Jeanne L. Coffin is a biologist with a background in community development and an interest in infectious diseases in conservation and agricultural settings. She graduated from Tufts University with an MS in Conservation Medicine in September 2012, and from Macalester College with a BA in Biology in 2007.

Her undergraduate senior capstone was titled The Wildlife/Livestock Disease Interface: A Case Study in the Ngorongoro Conservation Area, Tanzania. She was an Environmental Education Volunteer with Peace Corps Morocco from 2008-2010. Her Masters case study was in the applications of participatory methods to conservation medicine, with a special focus on using participatory epidemiology to address the situation of anthrax in western Uganda.

JEANNE COFFIN

Tufts University
USA

ONE HEALTH APPROACH FOR ASSESSING IMPACTS OF ANTHRAX
on the Human-Animal Interface in Rural Uganda Using Participatory Epidemiology Tools

Jeanne COFFIN[1]
MSc, Fred Monje2 DVM, MPH*, Grace Asiimwe-Karim2 DVM, MPH**expected 2013
Advisors and Collaborators: Janetrix HELLEN AMUGUNI[1], DVM PhD, Terence ODOCH, DVM[2]
Patrick ATIMNEDI, DVM[3], Jeffery MARINER, DVM[4]

ABSTRACT

Anthrax is enzootic within Uganda's Queen Elizabeth National Park (QENP) and the surrounding area, affecting wildlife, domestic animals, and humans. The 2004/2005 QENP outbreak killed 306 hippopotamus, 143 other wild animals, and 405 domestic animals; a 2010 outbreak in QENP killed 154 wild animals (132 hippopotamus); and a 2011 outbreak in Sheema district temporarily halted local beef sales and killed 2 humans and 7 cattle.

A multi-disciplinary team of investigators from Makerere University African Field Epidemiology Network (AFENET) fellowship program, a biologist and Tufts Institute of the Environment Fellow in the Masters in Conservation Medicine program, and wildlife and production veterinarians are working together under the supervision of faculty from Makerere University and Tufts University as well as staff at the Uganda Wildlife Authority and the International Livestock Research Institute (ILRI) to assess the impact of anthrax on humans, wildlife, and domestic animals around QENP. Using a One Health approach, the focus is on how humans and animals interact and how anthrax impacts the livelihoods and therefore the perceptions of conservation and public health efforts in the QENP area.

The team is using participatory epidemiology approaches to evaluate and design disease surveillance and management strategies, to assess perceived disease impacts, current surveillance efforts, and local conservation efforts in order to investigate anthrax's impact on livelihoods in the QENP area. These findings will be used to propose a conservation medicine and One Health approach to the management and prevention of anthrax through a network of stakeholders. This project is partly funded by the Tufts University Institute of Environment Graduate Fellowship Program.

INTRODUCTION

Anthrax (Bacillus anthracis) is a reportable disease found globally. Any case, whether human or animal,

[1] Tufts University, Boston, MA, USA
[2] Makerere University, Kampala, Uganda
[3] Uganda Wildlife Authority, Kampala, Uganda
[4] International Livestock Research Institute, Nairobi, Kenya

domestic or wild, is supposed to be reported to the appropriate veterinary and human health officials to initiate the necessary control measures. Disease control strategy is well established (Turnbull 2012), as vaccination is sufficient to stop an outbreak when combined with animal movement and carcass control. However, due to the complexity of the life cycle and the unknowns regarding the bacteria's life in the soil, it is difficult to predict when and where outbreaks will occur. Further, disease control can be unpopular in agricultural areas, as the standard control methods have serious economic implications.

The disease is an ancient and virulent zoonotic disease with a complex natural ecology. The bacteria are a close relative to several species of common soil bacteria (Saile et al. 2006) and Anthracis bacillus also spends much of its life cycle in the ground (Schuch et al. 2009). This is the part of the life cycle we know least about. Historical research indicates that certain soils are more hospitable to the bacterial spores (van Ness 1971), and current research indicates the bacteria may replicate as saprophytes (Saile et al. 2006). Other recent research also indicates that spores may be able to germinate and replicate in common soil amoeba (Dey et al. 2012). These new theories may help solve the mystery of how apparently low spore counts can spike under the appropriate conditions. Traditionally, spores are thought to be activated and/or concentrated by varying climatic factors (van Ness 1971, Hampson et al. 2011), creating the opportunity to infect herbivorous animals as they graze via inhalation or ingestion.

Once within the body, the spores germinate, and the vegetative cells multiply rapidly, leading to septicemia. The disease causes sudden death, with the animal often displaying blood oozing from all bodily openings, and sometimes a lack of rigor mortis (Dragon 1999). If either the carcass is opened, the bacteria in the animal sporulate and contaminate the ground surrounding the carcass. People can be infected by ingesting infected meat, or by inhaling or swallowing spores during slaughter, treatment, disposal of carcasses, or use of dried skins later. As in herbivores, gastrointestinal or inhalation anthrax can quickly prove fatal to humans (Beatty et al. 2003). Cutaneous anthrax is less serious. Predators often exhibit resistance to the bacteria (Lembo et al. 2010).

