GeoHealth: A Surveillance and Response System Resource for Vector Borne Disease in the Americas

Prixia del Mar Nieto¹,⁷, Moara Rodgers¹,⁷, Elivelton Fonseca⁶, Ryan Avery¹, Jennifer McCarroll¹, Rebecca Christofferson¹, Jeffrey Luvall², SJ Park³, Mara Bavia⁴, Raul Guimaraes⁵, John Malone¹

¹ Pathobiological Sciences, LSU School of Veterinary Medicine USA
² NASA Marshall Space Flight Center, Huntsville AL USA
³ Electrical Engineering and Computer Science, LSU USA
⁴ Federal University of Bahia, Salvador, Brazil
⁵ Sao Paulo State University, Presidente Prudente, Brazil
⁶ Federal University of Uberlandia, Uberlandia, Brazil
⁷ Meraki One Health consultancy. Meraki Solutions®

#2021AmeriGEOWeek
OBJECTIVES

• Construct a geospatial health resource data portal
• Map and model the epidemiological risk of two prototype vector borne diseases: Visceral leishmaniasis and Aedes borne arboviruses
• Process big data to discover ‘hidden’ associations of disease for ecological niche modeling vs hypothesis-driven statistical analysis
• Implement dissemination and training programs to promote geospatial mapping and modeling for VBD as envisioned in GEOSS.

#2021AmeriGEOWeek
SURVEILLANCE AND RESPONSE SYSTEM FOR VISCERAL LEISHMANIASIS

1. Satellite Climatology Models (1km) 2017-2019 Data
   - VIIRS-8d LST
   - GPM
   - SMAP
   - GOES-16

2. Biology based models vector *Lutzomyia longipalpis* GDD – Water budget / Generations per year

3. WorldClim2 Model - 30-Year Climate Station Tmax/Tmin/Prec Water Budget (Prec/PET)

4. Statistical models

5. Agriculture scale (30 m)
   - Landsat 8; Landsat Legacy
   - ASTER
   - ECOSTRESS

6. Household scale < 1m (Household = epidemiologic unit)
   - Worldview 2,3 *GeoEye

#2021AmeriGEOWeek
From 2015 to 2018:
VL Cases: 202 municipalities in Bahia
Vector: 76 municipalities in Bahia

#2021AmeriGEOWeek
Results suggest *direct* earth observing satellite measurement of soil moisture by SMAP can be used *in lieu* of models calculated from classical thermal and precipitation climate station data to assess VL disease risk and to guide control program interventions.

**Visceral Leishmaniasis**

**Lutzomyia longipalpis**
Objective: to define a suitability gradient in the environment for propagation and transmission of the *Lutzomyia longipalpis-Leishmania chagasi* system.

Little data is available in environmental preferences and limits of tolerance in relation to climate.

These factors were estimated by using data from:
- A 30-year average monthly climate surface grid (18 x 18 km cells) of South America including data on:
  - Maximum temperature
  - Minimum temperature
  - Precipitation
  - Potential evapotranspiration (PET)
- Human VL prevalence dataset. (SINAN)
- Developmental data obtained from research studies where *Lu. longipalpis* colonies were established and maintained in the laboratory.
### Developmental times, temperature, adults longevity and productivity of *Lu. longipalpis* colony as observed by different authors

<table>
<thead>
<tr>
<th>Developmental times</th>
<th>At room temperature 25°C¹, relative humidity 80%². From engorge to the first emerge of adults is 35³-40¹ days. Breed in less constant conditions (48-54)¹ (25-42)².</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hatching</td>
<td>4-9 days¹ and 6-9 days².</td>
</tr>
</tbody>
</table>
| Larvae              | Larvae (four instars) 14-19 days²  
| First instar        | 3-5 days (first week)¹  
| Second instar       | 2-4 days (second week)¹  
| Third instar        | 1-5 days (send week)¹  
| Fourth instar       | 3-9 days (third week)¹  
| Pupae               | Emergence from pupae on day 10¹ (most of the adults) and 8-9 days². Few males emerge as early as 7 days¹.                                                                                   |
| Adults longevity    | From 2 weeks-one month (adults are robust in rough conditions). In females that have taken blood is determined by when eggs are laid (few survive 24 hours after ovoposition). Most live for more than one month¹. |
| Productivity of the colony | 23 generations in 36 months¹ 23/3= 7.7                                                                                                             |
| Cultures of promastigotes and amastigotes | Promastigotes at 22 °C, amastigotes at 34 °C, reversion from amastigotes to promastigotes at 28°C⁴ |
Annual Potential Generations - *Lutzomyia longipalpis* - BAHIA
- Study temperature indoors and how it relates to temperature outdoors, at weather stations, and Landsat LST.
- Find a functional relationship to better capture the micro-environment of vectors
- Investigate how differences in temperature measured inside/outside/weather stations/satellite translate to altered estimates of transmission of arboviruses.
- We surveyed 5 houses in 3 different cities in Colombia over the course of a year with installed HOBO™ thermometers. We compiled weather station data available for the three cities (or nearest station) and are currently compiling the satellite readings to complete the dataset.

Figure 1 Location of Soledad (A), Sincelejo (B) and Neiva (C) in Colombia (Left superior panel) and the distribution of Temperature data logger inside each municipality highlighted as red circles.

Aedes-borne arbovirus risk models in Colombia. Rebecca C Christofferson and Victor Pena-Garcia
Extrinsic Incubation Period (EIP). This process is known to be influenced by both intrinsic factors (such as viral strain and/or mosquito population) and extrinsic factors (such as temperature and humidity).

Figure 8 (from Christofferson & Mores 2016): Schematic demonstrating the impact of mosquito mortality on the cumulative transmission potential of an arbovirus.
Figure 6 (from Christofferson & Mores 2016): Survival curves for comparisons of A) unexposed to infected mosquitoes at 30°C and B) unexposed to mosquitoes with a disseminated infection were significantly different.

Figure 7 (from Christofferson & Mores 2016): Survival curves for comparisons of A) infected mosquitoes across all three temperatures and B) mosquitoes with a disseminated infection across all three temperatures. Significant differences were found only between 26°C (red) and 30°C (blue) in both cases.
Bauru Daily ET wm-2
2018 Day 256

ECOSTRESS 70m res.

Min
196 wm-2

Max
370 wm-2

Mean
294 wm-2
User friendly course accessible to people in the public health sector, physicians, veterinarians, researchers, students and others interested in infectious diseases.

With GIS tools, it is possible to incorporate drivers and limiting factors that determine disease presence, do analysis, create maps and prediction models.

Implement Municipality Level Geospatial Surveillance and Response Systems fully interactive with municipality health field teams

The goal is mapping vector borne diseases, predicting high-risk areas and future disease outbreaks. It is an effective approach for the study and control of diseases, allocation of health resources, planning, the problem-solving process and policymaking at municipality level.
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Start</td>
<td>ARL 2</td>
</tr>
<tr>
<td>Current</td>
<td>ARL 5</td>
</tr>
<tr>
<td>Goal</td>
<td>ARL 6</td>
</tr>
</tbody>
</table>