Location and Setting of Zoonotic Gastrointestinal Parasites in the Peruvian Primate Trade

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**Background**

Zoonotic disease is the biggest source of emerging infectious diseases in humans, and 6 out of every 10 known infectious diseases in people are spread from animals. Most spillovers occur between human and primate because of similarities in physiology. The most recognizable spillovers occurred in the cases of HIV and Ebola, however countless bacterial and viral illness strains have made the jump.

Nine diseases are the focus of this project, and all have been shown to transmit zoonotically from primates to humans. They can cause gastrointestinal disease, manifesting in pathologies such as diarrheal disease, dehydration, and malnutrition.

Though the trade of wild primates is illegal in Peru, there is a large market of animals caught for use as bushmeat or pets. Primates are accessible and widely dispersed throughout Peru. Law enforcement lacks the resources to effectively combat illegal commerce. Researchers estimate that current rates of trafficking mirror those from prior to the 1973 legal ban on primate trade. These captured wild animals pose significant risk for introducing zoonotic infectious disease into human populations.

Due to the clandestine nature of the topic, particular illegal trade routes and market locations are hard to find. Geospatial analysis is a helpful tool in defining what regions of the country are at risk of zoonotic disease spillover, and which parasites are most common in primates of those areas. This research project focuses on the question: in what areas of Peru do illegally traded primates test positive for various gastrointestinal parasites, and in what settings are these positive primates located? The parasites of interest are stated below. Settings refer to wetmarkets (e.g. meat market), captivity (e.g. zoos), and pet houses (e.g. individual homes).

**Methods**

Data: Primate gastrointestinal and Peruvian geospatial datasets were merged for this analysis. Both were made available by Marwane Rosenbaum in Peru between 2010 and 2012. Rosenbaum ran all microscopy tests and data validation. Gastrointestinal data included microscopy for 9 parasites: Cryptosporidium, Hookworm, Trichuris trichiura, Ascaris, Blastocystis, Entamoeba, Giardia, Balantidium, and Strongyloides. Missions were imputed. The 1984 WGS Zone18S coordinate system was used.

Heat Maps: I selected data by positivity for any of the nine parasites, and exported the selected data as a shapefile. I repeated this step for each setting (wetmarket, pet house, captivity). I created a kernel density map for all parasites, then one for each distinct setting. I used a cell size of 1000 and search radius of 250000km for all parasites, 150000km for individual setting maps.

Dot Density Maps: I selected data by positivity for each parasite, creating nine distinct shapefiles. I then joined each individual parasite shapefile with a Peruvian departmento shapefile from ESRI. I selected data by positivity for each parasite, creating nine distinct shapefiles. I then joined each individual parasite shapefile with a Peruvian departmento shapefile from ESRI.

Descriptive statistics: There are a total of 134 primate samples. Entamoeba is the most common parasite found in the primates (N=60), followed by Hookworm (N=45) and Blastocystis (N=42). Trichuris trichiura is the common parasite (N=7), though Ascaris and Giardia were also rare (N=9). A majority of the sample primates are found in captivity (N=70), followed by pet houses (N=38) and Wetmarkets (N=26). Most primates are found in Lima (N=29), closely followed by the city of Pucallpa in departmento Ucayali (N=28). The fewest samples are located in the Southeastern region near Cusco.

Overall kernel density: The area with the highest concentration (0.0004 parasites/Km²) of primate samples positive for gastrointestinal disease is between the departments of San Martin, Amazonas, and Loreto in the north-central part of Peru. The second most dense concentration is near Lima in the Pacific coast.

Setting kernel density: All three settings have high concentration of samples near Lima, and Wetmarket clustering is only centralized there. Density of positive primates in captivity mirror those of the full sample, focusing particularly in Peru’s north-central. There are two distinct concentrations of positive primates found in pet houses and Pucallpa.

Dot density parasite: The Amazonas department shows the highest concentration of Hookworm, Entamoeba, Cryptosporidium, and Blastocystis. There are high concentrations of Hookworm, Entamoeba, Strongyloides, Giardia, and Cryptosporidium in Tumbes, while other parasites are nonexistent in that department. Ascaris, Balantidium, and Trichuris trichiura are evenly and sparsely distributed throughout Peru.

**Results**

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A major strength of this project is the data itself, as this population is typically hard to access due to illegality. All points are precise, with information down to latitude/longitude level. However, the sample size is small and some geospatial data had to be imputed. Another limitation is that multiple samples were collected at one site with the same latitude/longitude, making distribution visualization difficult. Parasite density was analyzed on a departmento level, though city polygons may be more appropriate for future studies.

Hypotheses generated from this study could lead to further analysis with this dataset. They are as follows: Is there clustering or correlation between certain parasite types, or between parasites and locations? Are there statistically significant relationships between setting and parasite type, or setting and parasite density? How do trade routes relate to these results, and how do patterns of deforestation?