There have been two recent outbreaks in Uganda's Queen Elisabeth National Park (QENP) wildlife populations. In 2004/2005, anthrax killed 306 hippopotamus and 143 animals of other species, mostly wild ungulates and elephants (Mapesa et al. 2007). There was another outbreak in 2010, which killed a smaller number of wildlife. The most recent outbreak in Uganda was not in the park, and it temporarily shut down local beef sales and claimed the lives of both humans (two) and bovines (five) in Sheema district in November 2011(Promed-mail 2011).

Anthrax appears to be endemic in western Uganda, given its recurrent outbreaks. This possibility is made more likely since the soils in western Uganda are often calcium rich, and are therefore presumably sufficient to support the longevity of anthrax spores (Ness 1971, Hampson 2011). In wildlife areas, it has been suggested that anthrax can act as an effective population control where the disease is endemic (Mapesa et al. 2007). This may be desirable for good wildlife management, but represents an ongoing risk to any livestock-keeping people who live near such wildlife areas (Hugh-Jones et al. 2002).

Current management of anthrax in Uganda officially follows OIE regulations as specified in the Terrestrial Animal Health Code (see OIE 2011 b). As such, the disease is reportable. All reports require implementation of ring vaccination, quarantine of meat and milk products, and strict movement control of animals for at least 20 days after the latest outbreak. In 2011, this whole sequence was played out in Sheema District, but not in time to prevent the deaths of two people. In practice, there is some question as to whether these management policies are well enforced. In wildlife, surveillance followed by appropriate disposal of carcasses is the operative management strategy (Mapesa 2007). This has recently been supplemented by initial efforts to monitor effects of disease in wildlife on the people who reside in QENP. Conservation Through Public Health (CTPH 2010), a non-profit that tries to mitigate harmful zoonoses and cross-species disease effects near conservation areas (Kalema-Zikusoka 2011), originally undertook this.

This application of participatory methods was modeled after the design of Mariner and Roeder 2003 and the CTPH efforts. It is intended to complement instead of repeat CTPH findings. By including both questionnaire and PE methodologies in one study, we attempted to address the criticism that participatory methodologies – and especially PE – are usually not balanced with quantitative methods (Toribio 20l1). The general goals of the study are to (1) gain a better understanding of disease interactions, especially anthrax, in the area; (2) explore the connection between the presence of serious diseases and perceptions of conservation efforts; (3) identify some operative recommendations for local and regional stakeholders to implement.

DEFINING TERMS

Conservation medicine is an emerging, interdisciplinary field that studies the relationship between human and animal health (or One Health) and environmental conditions (or ecosystem health/Ecohealth). It seeks to apply that knowledge to better the management of One Health and Ecohealth challenges.

It is important that One Health and Ecohealth practitioners have tools to work with, a toolbox of sorts. It has been argued that for these ideas to succeed, human and animal health will have to be linked together so that knowledge and practice can flow seamlessly from one to the other (Zinsstag 2009, Nara et al. 2008). However, there is more to the picture. The basis of health must be rooted in environmental and ecosystem understanding, from both ecological and sociological perspectives. This means that tools from all of these disciplines will have to be adapted to the unique problems that conservation medicine works to address. One such family of tools is participatory methods, or approaches, originally from anthropology but also applied in many other human centered fields of research and development. From that family, participatory epidemiology is one of the tools most tailored to use in One Health or Ecohealth projects. Thus, it was chosen as a methodology for studying the problem of anthrax in Uganda.

STUDY STRATEGY AND DESIGN

The multi-stakeholder nature of the politics and policy of anthrax in Uganda make it a good candidate for study with participatory methods (PMs) because they provide the option to make room for the input of as many stakeholders as the practitioners wish to include. We have aimed to include all stakeholders in the process, though have been severely limited by time constraints. We were not able to formally interview all stakeholders, and so we focused on the village level participants for interviews. We met many stakeholders (CTPH representatives, community animal health workers, sub-county extension workers, district level veterinarians, and a Uganda Wildlife Authority veterinarian), but the meetings were informal and used only for background information. We chose participatory epidemiology (PE), because the tools it encompasses are tailored to disease management. PE has been applied once to the situation of anthrax in Uganda by CTPH, and we have harmonized our study with this previous work.

OBJECTIVES

1. Define the relative perceived impact of livestock-wildlife diseases—focusing on anthrax—on human livelihoods in a sample of communities near QENP
2. Elucidate the response and response rationale of community members to disease, especially anthrax
3. Investigate the perception in local communities of the relationship between zoonotic disease and wild animals
4. Explore community perceptions of government efforts to aid in disease and conservation management

PROJECT PARTNERS

Partners came from the sectors of veterinary health, governmental wildlife management, and public health: two students in the African Field Epidemiology Network (AFENET) fellowship program, a field supervisor from the Uganda Wildlife Authority (UWA), and one Tufts Masters of Conservation Medicine (MCM) student. AFENET is a non-profit that builds public health programs, the capacity of existing ones, and professional connections. This fellowship program educates veterinarians in public health strategies. UWA is the governing body of wildlife management and conservation in Uganda, managing the protected areas in partnership with communities and organizations.

