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GLOBAL LIVESTOCK CRSP

The Avian Flu School's "Train the Trainer" Courses: An Overview and Assessment

Carol J. Cardona, University of California, Davis
Avian Flu School (AFS) Project

Research Brief 08-01-AFS November 2008

The Avian Flu School (AFS) was designed to help minimize the health and economic impact of H5N1 highly pathogenic avian influenza (HPAI) by providing the training necessary to improve a community's ability to prevent a HPAI outbreak and to respond to and recover from an outbreak. AFS is a multi-tiered, train-the-trainer program designed to educate animal health, public health, and agricultural extension workers about H5N1 HPAI, enabling them to deliver this information at the community level in developing countries. A pilot program of the four-day course, which consists of four modules and a practical session, was taught at the University of California, Davis; Sokoine University of Agriculture, Morogoro, Tanzania; and Texas A&M University in 2006. A total of 83 teachers, observers, coordinators, and trainees participated in the pilot courses. Course evaluation scores, provided by trainees, improved from four out of five during the first pilot course at UC Davis to over 4.4 out of five for the last pilot course at Texas A&M. Evaluation scores for the individual modules similarly improved. After minor modifications to the content in response to comments received during the pilot courses, additional courses were taught in Tanzania, Kenya, Uganda, Ghana, and Djibouti.

Background

As the current panzootic of H5N1 highly pathogenic avian influenza (HPAI) began to spread from Southeast Asia in 2003, it became evident that the lack of readily accessible information about the disease, especially in rural areas, was hindering efforts to contain its spread. A diversity of species, including humans, wild waterfowl, and domestic poultry, are affected by H5N1 HPAI. This increases the number of professional disciplines whose input is required in prevention and response discussions. Thus, the Avian Flu School (AFS) project assembled a multi disciplinary team to develop a curriculum targeted to the people most affected by the impacts of H5N1 HPAI and those most appropriately involved in prevention and response, such as poultry producers, district level veterinarians, agricultural extension staff, medical doctors, public health workers, wildlife professionals, and those raising poultry at the village level.

The course material was developed using a train-the-trainer model, a common approach for animal health, public health, and agricultural extension. AFS materials are designed in tiers based on the expertise of the intended audiences. In Tier I, professionals and national officials from public health ministries and veterinary service departments are trained. Tier I trainees then conduct Tier II trainings, mainly within their districts or organizations; the intended audiences are zonal and district veterinarians, agricultural extension staff, wildlife managers and public health workers, who will, at Tier III, reach their respective communities. Tiered training allows information to be delivered at different levels to different audiences, including those that may not normally be included, but which are at the forefront of disease detection and response, such as village poultry keepers.

AFS course materials are designed to be interactive and flexible, so that the course can be customized to the needs of each individual audience. For example, specific modules may be taught to individuals with relevant responsibilities and skipped for other audiences. The material is written and presented in a concise manner to facilitate comprehension and teaching. The course has been translated from its original English into French, Kiswahili, and Spanish.

AFS Curriculum

The AFS curriculum consists of four classroom modules and one practical session:

Module One: Overview. Module One serves as an introduction to the course. Students will be introduced to the various avian flu viruses and taken through the history of H5N1 HPAI. HPAI transmission, the risk of

H5N1 HPAI to humans, and the impacts of avian influenza are also incorporated into the overview. Students will become familiar with surveillance, testing and reporting methods, as well as coordination and management of avian influenza prevention programs and communications planning.

Module Two: Surveillance. Module Two focuses on surveillance of H5N1 HPAI. Students are educated on how to calculate sample size and perform appropriate and effective surveillance in poultry and captive populations, as well as in wild birds.

Module Three: Public Health and Worker Safety. Module Three provides information and methods to students in order to ensure the protection of public health and worker safety. Students are first introduced to general public education and protection and then familiarized with the more specific topics of protection and protocol as they pertain to poultry farm workers, backyard/smallholder owners, live-bird wet market workers, medical workers, public health teams, and first responders.

Module Four: Prevention and Response. Module Four's emphasis is on prevention of and response to avian influenza. In addition to these topics, students will be well-versed in recovery from avian influenza. Scenarios including smallholder poultry operations, wet (live bird) markets, commercial poultry facilities, zoological and aviary collections, and wildlife are utilized to give context to the discussion. Biosecurity planning and response plans are also key topics in this module.

Practical Session. The Practical Session is meant to provide applicable information for the proper prevention of and response to HPAI. Participants work through the packing and shipping of a diagnostic sample, donning and doffing of personal protective equipment, cloacal and oral cavity swabbing for samples, and vaccinating, bleeding, and safe slaughter and cleaning of a chicken.

Major Findings

Participant feedback. The Avian Flu School courses taught to date have been met with an enthusiastic reception. The vast majority of course participants indicated greater understanding of the module topics after taking the course and expressed confidence in imparting this knowledge to others.

Online surveys conducted with trainees after the pilot courses had a 66.1% response rate and showed that:

- 80.6 % are confident they could use the materials to train others;
- 36.1% trained others using the AFS course materials;
- 38.9% implemented behavioral change based on what they learned;
- 52.9% would not modify, add or eliminate any part of the training materials.

Regarding the stated learning objectives:

- 96.8% know the different paths of H5N1 HPAI transmission (54.8% did prior to the course);

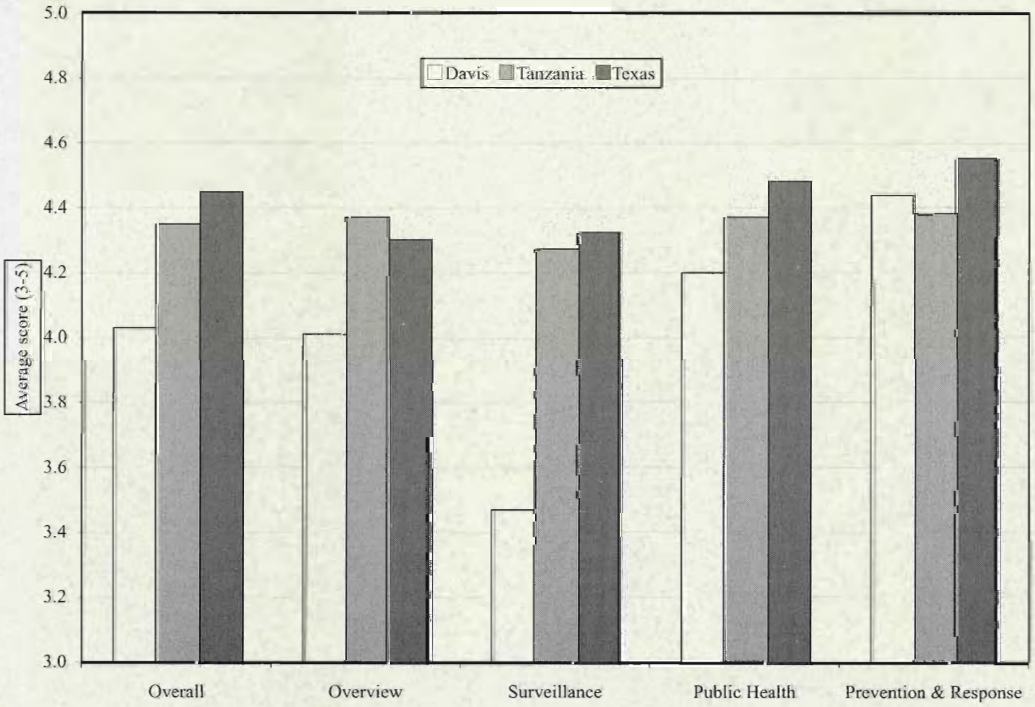
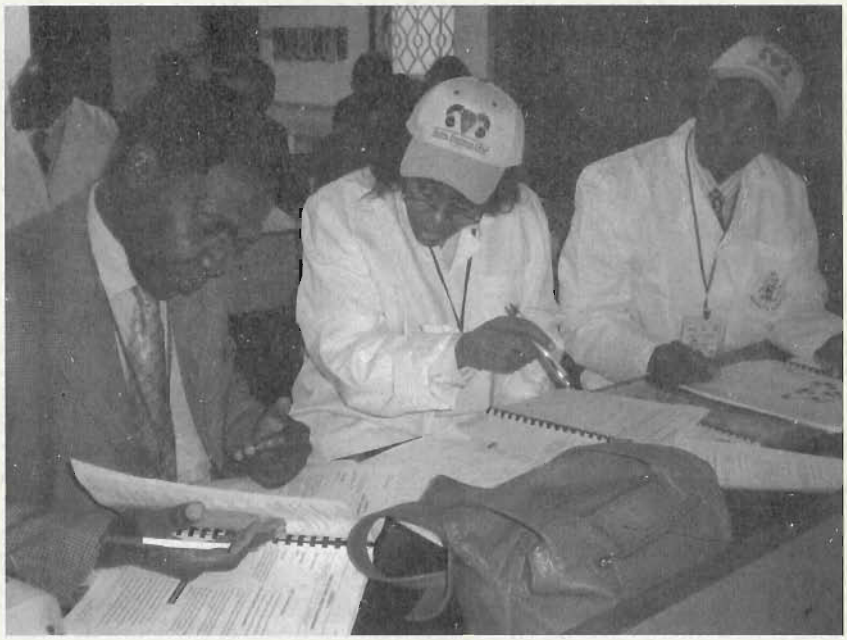


Figure 1. The overall and individual module average scores given by participants in evaluations conducted at each of the three Avian Flu School pilot courses. Average scores were calculated from individual scores, with 5 representing the best possible score, and 1 the worst.



At a national-level AFS training in Kenya in July 2007, animal and human health professionals are trained to be avian flu prevention and response instructors. Photo by David Bunn.

