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# SCANNING *P. BRASILIENSIS* THROUGH REMOTE SENSING AND GIS: NEW APPROACHES TO AN OLD EPIDEMIOLOGICAL PROBLEM

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**Abstract.** This paper presents a proposal of GIS application for identifying the habitat of *Paracoccidioides brasiliensis* fungus, the etiological agent of Paracoccidioidomycosis. Environmental characterization of endemic area through spatial analysis may allow new correlations between fungus infection and environmental conditions.

**Keywords:** Paracoccidioidomycosis, GIS, remote sensing.

## 1. Introduction

Paracoccidioidomycosis (PCM) is the main systemic mycosis in Latin America, caused by the fungus *Paracoccidioides brasiliensis* (Franco *et al*., 1994). This disease primarily reaches the lungs and spreads to other organs, representing a threat to the host life (Blotta *et al*., 1999). The endemic area of PCM extends from Mexico (23$^{o}$ N) to Argentina (35$^{o}$ S), with the largest number of occurrences in Brazil, Venezuela and Colombia (Restrepo, 1985). According to Coutinho *et al*. (2002), it is the systemic mycosis with the highest mortality rate in Brazil.

Although continuous efforts by several research groups, *P. brasiliensis* habitat still represents a riddle (Restrepo, *et al*., 2001). Apparently, the fungus has its natural habitat on soil or in the vegetation in the endemic region (Montenegro & Franco, 1994, Restrepo, 1994). However, the fungus has been rarely isolated from soil and related materials (Shome & Batista, 1963, Franco *et al*., 2000). The following issues, among others, increase the difficulty in finding the fungus in nature (Franco *et al*., 2000): prolonged period of latency, frequent migration of the inhabitants of the endemic area and lack of outbreaks.

*P. brasiliensis* occurs preferably in some restrict habitats, depicted by disturbed and humid vegetation, located near water sources (Bagagli *et al*., 2002). Nevertheless, this information does not allow to determine risk areas. The success in the disease treatment is associated to the diagnosis phase. Consequently, preventive policies to infection can not be applied where the agent habitat is unknown.

It has recently been confirmed *P. brasiliensis* infection in the nine-banded armadillo *D. novemcinctus* where human PCM is regularly diagnosed (Naiff *et al*., 1986, Bagagli *et al*., 1998, Corredor *et al*., 1999, Silva-Vergara & Martinez, 1999, Silva-Vergara *et al*., 2000). Bagagli *et al*. (2002) believe that the nine-banded armadillos represent good animal sentinels for locating the natural environment of the fungus in nature. This is because they have no large home ranges and live in constant and restrict areas for consecutive years (Layne & Glover, 1977, Loughry & McDonough, 1998).

Remote sensing and GIS have been successfully applied to other epidemiological problems, mainly to vector-borne diseases (*e.g*., malaria, Rift Valley fever, Lyme disease, African tripanossomiasis). The aim of the present paper is to apply geotechnologies to this epidemiological problem. By using this approach, the endemic area will be better characterized, allowing future analysis of possible relationships among *P. brasiliensis* and environmental conditions. If good correlations exist, it will be possible to map risk areas, which are useful tool for health planning.

## 2. Material and Methods

2.1 Study area

The studied area is in the Southwestern portion of São Paulo State, Brazil (between 22°30' and 23°30' Lat. S and between 48° and 49°30' Long. W).

2.2 Environmental data

This proposal comprises more precise characterization of the abiotic factors prevailing in this endemic area. Thus, spatial database includes:

- topography, hydrography and municipal boundaries (1:250000 scale);
- geology (1:500000 scale),
- geomorphology (1:500000 scale),
- soils (1:500000 scale),
- precipitation: data from 39 rain gauges from 1970 to 2001 allowed to estimate mean annual precipitation, mean precipitation for April to September ('dry season') and for October to March ('wet season');
- mean annual Normalized Difference Vegetation Index: NDVI composite images comprise 72 10-day images downloaded from the Global Land 1-km project Internet site http://edcdaac.usgs.gov/1KM/1kmhomepage.html, for the periods: April 1992 to March 1993 and February 1995 to January 1996;
- Land use map will be classified from Landsat TM-5 satellite image from 18/09/1999.

2.3 Biological sentinels

Geographical coordinates of armadillos studied by Bagagli *et al*. (2002) were plotted as a layer. Circular 10-km diameter sample areas centered on each point were created for future geographical analysis with other environmental layers.

2.4 Statistical methods

Geostatistical analysis were performed on every point and line layer (*e.g.*, average annual precipitation, contour lines). When spatial dependence was confirmed, interpolation through Kriging was carried out.

Microsoft Excel 5.0 will be used for statistical analysis by correlation and linear regression.

## 3. Preliminary Results and Future Directions

Digital database allowed to identify main features of the study area:

- Altitude ranges from 450 to 978 meters. Mean altitude is 622 meters with Standard Deviation of 99.2744.
- Different Mesozoic units (Formations) are found in the study area, including: the basalts of the Serra Geral Formation (nearly 23%), the Pirambóia sandstone (22.4%) and the Marília and Adamantina sandstones, covering 16.5% and 15.2%, respectively and, others (22.9%).
- Main geomorphologic features are wide hills (60.4%), elongated hills and ridges (18.9%), median hills (12.3%) and, others (8.4%).
- Soils at the study area comprise Oxisols 66.9% ('Latossolos Vermelhos e Vermelho-Amarelos'), Ultisoll 24.7% ('Argissolos Vermelhos e Vermelho-Amarelos') and, others (8.4%).
- Mean annual precipitation ranges from 1249 to 1606 mm. In the dry season, precipitation varies from 324 to 673 mm and from 840 to 1206 mm, in the wet season.

- Mean annual NDVI ranges from 0.19 to 0.64.

Preliminary results of geographical features agree with that described for endemic areas by Restrepo (1985), although great spatial variation occurs for infection and environmental conditions within the studied area. Future investigations are needed to track the relationships among the abiotic attributes, the biological sentinels and, the epidemiological data.

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