The partners had various roles in the project. Under an internship for the Tufts student, Dr. Patrick Atimnedi, Coordinating Senior Veterinarian at the UWA, agreed to be the field supervisor for the project. Two AFENET fellows (Fred Monje and Grace Asiimwe-Karimu under the instruction of Dr. Terence Odoch) collaborated on the background, methodology, and the implementation of this project. The Ugandan students conducted the field work and provided de-identified data to Ms. Coffin for analysis. Dr. Jeffrey Mariner, DVM the International Livestock Research Institute also advised on participatory epidemiology methods. In Kasese District, Community Animal Health Workers trained by the NGO known as Conservation Through Public Health were used to connect with the communities. This organization is an important stakeholder in the area, and has previously done somewhat similar research focused on anthrax in communities that live in Queen Elisabeth National Park. We have agreed to share data, and our data will be compared with theirs in the final report sent to the District level government and other stakeholders.

METHODS

Sampling

We chose two districts, Kasese and Sheema, based on the presence of past outbreaks and different proximities to the park. Within those districts we used purposive, or risk-based, sampling to select subcounties. The risk we are testing for is effect of proximity to the national park or outbreak on perceptions of anthrax, animal public health efforts, and knowledge of wild animal disease. Subcounties based on whether they are near to known outbreaks/park boundaries (<10 km), or far (>10 km) from outbreak/park boundaries. Random sampling of villages from within each subcounty was intended to reduce selection bias, but time did not allow us to use this method effectively. Where time was too short, a convenience sample of villages that had contacts we could work with were used instead. This meant that the villages chosen were those that already had either government extension workers or CTPH community animal health workers, possibly affecting our results. The sample of individuals from within each village was necessarily a convenience sample chosen by participants themselves and the community leaders who mobilized them.

Two sub-counties were selected from each district, resulting in 4 subcounties total. Two villages were chosen purposively from every subcounty, and ~10 households were chosen from each community (village). Individual village residents from each selected household completed the questionnaires. Each village had one or two focus groups (5-15 individuals), observations from one day, and 6 and 15 questionnaires. In Sheema district, we attended a farmers' workshop, where we collected 29 questionnaires.

Subject criteria

To effectively represent local knowledge, we wanted to cast a fairly wide net, including individuals from multiple social strata, gender, occupation, and adult age groups. Local dialects were accommodated with translators or with the language skills of the Ugandan student counterparts. Participants were given refreshments (sodas) by way of thanks for choosing to participate.

- Inclusion criteria: (1) Lives in study area more than 50% of the year, (2) Adults (age 18 and older) both male and female, (3) consents to participate, (4) chooses to attend focus group or questionnaire session.
- Exclusion criteria: (1) Lives in the study area less than 50% of the year, (2) less than 18 years of age, (3) does not consent to participate, (4) chooses not to come to the focus group or questionnaire session.
- Withdrawal/Termination criteria: Individual is aggressive, excessively overpowering, or chooses to cease participation for any reason. Termination will come into play only if the safety of other participants or researchers is threatened. Participants were aware that they could leave of their own free will at any time.
- Gender balance was encouraged, and when possible focus groups were separated by gender to aid in freer communication.

Data Collection

From PE we used semi-structured interviews including participatory exercises within focus groups. The Ugandan student collaborators facilitated these focus groups. Key informants – usually defined as individuals with specific knowledge of study topics – were not included in the data collection, but were encountered during the organizational process. The students conducting the focus groups and questionnaires used conversations with key informants to brief themselves about the local history of anthrax outbreaks and relevance of study topics. For non-participatory methods to crosscheck the focus groups, questionnaires were filled out. Three main strategies were used in the collection of data. (1) Questionnaire surveys were completed with individuals from the chosen communities. (2) Semi-structured interviews were conducted in focus groups. (3) Observation in the focus groups by the note-taking partner. Observations were also made on the approach and departure from the villages.

The second strategy listed above incorporated more than one participatory technique. Participants were asked to draw a community map at the opening of the focus group. Thereafter, the map was used as a touchstone throughout the focus group interview to aid understanding and communication. Villagers were asked about husbandry techniques and wildlife in the area, and then to identify, describe, and rank the three most important diseases to each livestock species. They were asked how those diseases affected their livelihood. Through a proportional piling exercise in a matrix, we investigated the effects the three diseases had on their livelihoods. They were also asked specifically about anthrax, their knowledge about it, and how it affected their livelihoods. Checklists and sample questionnaires are available upon request from the corresponding author.

Analysis Strategies

This study was originally designed for qualitative and spatial analyses. However, after completing the fieldwork, the authors decided to attempt quantitative analyses as well. The two Ugandan authors are mostly responsible for the quantitative analysis, and the US author is responsible for the qualitative and spatial analysis – though all three are assisting each other with the analyses for statistical ideas and design, and advice about on-the-ground details for the qualitative data.