- 87.1% are prepared to communicate to different audiences regarding an avian influenza emergency (12.9% felt prepared before the course);
- 80.6% are prepared to design a surveillance plan and modify it as the disease situation changes (16.1% were before the course);
- 96.8% know how to protect themselves and others from HPAI (38.7% knew how prior to the course);
- 96.8% are prepared to give advice on biosecurity issues in different poultry settings (22.6% were prior to the course);
- 77.4% know the response and recovery steps and procedures (16.1% knew them before the course);
- 93.5% could put on and remove their personal protective equipment following the recommended protocol (16.1% knew how prior to the course).

Since the initial pilot courses, AFS has conducted five Tier I courses in five countries, training 100 AFS instructors. These instructors have conducted seven GL-CRSP-supported Tier II courses, training more than 170 people at the district level in six countries. In addition, AFS instructors have conducted several other Tier II courses through their own organizations. The AFS curriculum has been ordered by numerous international organizations and utilized for workshops in Asia and elsewhere.

Practical Implications

Model for further training. The success of Avian Flu School, as measured by participant surveys, indicates that the model would be useful if adapted for educating trainers about prevention and response strategies for other diseases in developing countries.

Collaborative effort among participants. One of the unanticipated outcomes of the AFS training courses has been the exchange of ideas and information among participants. In one case, the development of a village Newcastle vaccination project was proposed in collaboration with trainees from the Tanzanian pilot course. During the exercise in the surveillance module (Module Two), two groups of participants proposed a novel strategy to institute a Newcastle disease vaccination program in selected villages, to prevent clinical disease associated with viscerotropic velogenic Newcastle disease (VVND).

VVND is endemic in many parts of the developing world, and is clinically indistinguishable from HPAI. The cost of the laboratory testing needed to differentiate these diseases is prohibitive and thus impractical for adequate surveillance for HPAI in rural areas. The trainees proposed the use of sentinel villages, in which chickens would be vaccinated for Newcastle disease and enrolled in a reporting system for mortality events.

A chicken die-off in Newcastle-vaccinated chickens is much more likely to be caused by HPAI than a mortality event in non-vaccinated chickens. If mortality is reported, veterinarians in the region have been equipped with rapid flu detect kits that can be used to test for influenza type A. This program optimizes the use of influenza tests, which are expensive and in short supply in Tanzania, as they are in many countries.

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About the Author: Dr. Carol J. Cardona, DVM, PhD, DACPV, is a member of the University of California, Davis faculty with joint appointments in Cooperative Extension and the Department of Population Health and Reproduction. Email: cjcardona@ucdavis.edu

Avian Flu School (AFS) was created to address the need for a train-the-trainer program to disseminate the knowledge necessary to minimize the health and economic impacts of H5N1 HPAI by improving the ability of a country, district or community to prevent, respond to, and recover from an outbreak. The project is led by Dr. Carol J. Cardona, University of California, Davis. Email: cjcardona@ucdavis.edu.

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GLOBAL LIVESTOCK CRSP

An Overview of the Newcastle Disease Avian Influenza Control Research Project

Peter Msoffe, Sokoine University;
Carol J. Cardona, University of California, Davis
Avian Flu School (AFS) Project

Research Brief 08-02-AFS November 2008

In 2007, the Newcastle Disease Avian Flu Control Research Project, a sub-project under the Global Livestock CRSP Avian Flu School, was initiated in Tanzania. Because the symptoms of Newcastle disease are very similar to those of avian flu, it is difficult to institute an effective avian flu control program without a Newcastle disease control strategy. The project is thus aimed at: 1) designing a model for a sustainable Newcastle disease vaccination program in rural villages, 2) assessing the prevalence of poultry diseases, and 3) designing methods and strategies for improving poultry health at the village level. Village chicken vaccinations were organized, supervised and conducted by trained village vaccinators in selected villages in three wards, one ward each in Mtwara, Morogoro and Iringa regions. The briefing and training of local policy makers and of local agricultural leaders is very important to the success and sustainability of village-level Newcastle disease vaccination programs and poultry development efforts throughout Tanzania and other African countries.

Background

A Highly Pathogenic Avian Influenza (HPAI) train-the-trainer pilot workshop was conducted in Morogoro, Tanzania in August of 2006, as part of the Avian Flu School (AFS) assessment. During this interactive workshop, participants were asked to design a plan for improving biosecurity and preventing an outbreak of HPAI at the village level. Participants from the Mwanza and Mtwara regional Veterinary Investigations Centers described how diseases, particularly Newcastle disease, caused 60-75% mortality in the free-ranging chickens in villages.

Newcastle disease is a contagious viral disease of poultry, and its most deadly form is common in many developing countries. In Africa, it is the chief impediment limiting village chicken productivity. The symptoms of Newcastle disease are very similar to those of HPAI, and the two diseases cannot be differentiated without laboratory-based diagnostic testing. It is therefore difficult to institute an effective HPAI control program without a Newcastle disease control strategy.

The Tanzania workshop participants discussed the successful Newcastle disease vaccination pilot programs in the Mwanza and Mtwara regions, where the thermostable Newcastle vaccine (I_2 strain) was used. The I_2 vaccine, which is generally distributed through district veterinarians, is produced by the Tanzanian government and is very inexpensive, costing about one U.S. dollar for a vial containing doses for 400 birds. In Tanzania, the national Newcastle disease vaccination schedule calls for vaccinating three times per year during the months of January, May, and September. The vaccine is applied by eye-dropper, whereby a single drop is applied to the eye of each chicken.

The workshop participants proposed a plan that involved coupling Newcastle disease vaccinations with a participatory process to develop methods and strategies for improving biosecurity and disease prevention at the village level. The design of the plan was based on the concern that due to the high mortality of village chickens, very little value is attributed to chickens at the village level, and thus, there is little interest in investing time and resources in improving biosecurity to prevent HPAI, Newcastle, and other diseases. However, if poultry productivity improves as a result of the Newcastle vaccination, the added resource value would lead to increased interest in investing in chickens. An important benefit of the Newcastle Disease Avian Flu Control Project is that project villages that vaccinate chickens against Newcastle disease become sentinel villages for early detection of HPAI. In other words, if there is massive mortality of chickens, HPAI should be suspected immediately in the Newcastle-vaccinated flocks.

Methods

The project involves five major steps:

Step One. A strategic component of this project is that the support of local leaders is key for the long-term sustainability of district- and village-level efforts to improve poultry health and productivity. If local leaders are not informed regarding the project purpose

and methods, they are not likely to offer support or to authorize local resources for expanding the program. And, worse, if they do not understand the potential of the project, they may see it as a diversion from other local priority projects. Thus, the first activity of the project was conducting one-day briefing and training workshops on avian health and production for district and ward leaders, emphasizing the importance of disease control, especially for Newcastle disease and avian influenza. Two hundred and twenty-four local leaders were trained and briefed on the project in seven one-day training workshops. Following the local leaders' training, at least one region adopted the program district-wide, and later across the entire zone of the southern highlands of Tanzania. The local leadership in Iringa adopted the Newcastle vaccination program as part of the rural development agenda for the district. The program was planned for the entire zone and was launched May 5, 2008, in a kick-off week called 'Kuku Week' (translated as "Chicken Week").

Step Two. Training village chicken vaccinators and record-keepers to implement the vaccination program and to provide adequate documentation of chicken disease, productivity, and the impact of the Newcastle disease vaccinations were included in this step. For this, 25 data collectors and 60 chicken vaccinators were trained. Good record-keeping is a very important component of poultry stewardship. Poultry health and productivity records are critical tools used to recognize increases in sick or dead birds or to evaluate changes in productivity.

Step Three. Consistent with the national Newcastle disease vaccination schedule, village chickens were vaccinated by the village vaccinators in selected villages in three wards, one ward each in Mtwara, Morogoro and Iringa regions. To date, the project has organized, supervised and conducted Newcastle disease vaccinations twice in all three wards and three times in Iringa and Mtwara. Table 1 indicates the total number of chickens vaccinated for the first and second vaccinations.

Step Four. Conducting socioeconomic surveys in a sample of households participating in the project to assess the knowledge of chicken diseases among villagers and to assess the importance of chicken production to their livelihoods are components of this next step.

Step Five. The last project activity will be collecting and evaluating diagnostic samples of poultry diseases in the project villages. The key element to this activity is to evaluate the antibody titers against Newcastle disease, as measured by the hemaglutination inhibition test, at different times in a year and to establish the patterns for other diseases following an increase in the numbers of chickens and their age stratification.

Preliminary Findings

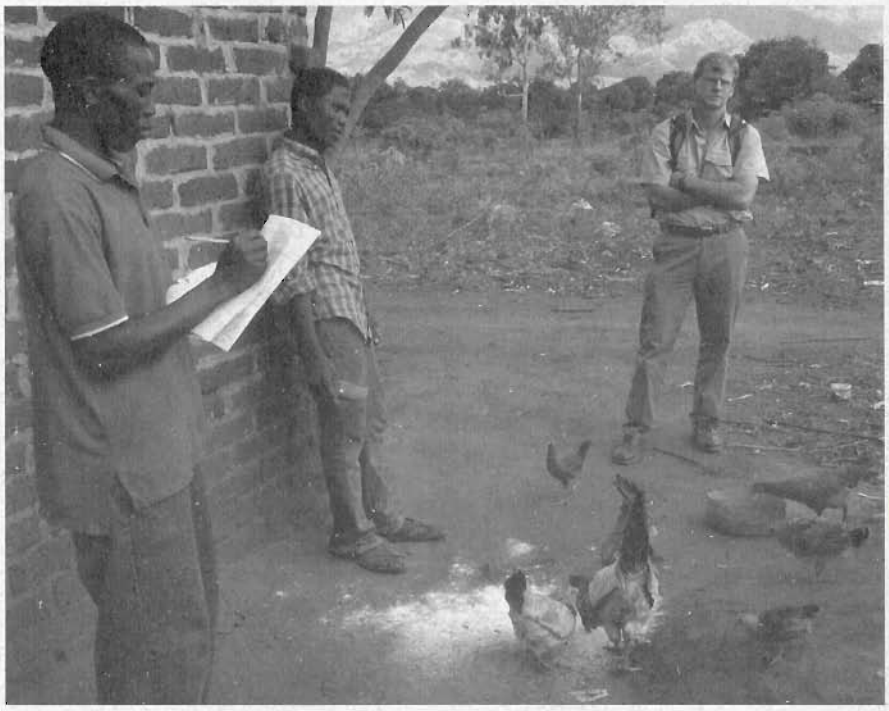
The briefing and training of local policy makers and of local agricultural leaders is very important to the success and sustainability of village-level Newcastle disease vaccination programs and poultry development efforts. Local officials that have participated in poultry health briefing-trainings have shown strong interest in adopting local policies and providing funds to support poultry vaccination and development programs. It is encouraging that local leaders are now spreading the message on vaccination and the need to improve poultry management. In Iringa, they have already set by-laws on compulsory Newcastle disease vaccination with penalties to defaulters. Newcastle disease vaccination yields dramatic and rapid increases in the productivity of village chickens. Village chicken numbers in the Iringa study area increased 50 percent between the first and second rounds of vaccination.

