice were 88% (Sao Miguel) and 80% (Terceira). The highest rates among black rats were 33% (Sao Miguel) and 23% (Terceira); among brown rats, the highest rates were 67% (Sao Miguel) and 40% (Terceira). Three of 11 (27.3%) hedgehogs captured on Sao Miguel were seropositive for leptospirosis. One weasel and 1 ferret were captured; both were seronegative for leptospirosis. The authors noted that the high observed prevalence rates suggested that small mammals were serving as important reservoirs of leptospirosis and may have represented a significant risk to the health of both people and livestock on the Azores (Collares-Pereira et al. 1997).

## PROPOSED ACTIONS TO REDUCE LEPTOSPIROSIS IN THE AZORES

The goals of the leptospirosis project in the Azores is to reduce human cases and leptospirosis prevalence rates in wild and domestic animals. It is assumed that reaching these goals will require a long-term reduction in densities of populations of introduced rodents in the Azores. Achieving the goals will help preserve the pastoral lifestyle while improving the economy of the Azores. Once a disease is established in free-ranging wildlife populations, it becomes very difficult to predict, monitor, control, and eradicate (Wobeser 1994). Torten and Marshall (1994) noted that "Although the absolute eradication of leptospirosis is an impossible task, proper prevention and control methods can greatly reduce the incidence of this disease in both humans and domestic animals."

Action should be taken in four key areas to achieve the project's goals:

1. Better understand the ecology and epidemiology of leptospirosis in the Azores
2. Better understand the biology and ecology of rodents in the Azores and develop effective control methods
3. Improve farm practices and animal husbandry to reduce the occurrence of leptospirosis on farms in the Azores
4. Improve the infrastructure of the Azores to allow a sustained reduction of leptospirosis

In the first key area, a concerted effort should be made to determine the prevalence rates of leptospirosis in humans, companion animals, livestock, and wildlife. This effort would include the identification of 1) the serovars that occur in the various groups of animals, and 2) which species serve as maintenance hosts for each serovar. An effort should be made to identify the spatial and temporal aspects of the disease across the Azores landscape. The environmental occurrence and persistence of leptospirosis need to be determined and addressed. In addition, the risk factors associated with the disease in the Azores must be identified, perhaps through thorough study of the past and present human cases.

In the second key area, field studies should determine where rodents occur in the Azores, which primary habitats and foods are primarily used, and what seasonal patterns of movement, habitat use, and foods are evident. Seasonal population densities should be determined as well as reproductive and mortality rates. Finally, the extent to which the three introduced rodent species are associated with and dependent upon humans and their habitations should be determined.

Once the rodent populations are better understood, a comprehensive rodent control program can be established. This program should use an integrated pest management (IPM) strategy. Important components would include sanitation and the rodent-proofing of buildings. A routine rodent monitoring schedule should be established. Effective control methods, including traps and rodenticides, must be developed, made readily available, and used. A corps of personnel trained in rodent biology, ecology, and management should be established and properly equipped. As an initial step in

this direction, Veterinary Services in the Azores recently hired and trained a rodent staff person to begin addressing these issues.

In the third key area, the conditions on farms must be improved so that they are less favorable to the occurrence of leptospirosis. A regular program of testing cattle for leptospirosis, with the subsequent removal of infected animals, should be initiated. More cattle should be vaccinated, an undertaking which would require a sizable commitment of funds. Farm workers (and others in occupations at risk) should be encouraged to use protective equipment and clothing and to practice good occupational hygiene. This effort should be incorporated into an expanded public education program. Farm families should be encouraged to drink only pasteurized milk and to use only safe water sources. They should also be encouraged to practice good farm sanitation. Wildlife should not have access to cattle feed or livestock water supplies. The presence of standing water in pastures should be eliminated or minimized. Farm personnel should monitor and control rodent populations and minimize the use of farms by wildlife. Farmers should be encouraged to use cooperative extension-like services to aid them in implementing these changes on their farms.

In the fourth key area, an effective leptospirosis reduction program should be established that reaches all political, economic, cultural, and social sectors. Town mayors and their staffs should interact closely and regularly with the agencies of the autonomous regional government to effect a leptospirosis surveillance and management program along with an effective rodent management program. This effective interaction can only be accomplished with the "buy in" and cooperation of the farm community and related industries. The leptospirosis reduction program will require a substantial commitment of funds, trained personnel, and adequate facilities. Necessary facilities would include laboratories, a research center, and a cattle quarantine station. An effective vaccination program should be developed for livestock, companion animals, and at-risk people. Finally, the public education program should be expanded to help citizens increase their awareness of the leptospirosis hazard and how they can reduce that hazard through their own actions and by taking advantage of the expertise, methods, and materials available from the government and from other sources.

Progress in these four key areas has the potential to greatly reduce the occurrence of leptospirosis in the Azores. It should also reduce the number of human cases and help strengthen the agrarian economy of the Azores.

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