- Qualitative Analysis: looked at the various categories of data, summarizing the main themes, points, or ranks given in responses or discussions.
- Spatial Analysis: The differences between responses of focus groups are being compared by proximity of the given village to both anthrax outbreaks and Queen Elisabeth National Park. Reponses looked at included interaction of livestock with wildlife, diseases ranked as important, effects of disease on livestock rearing activities, livestock rearing challenges, and knowledge of livestock-wildlife disease transmission.
- Quantitative Analysis: Statistical tests being considered are linear regression, odds ratios, and the chi-squared test with EpiInfo software.

QUALITATIVE RESULTS

Top mentioned livestock raising challenges:

In Sheema, disease was ranked first in every focus group. Similarly, the price of medicines to treat the animals was also mentioned as challenging. Theft of animals and lack of land were ranked second. In Kasese, however, the top challenge was always related to conflicts with wild animals or park officials. In two focus groups disease or related disease issues, such as inaccessibility of veterinarians, made rank number two, but in others were more concerned with drought and lack of farming equipment for fodder and crops.

In the questionnaires participants were free to put their personal opinions, and so a wider range of answers was received. The following were the most mentioned challenges associated with livestock rearing. In Sheema the most frequent difficulties mentioned were disease, lack of/expensive drugs, theft, ticks, poor grazing/lack of land, and low market prices. In Kasese the top mentions had some in common with Sheema, but also some notable differences. Kasese's top challenges were marauding predators, no compensation for marauding predators, lack of grazing land, disease, drought, and theft.

There were more questionnaires taken in Sheema than in Kasese because the authors were able to attend the farmer's workshop in Sheema. In Sheema district the most mentioned diseases in the questionnaires were tickborne diseases (especially East Coast Fever), lumpy skin disease, worms, brucellosis, and anthrax. Other diseases such as foot and mouth disease, mange, and mastitis were also occasionally mentioned. In Kasese district brucellosis, and East Coast Fever were the top diseases mentioned. These patterns were confirmed by

TOP RANKED DISEASES FROM VILLAGE FOCUS GROUPS

Village	Disease 1	Disease 2	Disease 3
Mashonjwa 1	ECF	LSD	Mastitis
Mashonjwa 2	ECF	Mastitis	–
Mashonjwa 3	Anthrax	ECF	Brucellosis
Nyakihanga 1	Nonspecific diarrhea	FMD	3 day sickness
Nyakihanga 3	ECF	Brucellosis	Emerging rare diseases (difficult to ID)
Rwamunena	Tick-borne diseases (ECF)	LSD	Eye diseases
Rwenjubu	Brucellosis	New Castle	Trypanosomiasis
Kiganda 1	Tick-borne diseases (ECF)	Brucellosis	Anthrax
Kiganda 2	Anthrax	Brucellosis	Worms
Muhokya	FMD	Anthrax	New Castle
Muhokya	ECF	Worms	Trypanosomiasis

Table 4: Boxes in light grey are from Sheema District, and boxes in dark grey are from Kasese District. ECF = East Coast Fever, LSD = Lumpy Skin Disease. Notes -- In Kiganda 1 &2, brucellosis was referred to as "malaria of animals." In Rwamunena and Kiganda 1, "tickborne diseases" was reported in general, but upon further probing for symptoms and treatment ECF was the most commonly reported.

the focus group discussions with the addition of foot and mouth disease and anthrax. See Table 4 for details from focus groups.

AWARENESS

In Sheema participants were sometimes aware that brucellosis, anthrax, and TB, and worms could all infect humans as well as animals. Of those that knew of zoonosis, many did not know how to avoid specific diseases. In Kasese most participants were aware of the zoonotic characteristics of anthrax, TB, brucellosis, influenza, and worms.

Concerning the connection of disease to wildlife, Kasese also had a higher level of awareness than Sheema district. In Kasese interviewees, without prompting, specifically mentioned diseases coming from wild animals being difficult to control. In relation, it is perhaps not surprising that the level of contact livestock in Kasese had with wild animals was reported more frequently than in Sheema. In Sheema 47.8% of participants said their livestock had no contact with wild animals and 52.2% said they did have contact. In Kasese 42.3% said they had no contact with wild animals, and 61.5% said they did have contact. Further, 72% of respondents answering “no contact” in Kasese listed several wild animals that their animals come into contact with. In Sheema only 13.6% of respondents answering “no contact” listed any wild animals at all.

Specific awareness of anthrax also differed by district. Individuals who were aware of the effects of anthrax and proper prevention strategies were equally well informed in both districts, but there were fewer informed participants in Sheema. Kasese had a larger level of awareness than Sheema on general knowledge of the characteristics and appropriate response to anthrax as well as the fact that anthrax can affect wild animals as well as domestic ones.

EFFECTS ON LIVELIHOOD

In Sheema many mentioned the destructive effects of quarantines (“unable to sell animals or milk”, “unable to slaughter animals”). Other effects of animal disease reported were reductions in productivity due to time spent caring for animals, high expenditures on medicines/vaccines, the “government delays to intervene”, loss of animals, loss of body condition, loss of fertility, and individual mental distress – one man said he “can’t even sleep.” In Kasese there were similar reports: income problem, loss of animals, farmers can’t get the maximum profit from it (due to loss of milk, death of animals, and/or poor quality meat).