University-based poultry veterinary scientists may serve as key extension agents for the improvement of poultry health and productivity at the village level. Working in collaboration with regional veterinary staff and field staff of non-governmental organizations, a core group of university poultry specialists and a cooperative extension specialist

Table 1. The number of chickens that have been vaccinated in the three project wards.

Ward	First vaccination	Second vaccination	Third vaccination
Mlowa	17,320	25,820	N/A
Mzumbe	27,307	30,073*	N/A
Ufukoni	850	1700	N/A
Total	45,477	57,593	

**The number of vaccinated chickens excludes chickens from 80 households, which were not vaccinated because the owners refused to comply. The refusal was mainly based on the farmers erroneously believing that one vaccination would provide sufficient protection for their chickens.*



While speaking with village poultry farmers in Morogoro, Tanzania, AFS team members, including Project Manager David Bunn, assess the effectiveness of the Newcastle disease vaccinations and learn of poultry health problems. Photo by Danielle Knueppel.

have effectively extended their poultry health knowledge to village communities.

Practical Implications

Improving poultry health and productivity at the village level can be an important component of programs to reduce malnutrition in poor rural communities, since poultry is one of the few animal food sources available to poor families. In Tanzania, as in many developing countries, 80% of poultry production is village-based. Unfortunately, the productivity of village poultry has been severely limited by devastating poultry diseases. The development of effective strategies and practical methods for households and villages to improve poultry disease control is critical for attaining the benefits that poultry offer for providing income and food for rural poor families.

Avian influenza and Newcastle disease are two such diseases requiring control and management. The symptoms of Newcastle disease are very similar to avian flu, and the two diseases cannot be distinguished from one another without laboratory testing, which is often cost-prohibitive and requires resources not always available in rural communities of developing countries. Therefore, instituting an effective avian flu control program must include a Newcastle disease control strategy.

Furthermore, the practice of university-based veterinary scientists engaging local policy makers and agricultural leaders may be a model for animal health extension across Africa. Improvements in poultry health and productivity resulting from this study make the case for investment in a much larger poultry health extension program throughout Tanzania and other African countries.

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About the Authors: Dr. Peter Msoffe, DVM, PhD, is a member of the Faculty of Veterinary Medicine at Sokoine University of Agriculture. Email: msoffepl@suanet.ac.tz. Dr. Carol J. Cardona, DVM, PhD, DACPV, has joint appointments in Cooperative Extension and in the Department of Population Health and Reproduction at the University of California, Davis. Email: cjcardona@ucdavis.edu.

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GLOBAL LIVESTOCK CRSP

Impact Assessment of a Disease Vaccination Project in Rural Tanzania

Danielle Knueppel, Jim Ellis Award Recipient 2007-2008
University of California, Davis
Avian Flu School Project

Research Brief 09-01-AFS May 2009

The purpose of this study was to assess the socioeconomic impact of the Newcastle Disease and Avian Influenza Control Research Project, a chicken vaccination project designed by the GL-CRSP Avian Flu School (AFS), on villagers and households in rural Iringa, Tanzania. Findings showed that households in project villages kept significantly more chickens than households in control villages, however, there was no significant difference in income earned from chicken and egg sales between the project and control households. Likewise, no significant difference in the frequency of chicken consumption among mothers and children from project and control village households was found, yet both mothers and children from project village households consumed eggs more frequently than mothers and children from control village households. Women in project villages reported higher measures of empowerment, as well as a trend towards less household food insecurity. Interestingly, measures of support for the vaccination of chickens were greater in control villages than in project villages. In conclusion, an intervention as simple and inexpensive as vaccinating chickens for Newcastle disease can have a beneficial impact on the livelihoods and well-being of women, children and resource-poor farmers. To enable farmers to attain these benefits, policymakers and development practitioners can establish vaccination programs, facilitate farmers' access to vaccines and markets for chickens and eggs, and provide training and education programs on the best practices for chicken production along with the nutritive value of consuming poultry, eggs and other animal source foods.

Background

Small-scale, family-based poultry production can provide a practical and effective way to alleviate poverty, particularly for women and resource-poor farmers. Family-based poultry production systems are characterized by low productivity and face constraints related to high mortality and disease rates, housing, feeding, breeding, marketing, credit, education/training, and extension (Permin et al. 2004; Guèye, 2005). Despite these challenges, village chickens play a vital role in many poor rural households by providing an important source of high-quality nutrition and income with very little cost or management.

A major constraint to family-based poultry production in Tanzania is viscerotropic velogenic Newcastle disease (hereafter referred to as Newcastle disease), which is caused by a virus and is capable of causing up to 80-100% mortality in unprotected flocks (Sonaiya and Swan, 2004). Several vaccines against Newcastle disease have been developed and used to significantly decrease chicken morbidity and mortality rates. One of these vaccines, the I-2 vaccine, can easily be administered to chickens in the form of an eye-drop, is produced in Tanzania, and is relatively inexpensive. A dropper vial of the I-2 vaccine, enough to vaccinate about 400 chickens, costs 2,000 to 3,000 Tanzanian Shillings (1 USD ≈ 1,200 TSH in 2008). An increase in poultry production can lead to an increase in household income and/or consumption of chicken and eggs, and, subsequently, an increase in household food security. Food security is defined as a state in which "all people at all times have both physical and economic access to sufficient food to meet their dietary needs for a productive and healthy life" (USAID 1992).

The Newcastle Disease and Avian Flu Control Project (NDAFCP), a sub-project under the GLCRSP-funded Avian Flu School, is a research project aimed at improving poultry health and production, and improving avian flu control strategies in rural Tanzania (Msoffe and Cardona, 2008). As part of the NDAFCP, Newcastle disease vaccinations were conducted in three project villages in rural Iringa Region. The purpose of this study was to assess the socioeconomic impact these vaccinations on households in rural Tanzania. Specifically, the study measured the impact that an increase in numbers of chickens has on: 1) household income from chicken and egg sales, 2) household food security, 3) consumption of eggs and chickens among children and women, 4) the empowerment of women, and 5) household support for chicken vaccinations. Three control villages were selected based on similarities (socioeconomic, location and infrastructure) to the project villages for comparison.

The study used a mixed method approach for data collection, including key informant interviews and a cross-sectional household survey. Key informant interviews were conducted in the six villages with male and female village leaders, and household interviews were conducted (n=237) with mothers having at least one child between 1-5 years of age (40 households per village selected at random).

Major Findings

There were no significant demographic differences between households in project and control villages. The mean number of chickens owned by households in the project villages was 14, while for households in control villages it was 8.4, a statistically significant difference. When respondents were asked to compare the current year to the previous year, more respondents from project village households reported an increase in the numbers of chickens raised and numbers of eggs collected compared to respondents from control village households.

To prevent diminishing immunity and to assure that all chickens above three weeks of age are vaccinated, it is recommended that chickens be vaccinated against Newcastle disease three times per year. Although the aim of the program was to vaccinate all chickens in the project villages three times during the previous year, the vaccination coverage was not as complete as intended. Approximately 20.2% of the households had vaccinated their chickens three times and 43.7% had vaccinated their chickens twice. In the control village households, 92.4% had not vaccinated their chickens during the previous year. It is interesting to note, however, that even without complete vaccination coverage project village households kept significantly more chickens. This may be because rates of immunization in the flocks were higher than actual rates of inoculation. The I-2 vaccine is a live virus that can spread from bird to bird. Further work to characterize the transmission dynamics of the I-2 vaccine in this setting is needed to fully understand the impacts of vaccination.

According to key informants, chickens are primarily used for sale, secondarily for household consumption, and thirdly, are given as gifts. Eggs are primarily reserved for hatching into chickens, secondarily for household consumption, third, for sale, and fourth, as gifts. Although a greater number of project village households sold chickens and eggs compared to control village households, overall, relatively few households sold chickens and eggs. The mean price households obtained for chickens and eggs was similar in the project and control villages. The study did not find a significant difference in income earned from chicken and egg sales between households in project and control villages. However, project village households tended to sell more eggs and showed a trend towards greater income from egg sales compared to control village households.

Regarding measures of support for Newcastle disease vaccinations, the mean amount of money respondents from households in the project villages were willing to pay to vaccinate one chicken was 99.6 Tanzanian Shillings (US $0.07 in 2008). Respondents from households in the control villages were willing to pay 210.8 Tanzanian Shillings (or US $0.16). When asked about the perceived importance of and benefit from Newcastle disease vaccinations, surprisingly, more control village households than project village households perceived the vaccinations to be 'extremely important' and expected they would gain a 'very large benefit' from vaccinating their chickens. These measures of support defied original study expectations. Reasoning for these findings may be twofold. First, because households in the project villages did not pay for the vaccinations, they may not have valued them. Furthermore, vaccination recipients may have been reluctant to offer any money for the vaccine, thinking that if they offered to pay they would not receive vaccinations for free in the future. Second, because of the close proximity of the project and control villages, households in control villages may have heard about the beneficial effects of the vaccinations, increasing the demand for and perceived importance of vaccinating chickens.

