HOST BEHAVIOR AND RESOURCE SHIFTS: FEEDING ACTIVITY OF THE COMMON VAMPIRE BAT AND RABIES TRANSMISSION IN THE PERUVIAN AMAZON

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LACSI SUMMER 2013 GRADUATE FIELD RESEARCH TRAVEL AWARD PROPOSAL

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Summary of Proposed Research
Changes in food resource abundance can dramatically alter wildlife behavior and physiology. Resource shifts can also affect the transmission of infectious disease, although this has rarely been quantified. I propose to use the common vampire bat (*Desmodus rotundus*), which transmits rabies virus through biting and feeds on large mammals, as a model system for how foraging behavior interacts with the dynamics of a lethal zoonotic disease. I will address the links between bat feeding activity, susceptibility, and exposure to rabies virus through mark-recapture, behavioral, and laboratory approaches. This is a novel area of work, as other recent work on bats indicates that resource shifts can have consequences for human health.

Introduction

Human-driven changes in food resources can dramatically alter wildlife behavior and physiology. For some species, humans enhance resources by provisioning through bird feeders or agriculture (1). For other species, humans deplete resources through overharvest or habitat degradation (2). These resource shifts can alter infectious disease dynamics, although this has rarely been quantified. Changes in resources can affect transmission through changes in host density and contact (3). Resources can also influence host nutrition and foraging effort, altering host physiology and susceptibility to infection (4). Because resource shifts can intensify or curtail disease processes, I will ask how such changes alter the foraging behavior, susceptibility, and exposure of a common bat host to a pathogen of public health and economic concern.

My research will use the common vampire bat (*Desmodus rotundus*), which feeds on mammal blood and transmits the lethal rabies virus through biting (5), as a model for how resource shifts alter disease dynamics. In Latin America, livestock rearing provides bats with an accessible food resource that inflates bat density and might facilitate rabies persistence (6). Inversely, hunting activities can deplete wild food sources of bats, which might increase bat feeding on humans and fuel rabies outbreaks (7). Bats in the Peruvian Amazon are subject to both of these resource-altering processes, and my research will explore three questions related to bat foraging behavior, susceptibility, and rabies exposure across contrasting sites.

1. How does resource availability influence bat foraging activity and dietary preference?
2. How does bat foraging activity interact with physiology to influence susceptibility?
3. How do these processes interact to affect rabies exposure in bats?

Research Plan

To address these questions, I will add unique components to an ongoing study of vampire bats across Peru based at the University of Georgia (UGA) and aided by collaborations with the Centers for Disease Control and Prevention (CDC) and Peruvian Ministry of Health. I am enrolled in UGA's PhD program in Ecology, where I am mentored by Dr. Sonia Altizer, an expert in the ecology of infectious disease. This project will serve as my dissertation research.

My preliminary field research will take place in the Department of Amazonas, where human rabies outbreaks have been reported (8). I will select four sites to represent a gradient of low to high vampire bat prey availability: heavily hunted, lightly hunted, low livestock, and high livestock. Hunting sites will be located in Condorcanqui Province and livestock sites will be located in Bagua Province. I will use mist nets and harp traps to capture bats at two roosts per site separated by 20 km to limit movement between colonies (9). 30–40 bats per site will be captured during my field research in Summer 2013 (June–August) and marked with wing bands for mark–recapture, resulting in a total sample of 120–160 bats. We will record demographic data and collect blood samples for serology and immune assays (10). To determine bat food sources, tissue samples will be collected with Miltex biopsy punches for stable isotope analysis to infer long-term feeding in livestock or wildlife habitat (11). To obtain species-specific diet data, we will extract bloodmeals from a subset of adults per site (n = 5–10) using Argyle feeding tubes and FTA mini cards (12). To obtain data on bat foraging effort, we will equip this subsample with lightweight GPS dataloggers to record forage distance and time spent foraging (13).

Laboratory assays will be conducted at the CDC and UGA. I will detect rabies virus–specific neutralizing antibodies, indicating recent rabies exposure, in serum using a rapid fluorescent focus inhibition test (14). Blood smears will provide baseline immune data through white blood cell counts, and hemoagglutination and bacterial killing assays will quantify immune responses important for pathogen clearance, such as antibody and complement production. Enzyme immunoassays will be used with standard radioimmunoassay kits to quantify stress hormones (15). Bloodmeal samples will be analyzed with a quantitative PCR assay to detect mammalian mitochondrial DNA (12). Tissue samples will be analyzed by stable carbon isotope analysis by collaborators at the Leibniz Institute for Zoo and Wildlife Research in Germany (11).