Specific to anthrax, only one respondent in Sheema said they had been directly affected, pointing to a reduction in income. However, many respondents mentioned the destructive effects of disease quarantines in general, and referred to the quarantine due to anthrax last year as a prime example. In Kasese there were several who had been directly affected by anthrax, and they said it was expensive to treat, resulted in a loss of livelihood/income, a loss of animals, and a lack of manpower.

In the focus groups, participants were asked to rank the disease impacts. In Sheema general disease and anthrax were separate. In Kasese this distinction was removed to avoid biasing the exercise that followed the ranking exercise.

Focus group participants in Kasese were asked to complete disease vs. disease impact matrices in a proportional piling exercise to probe into the deeper effects of disease on their livelihoods. One of the impacts mentioned was conflict (in Rwenjubu), an unexpected response, as most addressed financial concerns.

Sheema	General Disease Impacts		Anthrax Impacts		
Ranked 1st	Reduction in milk	Treatment expenditure	Lower income	Death of animals	Loss of animals
Ranked 2nd	Animals die	Milk reduction	Not allowed to eat milk or meat	Increased expenditure	Loss of income
Ranked 3rd	Blockage of teats	–	Social isolation – by members of other communities	Lack of meat and milk	Isolated from other livestock farmers

Table 5: General and anthrax specific disease impacts from Sheema District.

Kasese	General Disease Impacts				
Ranked 1st	Poverty/no income	Deaths of animals	Loss of animals	Loss of animals	Loss of calves
Ranked 2nd	Conflict*	Loss of milk	Expenditures in treatment	No sale of animals	Expenditures in meds
Ranked 3rd	Death	Poor quality [animals]	Loss of human lives	Little or no milk and meat quality	Loss of milk

*Table 6: Disease impacts in Kasese District. *Both at home and between homesteads and government.*

FURTHER INFORMATION ON ANTHRAX

Anthrax was not considered to be among the most important diseases in villages in Sheema district, except in one focus group. This was one of the villages that had an anthrax outbreak, and they said it was very costly to them though also very rare. Most other Sheema villages reported that they hadn't any direct experience with anthrax. However, when participants were asked to locate an anthrax outbreak on their participatory map, every Sheema village could point to an outbreak that had occurred less than 10 km from their village. This is despite the fact that 3 of our focus groups were ~30km from the formally reported anthrax cases (see map). The locations pointed out by the participants do not converge in one place, nor do all match up with known (reported) anthrax outbreaks. This could have been reported due to a desire to please, but the field workers reported that they seemed to be genuine reports. This indicates that there may have been more anthrax outbreaks than officially reported. There were also reported historical anthrax outbreaks on Kasese participatory maps, but it is unclear if these are part of previously reported outbreaks in the national parks or not.

Further, two unofficial reports of suspected anthrax cases came to the attention of the authors during fieldwork in late July 2012, including an animal supposedly testing positive at a laboratory near one of the study areas. These have not been formally reported precisely because of the economic damage a full-fledged quarantine causes to the cattle centered and dependent culture of western Uganda. One other interesting observation that we heard from several participants in Sheema district was that most anthrax-infected cows have been coming from Mbarara District. They said that they tend to be a bit more suspicious of cattle coming from there because they have more anthrax in Mbarara than they do in Sheema district.

Table 7: Tables of matrices of disease and disease impacts in all villages from Kasese District. Proportions are listed as proportion of impact per disease, and are expressed as out of 1.00 instead of 100. Colors are coded as follows: Pink x > 0.50, Purple 0.49 > x > 0.35, Yellow 0.34 > x > 0.20, and White x < 0.19.

Rwenjubu	Kasese	Impacts Poverty (no income)	Home Conflicts	Death
Diseases	Brucellosis	0.17	0.04	0.11
	New Castle	0.22	0.00	0.07
	TRP	0.20	0.06	0.12

Kiganda 1	Kasese	Impacts Deaths of animals	Loss of Milk	Poor quality, loss of value
Diseases	TB	0.52	0.27	0.20
	Brucellosis	0.52	0.32	0.16
	Anthrax	1.00	0.00	0.00

Kiganda 2	Kasese	Impacts Loss of animals	Treatment Costs	Loss of life in human beings
Diseases	Anthrax	0.40	0.20	0.40
	Brucellosis	0.33	0.33	0.33
	Worms	0.30	0.35	0.35

Muhokya 1	Kasese	Impacts Loss of animals	No sale of animal	Poor milk and meat quality	Quaranti ne
Diseases	FMD	0.21	0.15	0.21	0.43
	Anthrax	0.23	0.30	0.24	0.23
	New Castle	0.29	0.29	0.22	0.20
	TRP	0.35	0.25	0.40	0.00

Muhokya 2	Kasese	Impacts Loss of calves: abortion, delayed estrus	Drugs expenditure	Loss of milk quality	Lost time
Diseases	ECF	0.28	0.25	0.19	0.28
	Worms (Enjoka)	0.39	0.32	0.13	0.16
	TRP	0.14	0.22	0.39	0.25

In Kasese district questionnaire participants asked for sensitization of communities and more veterinary personnel. Focus groups were a more fertile ground for suggestions. In Sheema they suggested free annual vaccinations, more veterinary personnel, better enforcement of outbreak quarantines, and provision of drugs. In Kasese there were requests for veterinary personnel/extension workers at subcounty or parish, routine vaccinations, tsetse fly control, sensitization about disease, compensation by the national park for damages by wild animals, regular vaccination drives, and regulation to encourage competition amongst the middlemen to provide better prices for the farmers.