Women's empowerment, defined as the transfer of authority and resources to enable women to obtain greater autonomy and control, was measured by asking women respondents about the person who made decisions regarding chicken and egg use, who sold chickens and eggs, and who kept the money from chicken and egg sales within their household. In the majority of the households (89.1% of project village households and 87.3% of control village households), the female head of the household was the primary caretaker of the household's chickens. Female heads of household in project villages tended to play a larger role in both deciding whether to eat or sell chickens and eggs, and in selling chickens and eggs than in control villages. The female heads of household in both project and control villages usually kept the money from both chicken and egg sales.

There was no significant difference in the frequency of chicken consumption among mothers and children from project and control village households. However, both mothers and children from project village households consumed eggs more frequently than mothers and children from control village households.

A nine-item food insecurity scale, based on the Household Food Insecurity Access Scale (HFIAS), developed by the United States Agency for International Development (USAID) Food and Nutrition Technical Assistance (FANTA) Project (Coates et al. 2007), was used to measure household food insecurity. In brief, the scale is based on a household's experience of problems regarding access to food, and represents the various aspects, or domains, of

food insecurity found to be universal across cultures (Coates et al. 2006; Webb et al. 2006). Households receiving vaccinations had a mean food insecurity score of 8.1, while households not receiving vaccinations had a mean food insecurity score of 10.4. Food insecurity scores range from 0-27 with a high score representing greater food insecurity.

By investigating the correlations between household socioeconomic characteristics with household food insecurity and chicken and egg consumption among mothers and children, findings revealed that higher levels of maternal education, paternal education, and household wealth were associated with less food insecurity. Households with younger mothers and fewer members also were relatively less food insecure. Agro-pastoralist households were more likely to experience higher levels of food insecurity than agriculturalist households.

Maternal education was positively related to both chicken and egg consumption in mothers and to egg consumption in children. Greater household wealth was associated with higher egg consumption among mothers and children and greater chicken consumption among children. Mothers from pastoral households consumed significantly fewer eggs than mothers from agricultural households. Girls consumed both chicken and eggs more frequently than did boys.

The household socioeconomic characteristics found to be significant predictors of household food insecurity and chicken and egg consumption among mothers and children were included in multivariate models to determine whether differences in food insecurity scores and frequency of chicken and egg consumption varied when accounting for the effect of the socioeconomic characteristics. When controlling for household characteristics related to food insecurity, a statistically significant difference in mean food insecurity scores between project and control households was no longer present. Instead, project households showed a trend towards experiencing less food insecurity. However, significant differences in mother's and children's egg consumption remained.

Table 1 shows how the project village households were impacted by Newcastle disease vaccinations. Although measurements of support for chicken vaccinations were weaker in project villages and were subsequently listed as a negative impact in Table 1, it may be that the methodology used to measure support did not accurately capture support for vaccinations. In regards to women's empowerment, although female heads of household in project villages tended to play a larger role in decision-making related to chicken and egg use than in control villages, it is difficult to determine the mechanisms behind these findings and in this cross-sectional study, it cannot be infered greater women's empowerment due to the vaccination project. Lastly, food insecurity is shown as both positive and no impact because project village households were only slightly less food insecure than the control village households.

Table 1. Summary of the impacts of chicken Newcastle disease vaccinations.

Measured Outcomes	Positive Impact	Negative Impact	No Impact
Household chicken numbers	X		
Income from chicken sales			X
Income from egg sales			X
Support for vaccinations		X	
Women's empowerment	X		
Chicken consumption			X
Egg consumption	X		
Food insecurity	X		X

Practical Implications

In general, the vaccination of chickens against Newcastle disease appears to have a beneficial impact for rural households involved in small-scale, indigenous chicken production. Households vaccinating their chickens have a larger number of chickens than non-vaccinating households, and show a trend towards less household food insecurity. Women and children from households vaccinating chickens consume eggs more frequently than non-vaccinating households, and women may enjoy greater autonomy and control over resources due to increases in chicken production. Additional beneficial impacts, such as increased income from chicken and egg sales and increased chicken consumption might not be noticeable initially, but may develop as time progresses and with continued chicken vaccinations.

A logical progression of events due to increased chicken survival may be as follows: 1) households begin to keep more chickens; 2) a larger number of eggs are collected and consumed; 3) when household egg consumption is satisfied, households begin to sell a greater number of eggs; 4) households begin to sell chickens due to a number of reasons, such as a limited capacity for keeping chickens, the need for money, or the access to markets and/or buyers; 5) thereafter, households may begin to consume more chicken either from household stocks or by purchasing them. If this progression is accurate, then the timing of this study may have come too early to notice changes in chicken sale and consumption *(at the writing of this brief, the AFS project is conducting a follow-up evaluation led by the author).*

An intervention as simple and inexpensive as vaccinating chickens for Newcastle disease can have a beneficial impact on the livelihoods and well-being of women, children and resource-poor farmers. To enable rural farmers to attain these benefits, policymakers and development practitioners can establish vaccination programs, facilitate farmers' access to vaccines and markets for chickens and eggs, and provide training and education to rural households on the best practices for chicken production and the nutritive value of consuming poultry, eggs and other animal source foods.

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About the Author: Danielle Knueppel, Jim Ellis Award Recipient 2007-2008, received her MSc. in International Agricultural Development from the University of California, Davis in the Fall of 2008. Her thesis, the subject of this brief, was conducted in collaboration with the Avian Flu School Project. She may be contacted by email: dknueppel@gmail.com.

Avian Flu School (AFS) was created to address the need for a train-the-trainer program to disseminate the knowledge necessary to minimize the health and economic impacts of H5N1 HPAI by improving the ability of a country, district or community to prevent, respond to, and recover from an outbreak. The project is led by Dr. Carol J. Cardona, University of California, Davis. Email: cjcardona@ucdavis.edu.

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GLOBAL LIVESTOCK CRSP

A Poultry Health Program for Developing Countries

Carol J. Cardona and David A. Bunn,
University of California, Davis; and Peter Msoffe,
Sokoine University of Agriculture
Avian Flu School Project

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The Poultry Health for Development project of Avian Flu School International was developed in response to the need among rural households for information about poultry health and disease management. Poultry is a vital resource for rural families and communities across Africa, particularly for the poor. Women and children at the village level often raise chickens, ducks, guinea fowl, and other poultry. The sale of eggs and chickens provides money to buy food during droughts, to purchase materials for the home, and pay for school fees and health care costs, in addition to providing meat and eggs for consumption. Unfortunately, as much as 80 percent of smallholder poultry in Africa die from poultry diseases, despite the existence of several cheap and effective vaccines and treatments. Therefore, improving poultry health extension services to help prevent and more effectively treat poultry diseases has tremendous potential to improve the livelihoods and the health of the rural poor in Africa. Training workshops in developing countries using the Avian Flu School curriculum revealed that in areas where poultry have heavy disease burdens, smallholder poultry keepers did not see the relevance of highly pathogenic avian influenza. The Poultry Health for Development curriculum developed by the Avian Flu School International provides a basis for the design and implementation of appropriate poultry health disease prevention strategies, by asserting that poultry owners can be engaged to protect their flocks when they understand the poultry health and management issues that must be overcome for their protection.

Background

More than 90% of the human population in the developing world depends on free-ranging poultry flocks as sources of food, and these flocks contribute significantly to food security. However, poor poultry disease management in developing countries compromises the benefits of poultry production for villagers and the rural poor. Historically, smallholder poultry producers have paid scant attention to the health of their flocks for several reasons:

- Historically, nothing happens when they report diseases to animal health authorities or there is little remedy which can be offered.
- Owners often do not realize or believe that poultry diseases can be prevented. Because Newcastle disease and other poultry diseases are so common, it may appear that heavy losses from disease are inevitable, so poultry keepers simply ignore or accept them.
- There may be little incentive to expend resources to control a disease outbreak in a population that the owner believes is going to die anyway.
- Many control strategies, such as culling sick birds, are unappealing because they result in less food security.

Methods. The Poultry Health for Development curriculum was designed to meet the need for information necessary to recognize, prevent, and control poultry diseases in developing countries.

The major project components are as follows:

Develop a poultry health curriculum. Program personnel developed a poultry health curriculum for training field veterinarians and paraveterinarians working in Africa specifically, but for developing countries more generally. The course was designed to be delivered over a five day period. Teaching modules were modeled on those used for Avian Flu School (AFS) and included interactive learning techniques and exercises. A full wet-lab was included in the course, providing trainees with instruction in personal health and safety, poultry handling techniques, external examination of birds for clinical signs and parasites, how to collect, pack, and ship diagnostic samples, as well as necropsy procedures, the recognition of lesions, and tissue collection methods.

Develop tools for clinical diagnoses of poultry diseases. A diagnostic decision-tree and disease chart were developed to assist animal health workers in identifying and diagnosing poultry diseases in the field. In addition, a handbook of poultry diseases with a focus on those important in Africa, was assembled, covering the major diseases and non-infectious conditions.

Conduct pilot course(s) with new poultry health curriculum. The course curriculum was pilot tested from July 14-18, 2008 at Sokoine University of Agriculture (SUA)

Table 1. The training curriculum modules, their themes and the specific lessons covered.

Module	Topic	Lessons
Module 1	Village and smallholder poultry production	Poultry benefits and challenges Introduction to fowl Managing production Marketing local chickens
Module 2	Diagnosing disease in poultry	Recognizing disease states Disease transmission Causes of clinical signs Causes of disease Investigating clinical cases Diagnosis—a systems approach Diagnostic procedures
Module 3	Disease prevention	Biosecurity on smallholder farms Biosecurity in villages Biosecurity for live bird markets Applying biosecurity to your own site Vaccinating poultry
Module 4	Community poultry health	Sensitizing local leaders Developing a poultry health plan
Module 5	Duck production and health	Duck production Managing ducks Marketing ducks and their products Diseases of ducks

in Morogoro, Tanzania. The course was facilitated by six experts: two from SUA, one each from the University of Ghana, Makarere University in Uganda, and the University of Nairobi in Kenya, and a private practicing poultry veterinarian from Togo. At the conclusion of the course, participants completed a course evaluation that included suggestions for improvement of the curriculum.