Statistical analyses will be performed with R software, and GPS data will be analyzed with ArcGIS to calculate maximum distance traveled from a roost and time spent foraging versus resting to quantify foraging effort. In the main analysis, habitat type (forest and agriculture) and prey availability (high through low) will be analyzed as fixed effects, and capture site will be nested within habitat type as a random effect. General linear models will then test the combined effect of habitat type and prey availability on measures of bat foraging activity, physiology, and rabies exposure. Bat demographics will be included in the model as covariates.

Predicted Outcomes & Importance

Because vampire bats can starve within days (7), foraging activity and physiology, and in turn susceptibility and rabies exposure, should depend on prey availability. For Question 1, I expect bats in high-resource sites to display narrow stable isotope ranges and less bloodmeal diversity (feeding mainly on livestock). Bats in these sites might also spend less time foraging and forage over shorter distances. Because rabies persistence depends on bat movement between roosts (6), wide ranging behavior in hunted sites should lead to endemic rabies. For Question 2, I expect that supplemental food (i.e., livestock) decreases foraging effort (time and distance), lowers stress, and allows bats to invest more energy in immunity (16). Thus, for Question 3, I expect bats in high-resource sites to have lower rabies incidence due to reduced movement (lowering transmission) and greater immunity (lowering susceptibility).

Summer 2013 research will establish my doctoral thesis work through providing site establishment; preliminary data; and initiation of collaborations with researchers at the Peruvian Ministry of Health, Peruvian Ministry of Agriculture, and the U.S. Naval Medical Research Center in Lima. This work will also allow me to establish rapport with the communities where we will sample vampire bats, which besides facilitating the research process will provide opportunities for education and outreach regarding rabies risk. My full research from 2015–2016 will add replicate sites, increase sample size, and increase the subsample of bloodmeal analyses and bats equipped with GPS dataloggers.

Rabies carries a high public health and economic burden in Latin America, where human incidence is rising and annual livestock losses amount to $50 million (7). Thus by better understanding how human activities affect bat behavior and disease dynamics, this research will help inform rabies control and environmental management efforts. More broadly, my work will contribute our understanding of emerging bat-borne pathogens such as Ebola, SARS, and Hendra virus, which have all jumped from wild bats to humans over the past decades.

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Budget

I request **$1,500** from the Latin American and Caribbean Studies Institute (LACSI) for travel expenses during Summer 2013. This award will cover round-trip airfare from Atlanta, Georgia to Lima, Peru; round-trip bus fare from Lima to Cajamarca, and miscellaneous ground and boat transportation between field sites in the Department of Amazonas.

Airfare	$900
Bus transportation	$100
Ground and river transportation	$500
Total requested from LACSI	**$1,500**

The total funds for the remainder of my 2013 to 2014 budget for this project amount to **$14,000**. This leaves **$12,500** outside the scope of funds requested from the LACSI to be allocated towards field data collection, subsistence costs and salary for field assistants, sample storage and processing, and laboratory analyses. I have submitted grant proposals to a range of outside funding sources, and the total amount requested from each source is itemized below.

Bat Conservation International	$5,000
American Philosophical Society	$5,000
Animal Behavior Society	$1,500
Sigma Xi	$1,000
Total funds for project from 2013 to 2014	**$14,000**

Funds requested from Bat Conservation International will cover costs of field data collection supplies, subsistence costs for the primary investigator and two Peruvian field assistants, costs of exporting samples from Peru to the CDC and UGA, and transportation from UGA to the CDC to perform serology. Funds requested from the American Philosophical Society will cover the remaining cost of field data collection supplies, sample preservation, and salary for field assistants. Funds requested from the Animal Behavior Society will cover the costs of blood meal data collection equipment, molecular analyses, and stable carbon analyses. Lastly, funds requested from Sigma Xi will cover the costs of laboratory dispensables and assays to quantify stress hormones and immunity. Costs of serology will be covered by collaborators at the CDC.