DISCUSSION

The final conclusion must wait for the full analysis to be completed. However, some preliminary conclusions may be drawn from the qualitative data that has been presented. There does seem to be a noticeable difference between the answers received from Sheema and Kasese districts, and may be attributable to the distance from the QENP. There are also noticeable differences between those villages that were immediately adjacent to anthrax outbreaks and those more distant from them. Both of these differences are being explored through GIS spatial evaluation to see if they are significant.

The Uganda Wildlife Authority (UWA) conservation strategy is based on their mission, which is "To conserve, economically develop and sustainably manage the wildlife and protected areas of Uganda in partnership with neighboring communities and other stakeholders for the benefit of the people of Uganda and the global community." UWA has programs in place in many of their areas that tie the successes of tourism with community development initiatives. This does not necessarily include supporting veterinary healthcare in all situations. However, where such a connection between conservation and human or veterinary public health has been made (in the nonprofit sector), positive reactions have been reported (CTPH 2010). In CTPH 2010 participatory epidemiology (PE) was used to assess the impact of an ongoing anthrax outbreak in villages surrounded by Queen Elisabeth National Park. The Uganda Wildlife Authority (UWA) has an established method for dealing with anthrax outbreaks, and both the CTPH report and this case study were meant to inform the approach used with communities who are affected by the UWA methods.

The original report of anthrax in Uganda was that it was highly sporadic, occurring mostly in QENP amongst hippopotamus, buffalo, and elephants. There was the one outbreak in Sheema district, which prompted us to investigate in that area. Our research, however, has revealed that anthrax is much more widely distributed than

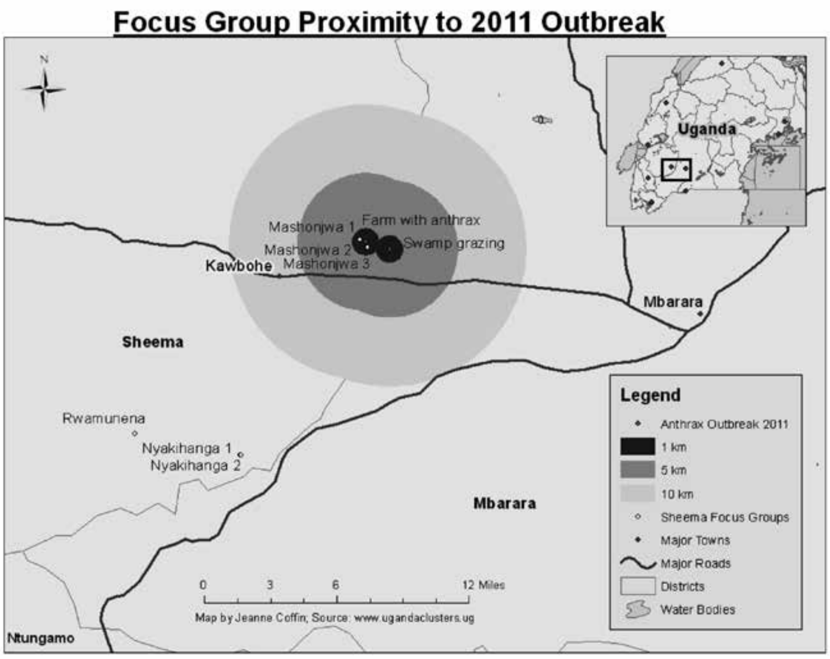

Figure 1: Buffer around 2011 outbreak showing 1, 5, and 10km boundaries surrounding the outbreak. Note that all three focus groups in Rwamunena and Nyakihanga referred to outbreak less that 10km from their villages in directions that did not correspond to the 2011 outbreak.

the reported outbreaks would imply. Reports of anthrax outbreaks were located in three places in Sheema district instead of the one place expected. Further, participants suggested that anthrax was still more common in the neighboring Mbarara district. This merits further investigation.

Similarly, our research found that the current use of quarantines is prohibitively expensive for village level individuals, and is presumably preventing them from reporting faithfully. It may be that the quarantines and associated vaccination programs are not well enough compensated to balance the unavoidable costs incurred by all individuals placed under quarantine. Effective quarantine compensation programs might tip the balance the other way. Community individuals might also be more willing to report anthrax cases and deal with the associated quarantines if there was adequate sensitization and education about the consequences of established B. anthracis in their soils. Many individuals did not report knowledge of anthrax, how to recognize it, or how to deal with suspected anthrax cases. Further, those that do know how still report choosing to butcher animals they suspect having died of anthrax.