Major Findings

The responses of participants in the first pilot of the poultry health course were positive overall (Figure 1). When asked which parts of the curriculum were of the most value, 41% indicated that all parts were equally valuable, while 41% suggested the sections on disease prevention were of most value. Nine percent of the participants indicated that the module on ducks was the most important, and some comments suggested that more information on the diseases of turkeys should be included as well. Finally, 9% found the community poultry health module to be of the most value. Several participants specifically commented that disease prevention in village settings needed more time for discussion, and some commented that they would like to have more detailed information about how to implement community poultry health projects. Further comments from the participants suggested that additional materials on poultry marketing or enterprise management and ways to supplement poultry diets at little or no expense should be added. Several participants noted the value of the interactive exercises in the course, and suggested adding more exercises that focus more specifically on typical village poultry disease scenarios.

Discussion

In the delivery of avian influenza trainings to poultry owners in Africa, it was found that there was little enthusiasm for disease prevention measures when resources were scarce. In places where poultry have heavy disease burdens people are reluctant to invest in preventative strategies. In light of these obstacles, a community-based strategy was developed to vaccinate free-ranging poultry flocks with thermostable Newcastle vaccine. This strategy served two objectives:

1) To engage village leaders in the efforts.
2) To prevent the death of birds, thus changing how poultry owners viewed their flocks.

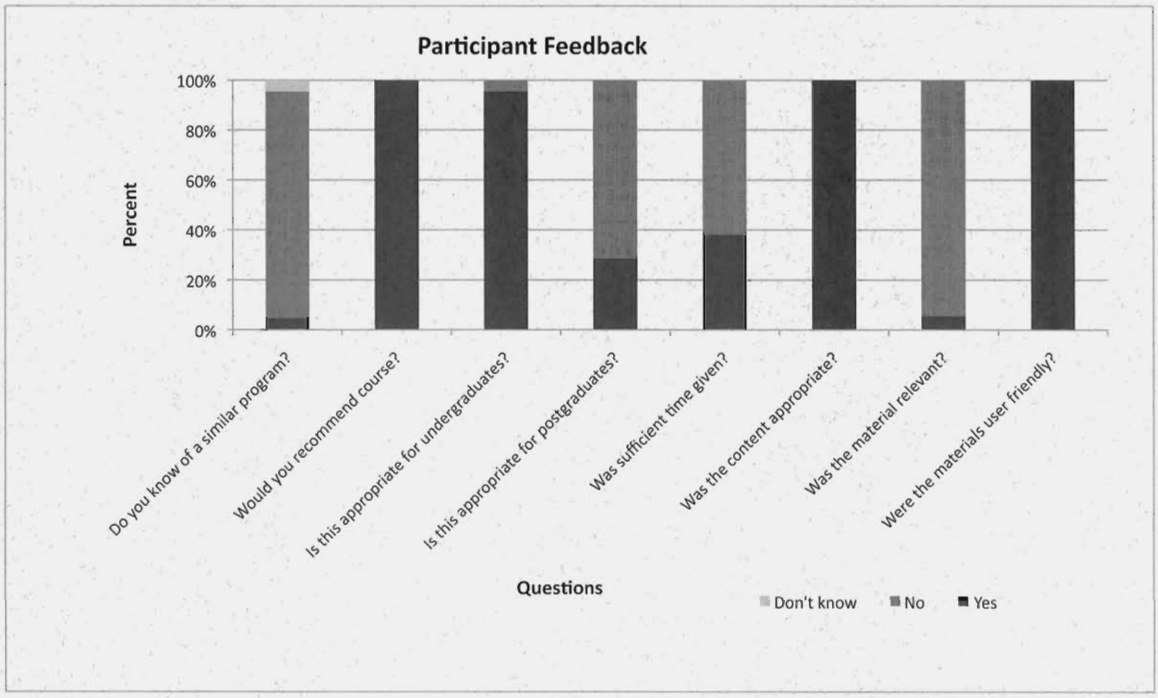
The subsequent phase of the strategy was to improve capacity in the veterinary and animal professional communities to recognize, diagnose, and treat poultry diseases. The poultry health course and handbook were developed as part of this latter phase in the program (Avian Flu School, *Forthcoming*).

Practical Implications

Historically, poultry production in the United States was complicated by high morbidity and mortality rates until vaccination for Marek's disease (a poultry disease causing paralysis and death) in 1970 gave producers the ability to prevent infection in their flocks. However, following the control of Marek's disease through vaccination, other poultry diseases became more evident. Similarly, the vaccination of poultry for virulent Newcastle disease in Africa may result in the appearance of new diseases that threaten poultry health, some of which may present human health threats as well. Poultry health must be considered comprehensively by the veterinary medical community rather than diseases being treated individually without a broad contextual framework.

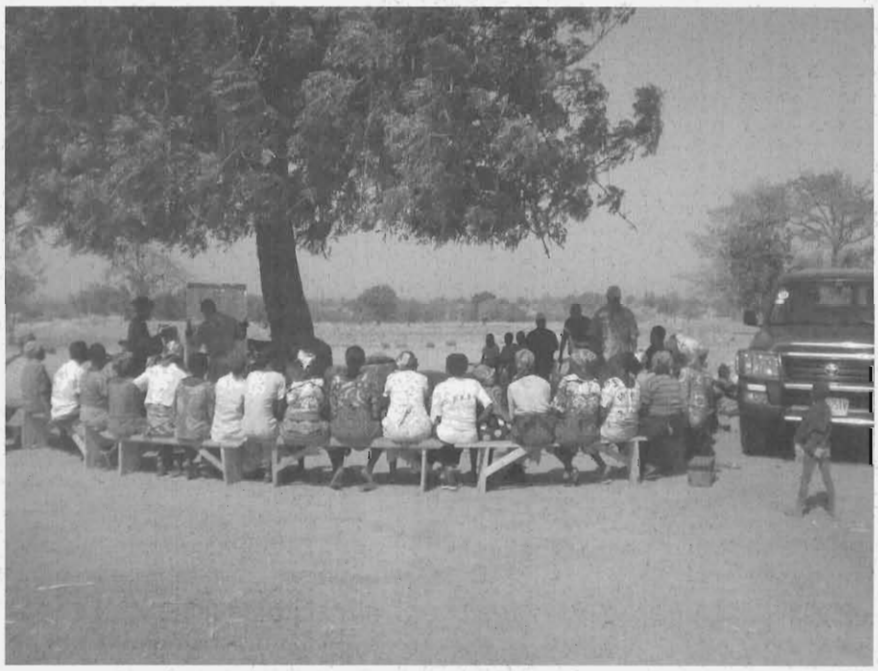
Poultry owners need to be provided with methods for protecting their flocks in ways they can understand

Figure 1. Evaluation of the first pilot of the Poultry Health for Development curriculum by participants.



and implement in the settings in which they live. Many recommendations for stopping the movement of HPAI H5N1 Avian Influenza in free-ranging populations of domestic fowl, for example, are too long-term to impact immediate needs in developing countries. Shifting poultry production to commercial facilities, especially in rural areas, is not possible within any reasonable time frame. Introducing cold storage to rural locations to reduce the need for local live chickens is also not achievable until critical infrastructure and economic obstacles are overcome. Eliminating village poultry would therefore have devastating consequences for the food security of rural households, as there is no equivalent food source with which to replace it.

The Poultry Health for Development curriculum developed by the Avian Flu School International provides a basis for the design and implementation of appropriate poultry health disease prevention strategies, by asserting that poultry owners can be engaged to protect their flocks when they understand the poultry health and management issues that must be overcome for their protection.



The Poultry Health for Development Program conducted village poultry health and production courses for women participating in the GL-CRSP Enhancing child Nutrition through Animal source foods Management (ENAM) Program in Ghana. Here, the women from the Navrongo ENAM community in northern Ghana are seated in the shade for the training course, which involved demonstrations of chicken and guinea fowl husbandry along with vaccinations. Photo by David Bunn.

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About the Authors: Dr. Carol J. Cardona, DVM, PhD, DACPV, has joint appointments in Cooperative Extension and in the Department of Population Health and Reproduction at the University of California, Davis. Email: cjcardona@ucdavis.edu. David A. Bunn, MS, is the Project Manager of the Avian Flu School, School of Veterinary Medicine, Wildlife Health Center, University of California, Davis. Email: dabunn@ucdavis.edu. Dr. Peter Msoffe, DVM, PhD, is a member of the Faculty of Veterinary Medicine at the Sokoine University of Agriculture. Email: msoffepl@suanet.ac.tz.

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GLOBAL LIVESTOCK CRSP

Implementing Poultry Vaccination and Biosecurity at the Village Level in Tanzania: A Social Strategy to Promote Health in Free-Range Poultry Populations

Peter Msoffe[1], David Bunn[2], Amandus Muhairwa[1], Madundo Mtambo[1], Hamsa Mwamhehe[3], Ayubu Msago[4], Malongo Mlozi[1], and Carol Cardona[2]
[1]Sokoine University of Agriculture, [2]University of California, Davis, [3]Veterinary Investigation Center, Tanzania, [4]Wildlife Conservation Society, Tanzania
Avian Flu School Project

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Local chickens are an important resource benefiting the livelihoods of impoverished people in developing countries. Household chicken production provides food and income and is an important component of food security for the rural poor. However, rampant poultry diseases, predation, and poor production practices are among hindrances to improving village poultry productivity. The human community structure in African villages provides the social setting necessary for collective action to prevent diseases among free-ranging poultry. The Newcastle Disease and Avian Flu Control (NDAFC) project was aimed at testing the effectiveness of a multi-level community approach to implement a Newcastle disease vaccination and general poultry health and management program in three districts in Tanzania. The project successfully trained 197 local leaders, 86 village chicken vaccinators and 196 farmers in three wards of Tanzania. The vaccination of 158,343 chickens in selected villages of the three wards substantially controlled Newcastle disease. This field research has confirmed the importance of local social and technical considerations in developing intervention strategies, the value of engaging local leadership, and the benefit of designing holistic rather than singular-purpose animal health programs.

