Identifying Geographic Areas at Risk of Soil-transmitted Helminthes Infection Using MODIS Products: Boaco, Nicaragua as a Case Study

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Background of the Diseases
- Helmithiasis (Neglected Diseases)
- Sanitation
- Health Impact

Study Area
- Boaco, Nicaragua

In situ data from AMOS

Remote Sensing
- MODIS Land Surface Temperature (LST)
- MODIS Normalized Difference Vegetation Index (NDVI)
- MODIS Land Cover Land Use Type (LCLU)

Results

Conclusions

Recommendations
Background

- Environment is a major factor for health, both directly or indirectly
  - Sanitation, poverty, neglected diseases
  - Natural environment
- A number of agents of diseases are carried by vectors and reservoirs whose viability depends on given environmental conditions
- Such conditions describe not only the characteristics of the natural environment but also of sanitation
- Such conditions can be inferred with satellite data
  - Temperature
  - Presences of water bodies
  - Soil moisture
  - Vegetation
  - Elevation
  - Precipitation

Background cont.

- Soil transmitted helminth infections, Helminthiasis, Neglected Diseases
- Impact
  - Reduced physical growth
  - Weak physical fitness
  - Impaired cognitive functions
  - Increase with intensity of infections

Photo courtesy Dr. Ligia Cruz Espinoza

1. UNICEF, 2006. Progress for Children
Background cont.

Ascaris lumbricoides

Life cycle

2 to 3 months after ingestion of the eggs, the mature worms commence egg laying in the intestine

2 or 3 weeks outside the host to develop to the infective stage
Microscopic Evaluation

*Ascaris suum* zygotes inactivated

*Ascaris suum* developed larva

Photos Courtesy of Dr. Ligia Cruz Espinoza
Background cont.

Ascaris lumbricoides

Female

Male

http://curezone.com/image_gallery/parasites/ascaris/
Background cont.

- Ascaris lumbricoides
- Trichuris trichiura
- Necator americanus
- Ancylostoma duodenale

Soil
Study Area

*Ascaris lumbricoides*
*Trichuris trichiura*
*Ancilostoma duodenale*

AMOS Health & Hope
[http://www.amoshealthandhope.org/Health_for_all/Home.html](http://www.amoshealthandhope.org/Health_for_all/Home.html)

MODIS Land Surface Temperature (LST)
1:30 pm

MYD11A1  1 km daily
Study Area

*Ascaris lumbricoides*
*Trichuris trichiura*
*Ancilostoma duodenale*

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MODIS Land Surface Temperature (LST)
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MYD11A1  1 km daily
Remote Sensing

*Ascaris lumbricoides*
*Trichuris trichiura*
*Ancylostoma duodenale*

MODIS Normalized Difference Vegetation Index (NDVI)

MYD13Q1

250 m

16 day
Remote Sensing

Ascaris lumbricoides
Trichuris trichiura
Ancilostoma duadenale

MODIS Land Cover
Land Use Type (LCLU)
MCD12Q1 Combined
500 m
Yearly
**LST**

*Thrichuris trichuria*

Wilcoxon Two-Sample Test:

Normal Approximation

Pr > |z| 0.0157

t Approximation

Pr > |z| 0.0161

Kruskal-Wallis Test

Pr > Chi-Square 0.0156

Positive: n=152
mean=26.27

Negative: n=244
mean=26.47
LST

*Ascaris lumbricoides*

Wilcoxon Two-Sample Test:

Normal Approximation

$$P \, r \, > \, |z| \, < \, 0.0001$$

t Approximation

$$P \, r \, > \, |z| \, 0.0001$$

Kruskal-Wallis Test

$$P \, r \, > \, \chi^2 \, < \, 0.0001$$

Positive: $n=111$
mean = 26.13

Negative: $n=285$
mean = 26.49
LST

*Ancilostoma duodenale*

Wilcoxon Two-Sample Test:

Normal Approximation

Pr > |z| 0.7824

t Approximation

Pr > |z| 0.7825

Kruskal-Wallis Test

Pr > Chi-Square 0.7813

Positive: n=10
mean=26.61

Negative: n=386
mean=26.39
**NDVI**

*Trichuris trichuria*

Wilcoxon Two-Sample Test:

- Normal Approximation
  - Pr > |z| 0.029
- t Approximation
  - Pr > |z| 0.0301
- Kruskal-Wallis Test
  - Pr > Chi-Square 0.295

Positive: n=152
  - mean=0.756

Negative: n=244
  - mean=0.765
Ascaris lumbricoides

Wilcoxon Two-Sample Test:

Normal Approximation
Pr > |z|  0.6

t Approximation
Pr > |z|  0.1054

Kruskal-Wallis Test
Pr > Chi-Square  0.1045

Positive: n=111
mean=0.760

Negative: n=285
mean=0.761
**NDVI**

*Ancilostoma duodenale*

Wilcoxon Two-Sample Test:

Normal Approximation

Pr > |z|   0.7656

*t* Approximation

Pr > |z|   0.7658

Kruskal-Wallis Test

Pr > Chi-Square  0.7646

Positive: n=10
mean=0.777

Negative: n=386
mean=0.761
### Land Cover

Prevalence considering all three parasites together

<table>
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<th>Land Class</th>
<th>Posit.</th>
<th>Negat.</th>
<th>Odd ratio</th>
<th>n</th>
<th>Prevalence</th>
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<td>165</td>
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</tbody>
</table>

Evergreen broad leaf forest

Woody savannas

Croplands

Croplands/natural vegetation mosaic
Preliminary Conclusions

- As expected, the prevalence of the disease seems to increase with remotely sensed temperature.
- MODIS LST shows potential as a tool to identify areas at risk of helminthiasis however studies covering larger range in temperature are needed to more clearly show such applicability.
- Due probably to the small area of the study site, it was not possible to suggest the applicability of MODIS NDVI and Land Cover under the study conditions.
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