Other important notes to acknowledge are the importance of disease in the context of other livestock rearing challenges and the relative importance of anthrax among other diseases mentioned. Disease was not always the top concern, particularly in Kasese district. The encroachment of wild animals on the villages and their associated damages to crops and livestock is number one on their lists. This places them in conflict with conservation in the area, and must also be addressed along with their disease concerns if conservation is to continue successfully. Of the diseases mentioned, tickborne diseases and brucellosis seem to be among the most widespread problems. Since they are so widely distributed and commonly dealt with, they are likely as serious as the anthrax problem if not more so.

There are several areas that should be explored as further analysis is completed. Firstly, the issue of whether serious surveillance for anthrax in the environment, livestock, and/or wildlife should be considered. It is possible that such surveillance could help target areas for annual vaccine and education campaigns, if the resources were found. While it does seem that once again PE has been able to reveal a different picture of infection patterns than was previously acknowledged, it still needs to be evaluated beside the questionnaire efforts. This case study was not ideally designed to test questionnaires against PE, since they were conducted consecutively in half of the villages. This style of study may have allowed the effects of each technique to affect the other. Whether PE should become part of periodic surveillance efforts alongside questionnaires seems likely to be answered in the positive. If PE is to join in the epidemiological work in Uganda, the country is unusually well appointed to implement the method. AFENET already functions as an educational group, and may become part of a PE network that could coordinate wider efforts focused on one disease or many. There are established strategies for incorporating PE into existing or standard surveillance (Mariner et al. 2011).

Other strategies should also be considered for the control of anthrax. Another community-based strategy is the employment of community animal health workers (CAHWs). A network of community animal health workers (CAHWs) might also be an effective way to boost surveillance and control. They have been used to great effect with other diseases in Kenya (Catley 1999). When employed by Conservation Through Public Health (CTPH) they were well received in areas around QENP. Villagers asked for their return to the QENP area, saying that CAHWs associated with CTPH have been less active this last year. A non-community-based approach that might be taken to understand the distribution of anthrax is testing either the soil or animals to determine prevalence in either. Loop-mediated isothermal amplification (LAMP) assay testing is a relatively new technology that has been developed specifically for field-testing of pathogens, including anthrax. A recent effort by Jain et al. 2011 has had success testing soil for anthrax at very high levels of sensitivity. High sensitivity is vital for a soil bacteria like B. anthracis that is known to exist over long periods of time in low concentrations. Domestic canines could be used as an indicator species for historically present anthrax through a serology survey as in Lembo et al. 2011.

CRITICISM

Due to the lack of time used to complete the fieldwork, the participatory nature of this mini-study has dropped from a possible level 4 to a low level 3 on Pretty's 1994 topology of participation. The collaboration with local stakeholders and execution of participatory methods used were good, but the actual execution was far short of what had been planned. The lack of time meant that actual fieldwork had to begin immediately, without a practice section to perfect the techniques and refine the questionnaires and check list. The result of this is that the questionnaires, the check lists, and even the focus group activities had to be remodeled on the fly. Thus, in analysis, only some data is consistent across all groups. The consistent data is what was focused on in the results/confirmation section, but there was some other data that was lost in the process of refining. Unfortunately, in shooting for consistency, we were unable to attain our goal of having focus groups separated by gender. This is very unfortunate because in the one situation we were able to separate groups by gender, we got some interesting information from the women's group that was not reported in the men's group: a long forgotten instance of a case of anthrax, as well as an understanding of some skepticism surrounding the occurrence of anthrax in the area. Without this information, it would have been harder to conclude that anthrax is widely distributed.

The number of questionnaires collected was actually very good considering the short amount of time that we had available for the study. However, there were some weaknesses in collection. For example, in three of the villages, questionnaires were collected after the focus groups were conducted. This meant that the answers would most likely be biased by the topics and conclusions of the focus group discussion. However, we concluded that it would be more time efficient and less of a bias problem if one of the Ugandan student collaborators collected questionnaires while the other facilitated the focus group discussions. This became our dominant strategy. The inclusion of questionnaires taken from the selection of farmers that attended the farmers' workshop also helped to reduce the bias in the questionnaires by disassociating the conclusions in the questionnaires from those in the focus groups.

CONCLUSION

Participatory epidemiology has given a more complete picture of the situation surrounding anthrax in western Uganda. In the scale of challenges facing the people near the national parks, disease is not the top priority. Within disease, the importance given anthrax varies but is generally high. In order to improve relations between the national park and those living nearby it, any hardships that the park places on the nearby residents should be mitigated, including disease risks. A more complete survey of high risk areas regarding anthrax should include soil sampling and serosurveillance of canines. Knowledge of truly high-risk areas could inform targeted vaccination and risk-mitigation education programs. This should reduce the number of annual anthrax vaccines needed to completely control the disease around the national parks, increasing the efficiency of any such program.