Background

Local chickens are an important resource benefiting the livelihoods of impoverished people in developing countries. Household chicken production provides food and income and is an important component of food security for the rural poor. Selling local chickens is one of the few income-generating activities accessible to women in poor households. Local chicken production is a low input system requiring minimal investments to maintain. Chickens can even be raised in households without land, as they can be sustained through scavenging for sustenance between houses and on communal village land (Gueye 2000, Permin et al. 2001).

Rampant poultry diseases, predation, and poor production practices are among hindrances to village poultry productivity. Viscerotropic velogenic Newcastle disease (referred to hereafter as ND) and parasites have been identified as the major health threats to local chickens. It appears that the ecology of village chickens exposes them to ideal conditions for these health problems (Yongolo, 1996). Chickens from multiple households often congregate during scavenging to form one large sub-village or village flock, creating infectious disease exposure and transmission dynamics that are unique among poultry production systems, and where intervention strategies are difficult to apply.

While the human community structure in African villages allows for the co-mingling of household flocks (which creates biosecurity challenges), it may also provide the human social setting for collective action to prevent diseases and improve poultry production. In contrast to the social setting in North America, for example, where individual households are not prone to act collectively to improve animal production, village communities in Tanzania routinely act collectively (Msoffe personal communication, 2008). The community structure of the rural village setting in Tanzania is conducive to local collective action for implementing a community-based local poultry program, including a ND vaccination program.

The Newcastle Disease and Avian Flu Control (NDAFC) project was aimed at testing the effectiveness of a multi-level community approach to implement a Newcastle disease vaccination and general poultry health program in three districts in Tanzania. Authors hypothesized that successful intervention for disease control (animal or human) requires: 1) an approach that considers local social, economic, and biological settings; 2) community involvement; and 3) specific disease control efforts to be part of broader poultry health programs that address the priority diseases as measured by the community, as well as production and marketing problems faced by rural farmers.

Major Findings

Project outcomes were measured by: 1) assessing the number of people trained as a result of local leadership

engagement; 2) the numbers of birds vaccinated for ND; and 3) the change in status of ND in the villages after vaccination. A total of 197 leaders at district and ward levels were trained in the importance of village chickens, social and economic aspects of village poultry, an overview of avian influenza and other important poultry diseases, village poultry management, and their role in providing institutional support for the program. The trainees included all of the district veterinarians, agricultural extension staff, district councilors, ward education coordinators, ward/village executive officers, village chairpersons, and community development officers. The village and sub-village leaders selected vaccinator and recorder trainees. A total of 86 village chicken vaccinators were trained in three wards. In addition, 196 farmers were trained on similar topics as the local leaders, except that the training was presented as a drama, and project poultry experts answered farmers' questions. Three rounds of vaccination within a one-year period were conducted.

In total, 158,343 individual birds were vaccinated. The control of ND appeared to be effective. A survey conducted before the institution of the vaccination program found that an average of 53.1% household respondents in the three project wards reported an outbreak of ND in 2006. That number dropped to 15.7% in December 2007, after just one round of vaccination. During the data-recording period starting in December 2007, none of the farmers contacted reported outbreaks of ND in their flocks, indicating that the program was working.

Local Social and Technical Considerations Important for Effective Strategies. This project employed both social and technical strategies for implementing a program to improve poultry health. Limited household resources, the collective nature of the villages, the existing local governance structure and systems, and the ecological reality of free-ranging village chickens are the key features of the Tanzania rural setting that influenced project design.

Empowering Local Leaders Contributed to Success. Study results show that involving the local leadership in the planning and administration of the ND vaccination program was an effective approach--many people were trained and many chickens were vaccinated during the 18-month project period. But beyond these concrete measures of success, there were policies implemented which were prompted by preliminary indications of success before project outcomes were measured. Following the first two ND vaccinations, the Veterinary Investigation Centre for the Southern Highlands Zone organized district, ward, and non-governmental organization (NGO) leaders within the zone to utilize district and NGO resources to adopt an ND vaccination program throughout the area. The zonal program was launched with the declaration of May 5th 2008 as "Kuku Day" (chicken day) to initiate vaccinating chickens in all villages in the zone, which includes the Iringa, Mbeya, Rukwa and Ruvuma regions, covering a total of 24 districts. The coverage and impact of Kuku Day and the zonal ND vaccination program have not yet been appraised, but this action demonstrates a sense of ownership over the project and is a promising indication of the sustainability of the multi-level community approach to poultry health improvement. After the first year of the project period, leaders at all levels agreed to include ND vaccination in their planning and budgeting activities.

Social Structure of Villages is Conducive to Collective Strategies. This project was designed to take advantage of the established collective action of the village community to train and engage the village leadership as well as household poultry producers. The multi-level dimension of the project fully engaged the village leadership prior to training local vaccinators and households, instead of taking the more common approach of simply working directly with households (Yongolo et al., 1998). Early engagement of the village and sub-village leaders allowed them to exercise their normal leadership roles to mobilize the collective action of village residents. The training of local vaccinators and data-recorders contributed to technical capacity building that will remain in the local community after the life of the project.

Local Implementers Proved Effective. The vaccination and data recording carried out by local trained personnel was vital in giving the program a local familiar face. Farmers were inclined to interact with the local vaccinators more readily than if vaccinations were carried out by outside project staff or district staff. Training of farmers as well as vaccinators increased efficiency of the vaccination program because both parties were familiar with the issues and procedures. However, during the project, farmers were trained last, causing initial difficulties for the vaccinators and recorders working with them. These difficulties included explaining why the farmers had to vaccinate only healthy birds; why birds may die even after vaccination, hence farmers holding the vaccine suspect; and why records must be updated every week, among other issues. Most of the difficulties encountered by the vaccinators and recorders were significantly reduced after the farmers received training.

Holistic Approaches Addressing Priority Local Health Issues Are Likely to be More Sustainable. Successful programs for human or animal health require an inclusive, holistic strategy. In the setting of local poultry health in Africa, narrow approaches focusing only on ND, or focusing on disease prevention rather than the full range of poultry health and management skills, have had limited success. Other ND vaccination projects have reported early success, but later reported the emergence of other causes of poultry mortality as birds live longer (Yongolo et al.

1998). If farmers do not understand that ND vaccines only protect against ND or are otherwise unprepared for poultry diseases besides ND, confidence in the program falters when other diseases appear. A singular approach to preventing HPAI would likely have even less success because there is no short-term benefit to controlling an existing devastating disease like ND. Controlling HPAI and ND as part of a more holistic program to prevent poultry diseases and improving poultry husbandry has more promise for long-term success (Permin et al. 2001).

Novel Training Methods Engage Local Experience and Ideas. The authors found that novel training methods, which avoided traditional lecture-style presentations, were well received by the communities. In particular, the dramatic presentations delivered to village households were well received by the audiences, and deemed an effective way to present the material with non-traditional means. Additionally, interaction was encouraged in all courses. During the trainings, most participants shared personal experiences highlighting the importance of chickens for them. Some local leaders were also poultry farmers, and they also participated in these trainings. Farmers indicated that lack of knowledge had been the primary hindrance limiting their ability to improve poultry productivity, and they pledged to use their newly gained knowledge to improve production. Anecdotally, many trainees told trainers that the most useful part of the training was the briefing on poultry diseases and ways to control them, especially the concept of community disease control.

Practical Implications

The village community approach to poultry health management is well-suited to the ecological and social features of rural Tanzania. Ecologically, free-ranging chickens in a sub-village or village are essentially one flock, because they co-mingle during the day when searching for food. The principles of disease biosecurity necessitate that all of the households whose poultry co-mingle take collective action to prevent diseases in the village flock. Therefore, coordinated community action is imperative to improve the health of all poultry in the village setting.

Farmer Trainings Create a Local Disease Surveillance Network. At the village level, farmers' training implemented by the NDAFC identified the need to give trained project recorders additional training in poultry disease surveillance so that they can respond to village poultry health problems and report them to the extension agents. This cadre of trained recorders made disease identification and reporting effective and efficient. Decentralizing this task to the sub-village level will increase the likelihood that incidences of poultry diseases with high mortality and possible public health implications will be identified and reported early. This is important in the village settings of Tanzania where poultry interact freely with humans, especially children.

A Multi-Level Approach is Likely to be More Effective and Sustainable. Results from the NDAFC project suggest that engaging and training local leaders and

The Iringa District Commissioner injects a drop of the Newcastle disease vaccine into the eye of a village chicken on "Kuku Day" (Chicken Day), May 5, 2008. Kuku Day, organized by the Veterinary Investigation Centre for the Southern Highlands Zone, integrated district, ward, and non-governmental organization (NGO) leaders to utilize district and NGO resources to adopt a Newcastle disease vaccination program throughout the area. The zonal program, which includes the Iringa, Mbeya, Rukwa and Ruvuma regions and covers a total of 24 districts, was launched on Kuku Day with the objective of vaccinating chickens in all villages in the zone. Photo by Danielle Knueppel.

farmers, instead of engaging only government staff or individual households, will yield more effective and sustainable results for animal health. This kind of multi-level community approach may be practical and effective in many developing countries with grassroots social organizations like the village setting in Tanzania. The project demonstrates that it is particularly important to involve local leadership during planning and to give them a lead role during implementation of the program. Involving local leaders helps avoid conflicts with other development programs, especially infrastructural development in the villages. These leaders can also be of great assistance when setting up schedules for various development activities.

Implementing Effective Community Animal Disease Control Programs. Animal disease control programs in developing countries can be very difficult to implement. In developing countries generally and in Africa specifically, poverty and consequent lack of resources to apply interventions, are critical deficiencies. However, the existing community structure creates an environment for the implementation of community animal disease control programs that are simply not possible in many developed countries. Additionally, the close relationship of people to their sources of food and thus, their recognition of high priority problems like ND in poultry, gave project researchers the opportunity to capture community interest by solving a recognized problem. A poultry disease like ND, which affects community food security, ranks as a high priority in addressing community health.

Program Sustainability. Social and technical strategies are both very important to the success and sustainability of improving animal health in developing countries. The community structure in Africa utilized by the NCAFC project provides a basis upon which such strategies can succeed, especially when directed at a community asset like village poultry.

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About the Authors: Peter Msoffe, DVM, PhD, is a member of the Faculty of Veterinary Medicine at Sokoine University of Agriculture. Email: msoffepl@giant.suanet.ac.tz. Amandus Muhairwa, PhD, is a faculty member of the Department of Veterinary Medicine and Public Health, Sokoine University of Agriculture, Morogoro, Tanzania. Email: apm@giant.suanet.ac.tz. Madundo Mtambo, PhD, is a faculty member of the Department of Veterinary Medicine and Public Health, Sokoine University of Agriculture, Morogoro, Tanzania. Email: madundo@suanet.ac.tz. Hamsa Mwamhehe, DVM, is the District Veterinary Officer with the Ministry of Livestock Development and Fisheries, Southern Highlands Veterinary Investigation Center, Iringa, Tanzania. Email: vic@iringanet.org. Ayubu Msago is a field researcher of the Wildlife Conservation Society, Ruaha Landscape Program, Iringa, Tanzania. Email: auybuomsago@yahoo.com. Malongo Mlozi, PhD, is a faculty member of the Department of Agricultural Education and Extension, Sokoine University of Agriculture, Morogoro, Tanzania. Email: Daee@suanet.ac.tz. David Bunn, MS, is a field project manager for Wildlife Health Center of the University of California, Davis, and Project Manager of the Avian Flu School. Email: dabunn@ucdavis.edu. Carol J. Cardona, DVM, PhD, DACPV, is a member of the University of California, Davis faculty with joint appointments in Cooperative Extension and the Department of Population Health and Reproduction, and is the Principle Investigator for the Avian Flu School. Email: cjcardona@ucdavis.edu.

The Newcastle Disease and Avian Flu Control Project (NDAFC project) is a research sub-project of the Avian Flu School (AFS) project and was created to assess effective social and technical strategies for conducting Newcastle disease vaccination and preventing poultry diseases at the village level. The project is led by Dr. Carol J. Cardona. Email: cjcardona@ucdavis.edu.

The Global Livestock CRSP is comprised of multidisciplinary, collaborative projects focused on human nutrition, economic growth, environment and policy related to animal agriculture and linked by a global theme of risk in a changing environment. The program is active in East and West Africa, Central Asia and Latin America.

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GLOBAL LIVESTOCK CRSP

Avian Flu School Training-of-Trainers Program: An Effective Approach for Improved HPAI Prevention and Preparedness in Sub-Saharan Africa

A. Nicoli[1], D.J. Wolking[1], D.A. Bunn[1], G. Aning[2], S. Kiama[3], D. Byarugaba[4], P. Msoffe[5], and C.J. Cardona[1]
[1]University of California, Davis; [2]University of Ghana; [3]University of Nairobi; [4]Makerere University; [5]Sokoine University of Agriculture
Avian Flu School Project

Research Brief 10-01-AFS January 2010

To assess the impact of the Avian Flu School (AFS) training-of-trainers approach on knowledge dissemination, an AFS Evaluation Survey was administered in the Spring of 2009 targeting four countries where the AFS training-of-trainers course took place in 2007: Ghana, Kenya, Tanzania, and Uganda. The survey had two objectives: (1) to determine the number of people who received information about H5N1 highly pathogenic avian influenza (HPAI) through AFS training; and (2) to assess the extent to which the AFS instructors and trainees applied course knowledge to improve HPAI prevention or preparedness. In total, 80 respondents from the four countries participated in the survey. Results indicate that AFS succeeded in extending knowledge through a training-of-trainers approach, with nearly 60% of respondents affirming that they had conducted trainings in their own departments or organizations, and approximately 50% affirming that they had provided training to people outside their departments. Collectively, the respondents reported providing more than 150 multi-day trainings to others, extending the AFS curriculum to over 5,700 individuals. Respondents indicated that a broad array of people were impacted through the trainings, including veterinary medical professionals and students, animal extension agents, scientists, medical professionals, health workers, border agents, village leaders, poultry farmers and traders, livestock keepers, and school children. In addition, a large portion of the respondents (78%) reported sharing AFS course materials through channels outside of formal trainings, extending AFS's core educational message to an estimated 9,000 people, with the vast majority of those residing in Tanzania. In conclusion, the AFS project's training of trainers program is a model for an efficient approach to provide technical training to a large target audience over larger geographic regions. In this case, thousands of individuals received training on HPAI surveillance, prevention and outbreak response in a two-year period, thereby disseminating information from the national to the local levels.

Background

In response to the spread of H5N1 highly pathogenic avian influenza (HPAI) from southeast Asia in 2003, the Avian Flu School (AFS) project was initiated to assemble a multi-disciplinary team for the development of a curriculum targeting the people most affected by H5N1 HPAI, along with those most involved in its prevention and response (poultry producers, district level veterinarians, agricultural extension staff, medical doctors, public health workers, wildlife professionals, and those raising village poultry). AFS course material was developed using a 'train the trainer' model, a common approach for animal health, public health, and agricultural extension, structured into three tiers.

Tier I targeted health professionals and national officials from public health ministries and veterinary service departments; Tier II trainings, conducted by the trainees from Tier I, targeted parts of the curriculum relevant to the specific districts and organizations of the Tier I participants, with an intended audience consisting of zonal and district veterinarians, agricultural extension staff, practicing veterinarians, wildlife health managers, and public health workers, who then initiate Tier III trainings reaching their respective communities. This three-tiered training program incorporated an adaptable and interactive curriculum, allowing course customization to the needs of each respective audience. The AFS training-of-trainers program was launched as a pilot program at the University of California, Davis, Texas A&M University, and the Sokoine University of Agriculture, Tanzania in August 2006. Based on a series of outstanding evaluations and positive feedback from the pilot, AFS was extended across sub-Saharan Africa, conducting the official three-tiered program in Ghana, Kenya, Tanzania, and Uganda in 2007.

To assess the impact of the AFS training-of-trainers approach on knowledge dissemination, an AFS Evaluation Survey was administered in the spring of 2009 targeting the four African countries where the AFS training-of-trainers course took place. The survey had two objectives: (1) to determine the number of people who received information about H5N1 HPAI through AFS training; and (2) to assess the extent to which the AFS instructors and trainees applied course knowledge to improve HPAI prevention or preparedness. In total, 80 respondents from the four countries participated in the survey (Table 1).

Table 1. Survey respondents by country.

Country	No. of Respondents
Ghana	14
Kenya	27
Tanzania	11
Uganda	28
Total	80

Findings

Over 40% of the respondents (AFS trainees) indicated that they learned key points in several categories of information, as shown in Table 2. The project succeeded in extending knowledge through a training-of-trainers approach. Nearly 60% of the original University of California, Davis trainees (survey respondents) affirmed that they had conducted trainings in their own departments or organizations, and half affirmed that they had provided training to people outside their departments. Collectively, the respondents indicated that they provided more than 150 multi-day trainings to others, reaching over 5,700 people (Table 3). Trainings were provided in over 40 locations (towns, regions, or districts) within their departments, and nearly 60 locations outside of their departments.

A broad array of individuals were impacted through trainings provided by respondents, including all AFS originally intended audiences: veterinary medicine professionals and students, animal extension agents, wildlife researchers, poultry farmers and traders, village leaders, farmers, scientists, medical professionals, health officers, health workers, inspectors, border agents, livestock keepers, fishermen, and school children. In trainings conducted both within and outside their organizations, respondents most frequently used AFS materials pertaining to disease transmission, surveillance, and improving biosecurity, though the training manual was cited as the most frequent component of AFS materials used in their courses.

A large portion of the respondents (78%) indicated that they had shared AFS course materials in other ways than through a formal training course. As a result of formal and informal training and sharing of AFS materials, an estimated 9,000 individuals were reached, the vast majority through the efforts of respondents in Tanzania.

Respondents further indicated that the AFS course impacted their practices at work; 74% reported changing their methods or procedures as a result of information learned at the trainings. "Protecting human health" and "improving biosecurity/outbreak response" were the main areas of improvement to their work practices mentioned by respondents, followed by "teaching techniques". Survey participants were also asked if their organizations or departments had made changes to any guides, instructions, or protocols in a number of specific areas of practice based upon information they learned in the course. Table 4 summarizes the frequency with which respondents affirmed such organizational/institutional changes.

When asked about changes in guides, instructions or protocols regarding bird surveillance within the respondents' organization or department, there was an apparent increase in levels of information dissemination and reporting, with an increase in teaching emphasized by the Kenyan respondents. With regards to changes made to guides, instructions, or protocols on human health following the course, 40% of respondents replied that changes had been made, while respondents from Uganda and Kenya offered the most feedback particularly on the application of hygiene practices involving the protection and transportation of birds, the protection and disinfection of poultry caretakers following animal handling, and the general observance of hygiene practices by live bird dealers when handling poultry. Additional comments addressed communicating healthy practices outside respondents' own organizations, with cooperation between government departments, trainings, and information dissemination mentioned as achievements.

AFS training courses have also impacted biosecurity. Twenty percent (20%) of respondents indicated that biosecurity regulations of some kind were developed or more vigilantly enforced at live-bird markets or at poultry farms or sites. In Ghana, live bird dealers and poultry farmers were reportedly sensitized and are now more aware of the need for biosecurity in their work place; in Uganda, lobbying efforts targeting civic leaders/municipal authorities have been initiated to establish an isolated place for live bird markets; and in Tanzania, regulations have reportedly been developed to manage and register all hatcheries and establish requirements for poultry farms and hatcheries.