Beatty, M. E., Ashford, D. A., Griffin, P. M., Tauxe, R. V., & Sobel, J. (2003). Gastrointestinal anthrax: Review of the literature. Archives of Internal Medicine, 163(20), 2527-2531.

Catley, A. (1999) Methods on the Move: A review of veterinary uses of participatory approaches and methods focusing on experiences in dryland Africa. International Institute for Environment and Development (IIED).

Conservation Through Public Health –CTPH. (2010) Community knowledge, perceptions and practices about anthrax in Kasese and Rubirizi districts. A participatory epidemiology report.

Dey, R., Hoffman, P.S., and Glomski, I.J. (2012) Germination and Amplification of Anthrax Spores by Soil-Dwelling Amoebas. Appl. Environ. Microbiol. 78(22): 8075.

Dragon, D., Elkin, B., Nishi, J., & Ellsworth, T. (1999). A review of anthrax in Canada and implications for research on the disease in northern bison. Journal of Applied Microbiology, 87(2), 208-213. doi: 10.1046/j.1365-2672.1999.00872.x

Hampson, K., Lembo, T., Bessell, P., Auty, H., Packer, C., Halliday, J., ... Cleaveland, S. (2011). Predictability of anthrax infection in the Serengeti, Tanzania. Journal of Applied Ecology, 48(6), 1333-1344. doi: 10.1111/j.1365-2664.2011.02030.x

Hugh-Jones, M., & de Vos, V. (2002). Anthrax and wildlife. Revue Scientifique Et Technique De L Office International Des Epizooties, 21(2), 359-383.

Jain, N., Kumar, J. S., Parida, M. M., Merwyn, S., Rai, G. P., & Agarwal, G. S. (2011). Real-time loop-mediated isothermal amplification assay for rapid and sensitive detection of anthrax spores in spiked soil and talcum powder. World Journal of Microbiology & Biotechnology, 27(6), 1407-1413. doi: 10.1007/s11274-010-0592-3

Jones, K. E., Patel, N. G., Levy, M. A., Storeygard, A., Balk, D., Gittleman, J. L., & Daszak, P. (2008). Global trends in emerging infectious diseases. RID G-4768-2010 RID F-6183-2010. Nature, 451(7181), 990-U4. doi: 10.1038/nature06536

Kalema-Zikusoka, G. (2011). Integrating wildlife health and community public health to promote conservation and sustainable livelihoods. British Veterinary Zoological Society Proceedings,

Lembo, T., Hampson, K., Auty, H., Beesley, C. A., Bessell, P., Packer, C., . . . Cleaveland, S. (2011). Serologic surveillance of anthrax in the Serengeti ecosystem, Tanzania, 1996-2009. Emerging Infectious Diseases, 17(3), 387-394.

Mapesa, W. M., Patrick, A., & Charles, T. (2008). Managing the 2004/05 anthrax outbreak in Queen Elizabeth and Lake Mburo National Parks, Uganda. African Journal of Ecology, 46(1), 24-31. doi: 10.1111/j.1365-2028.2007.00796.x

Mariner, J.C., Hendrickx, S., Pfeiffer, D.U., Costard, S., et al. (2011) Integration of participatory approaches into surveillance systems. Rev. sci. tech. Off. int. Epiz., 30(3), 653-659.

Mariner, J. C., & Paskin, R. (2000). Manual on participatory epidemiology. (Animal Health Manual No. 10). Rome: Food and Agriculture Organization.

Nara, P. L., Nara, D., Chaudhuri, R., Lin, G., & Tobin, G. (2008). Perspectives on advancing preventative medicine through vaccinology at the comparative veterinary, human and conservation medicine interface: Not missing the opportunities. Vaccine, 26(49), 6200-6211. doi: 10.1016/j.vaccine.2008.07.094

OIE b. (2012). Terrestrial animal health code - anthrax. (No. Article 8.1.1).

Pretty, J. (1994). Alternative systems of inquiry for a sustainable agriculture. IDS Bulletin, 25(2), 37-48.

Saile, E., & Koehler, T. M. (2006). Bacillus anthracis multiplication, persistence, and genetic exchange in the rhizosphere of grass plants. Applied and Environmental Microbiology, 72(5), 3168-3174. doi: 10.1128/AEM.72.5.3168-3174.2006

Schuch, R., & Fischetti, V. A. (2009). The secret life of the anthrax agent bacillus anthracis: Bacteriophage-mediated ecological adaptations. Plos One, 4(8), e6532. doi: 10.1371/journal.pone.0006532

Toribio, T.-A.L.M.L. (2011) Editorial, Participatory Epidemiology: The emergence of a sub-discipline. The Veterinary Journal.

Turnbull, P. C. B. Guidelines for the surveillance and control of anthrax in human and animals. (No. WHO/EMC/ZDI/98.6). World Health Organization. Accessed May 2012.

van Ness, G. B. (1971). Ecology of anthrax. Science, 172(3990), pp. 1303-1307.

Zinsstag, J., Schelling, E., Bonfoh, B., et al. (2009) Towards a 'One Health' research and application tool box. Veterinaria Italiana, 45(1), 121-133.