Finally, 35% of respondents reported that changes had been made within their organization or department to guides, instructions, or protocols regarding diagnostic sampling

Table 2. Categories of key points learned in AFS trainings.

Learning category	Percent (%)
Disease transmission	71
Surveillance	55
Protecting human health	49
Sample collection	45
Improving biosecurity	39
Improving outbreak response	34

Table 3. Summary of details on trainings conducted by respondents.

	Within department/ organization			Outside department/ organization			Total*		
	Total	Ave	%	Total	Ave	%	Total	Ave	%
Trainings conducted	72	--	--	80	--	--	152	--	--
Distinct locations	44	--	--	58	--	--	--	--	--
No. of participants	2,071	29	--	3,637	45	--	5,708	38	--
No. of course days	150	2.1	--	137.5	1.7	--	287.5	1.9	--
Course evaluated - yes	23	--	32	23	--	29	46	--	30

*Includes training conducted by respondents both within their department/organization and outside of department/ organization.

procedures. Of these, 13% improved sample collection by making changes to specific sampling practices; 3% improved marking on samples; 3% increased lab stock and 3% improved transport of samples.

Respondents also suggested a variety of additional topics, or an expansion on the discussion of topics covered by the Avian Flu School, primarily through an expansion of the topic "communication with the public". Additional suggestions included: incorporating H1N1 (swine flu) information into the course; more information on poultry health and management; how to improve biosecurity among extensively managed chickens; more information on wild bird behavior and risk in the spread of HPA1 to livestock/domestic poultry; development of a summary module of the course which can be delivered to technical personnel; a more participatory approach of taking trainees to the field to try out practices; simulation exercises in response planning at the district level; and simplified trainings designed for farmer attendance.

Practical Implications

Addressing animal pandemic diseases like H5N1 highly pathogenic avian influenza requires a coordinated and multidisciplinary approach that integrates national and regional level disease surveillance, prevention, and response efforts within a local context typically hosting high-risk populations. In the case of avian influenza, this means broadcasting specific disease education and training messages to a broad array of stakeholders from policy-makers and district level veterinarians to village level live bird markets and backyard poultry producers. The training-the-trainers approach by design, is a pyramidal structure that when initiated spawns a multiplier effect throughout targeted audiences and beneficiaries, and when properly implemented, ensures that consistent messages and information are received from producers/consumers to decision-makers.

The Avian Flu School's implementation of this training-the-trainer approach is a model for an efficient approach to provide technical training to a large target audience over larger geographic regions. In this case, thousands of individuals received training on HPAI surveillance, prevention and outbreak response in a two-year period, thereby disseminating information from the national to the local levels. While this evaluation captured and quantified a component of the AFS training program's impact, other implications of AFS success are in part immeasurable; in Ghana, integrative AFS trainings have been associated with the effective control of three avian influenza outbreaks, a marked improvement over an outbreak in 2005 when the poultry industry nearly collapsed (Coppolillo et al., 2010).

Furthermore, the capacity enhancements supported by the training-the-trainer approach both at the individual and institutional/organizational level have provided a platform for the continued exchange of information across various levels and disciplines. These linkages will allow for the broadening of the program's scope to address other emerging pandemics like H1N1 (swine flu), if provided

Table 4. Respondents indicating their organizations or departments had made changes to guides, instructions, or protocols.

Areas of change in organizations' guides, instructions, or protocols	Yes (%)	No (%)	Total
Bird surveillance	33 (42)	45 (58)	78
Human health	30 (39)	47 (61)	77
Improving biosecurity at live bird markets or other poultry site	29 (39)	46 (61)	75
Avian flu outbreak response preparedness	42 (55)	35 (45)	77
Diagnostic sample collection procedures	27 (35)	50 (65)	77

with appropriate investments in curriculum and educational programming. Despite the success of the AFS program, the potential for the training-the-trainer approach in preventing and controlling animal and human pandemics remains largely untapped; an opportunity not to be missed by growing donor and development community interest in addressing emerging pandemics.

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About the Authors: Andra Nicoli, MA, is an Evaluation Analyst in the Center for Education and Evaluation Services (CRESS Center), Department of Education, University of California, Davis. Email: amnicoli@ucdavis.edu. David Wolking, MSc, Jim Ellis Award Recipient 2007-2008, is the Lead Writer and Editor for the Global Livestock CRSP at the University of California, Davis. Email: djwolking@ucdavis.edu. David A. Bunn, MSc, is the Project Manager of the Avian Flu School, School of Veterinary Medicine, Wildlife Health Center, University of California, Davis. Email: dabunn@ucdavis.edu. Dr. George Aning, DVM, PhD, is a Professor in the Animal Science Department at the University of Ghana. Email: gkwameaning@yahoo.com. Dr. Stephen G. Kiama, BVM, MSc., PhD, is a Professor in the Department of Veterinary Anatomy and Physiology at the University of Nairobi, Kenya. Email: kiama123@yahoo.com. Dr. Denis K. Byarugaba, BVM, MSc, PhD, is a Lecturer and Laboratory Director at the Makerere University Walter Reed Influenza Research Laboratories in the Department of Parasitology and Microbiology, Faculty of Veterinary Medicine, Makerere University, Uganda. Email: dkb@vetmed.mak.ac.ug. Dr. Peter Msoffe, DVM, MVSc, PhD, is a Professor in the Faculty of Veterinary Medicine at the Sokoine University of Agriculture, Tanzania. Email: msoffepl@suanet.ac.tz. Dr. Carol J. Cardona, DVM, PhD, DACPV, has joint appointments in Cooperative Extension and in the Department of Population Health and Reproduction at the University of California, Davis. Email: cjcardona@ucdavis.edu.

Avian Flu School (AFS) was created to address the need for a train-the-trainer program to disseminate the knowledge necessary to minimize the health and economic impacts of H5N1 HPAI by improving the ability of a country, district or community to prevent, respond to, and recover from an outbreak. The project is led by Dr. Carol J. Cardona, University of California, Davis. Email: cjcardona@ucdavis.edu.

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GLOBAL LIVESTOCK CRSP

Socio-economic Impact of Chickens Vaccinated against Newcastle Disease in Rural Communities of Mvomero District, Morogoro, Tanzania

Jacob Msuya, Jim Ellis Award Recipient 2008-2009, Sokoine University of Agriculture

Avian Flu School Project

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The Newcastle Disease and Avian Flu Control Project (NDAFCP) was initiated in several rural wards in Tanzania for the purpose of researching and implementing a sustainable Newcastle disease (ND) vaccination program while developing strategies for preventing Highly Pathogenic Avian Influenza (HPAI) at the village-level. The main goals of the NDAFCP were to pilot and assess training and extension methods for implementing a sustainable poultry vaccination program, and evaluating strategies for improving village poultry biosecurity. Following the initiation of the NDAFCP in several villages in Tanzania, this study was developed to assess the socio-economic impact of chickens vaccinated against ND in the rural communities of Mvomero District in Morogoro, Tanzania. A total of 180 households participated in the survey. Preliminary findings suggest that households do recognize the importance of raising local chickens for socio-economic advantage. In addition, the majority of respondent households perceived the ND vaccination program as beneficial to their general well being. However, a deepened dependency on external support for assistance with ND vaccines continues to hinder the independent development of local chicken production. Respondents indicated signs of readiness to contribute monetarily for the vaccine, but their assumption that the project will continue to facilitate free vaccination raises questions about the sustainability of ND vaccinations following the conclusion of the NDAFCP. It is recommended that additional methods to support the involvement of households in the ND vaccination programs be explored to continue facilitation of avian influenza prevention, control, and biosecurity objectives, but with greater emphasis on outreach and education to demonstrate the benefits of the program.

Background

In rural areas, particularly in sub-Saharan Africa, small-scale family-based poultry production offers a practical and effective means for income generation and poverty alleviation, especially among women and resource-poor farmers. In addition, village poultry provide an important source of high quality nutrition and income with very little cost or management. Improving poultry production therefore, has considerable potential from a rural development and livelihood enhancement perspective. Yet production improvements in rural areas among the resource poor are limited by several constraints, among them disease.

Viscerotropic velogenic Newcastle disease (ND) is caused by a virus and can cause up to 90% mortality in unprotected flocks (Sonaiya and Swan, 2004). There are several vaccines currently available that have been demonstrated to significantly reduce morbidity and mortality rates in chickens, among them the I-2 vaccine, which due to its low cost, local production in Tanzania, and easy administration by eye-drop is particularly useful among rural poultry operations (Ahiabor, 2010).

The Newcastle Disease and Avian Flu Control Project (NDAFCP), is a sub-project under the GL-CRSP funded Avian Flu School, researching improvements in poultry health and production, and avian flu control strategies in rural Tanzania (Msoffe and Cardona, 2008). The NDAFCP initiated ND vaccinations in three project villages in the rural Iringa Region of Tanzania in 2007. An impact assessment conducted on the vaccination program in 2008 revealed that the program had a beneficial impact on the livelihoods of women, children, and resource-poor farmers, as households involved in the program kept more chickens than households in control villages, program households more frequently consumed eggs than those in control villages, and women in NDAFCP villages reported higher measures of empowerment along with a trend towards less food insecurity (Knueppel, 2009).

Along with the NDAFCP in the Iringa Region, an additional NDAFCP program was piloted among rural communities in the Mzumbe ward, Mvomero District, Morogoro, Tanzania. The project targeted all villages in Mzumbe: Sangasanga, Tangeni, Vikenge, Lubungo, Changarawe, Mafuru, and Kimambila. Following completion of the vaccination program, the need arose to assess the socio-economic impact of the NDAFCP, enabling a comparison to the previous evaluation conducted in Iringa. This study was developed to conduct a separate assessment in Mzumbe, by investigating the

Figure 1. A hen and her chicks scavenge for food around a village in rural Tanzania. The Avian Flu School's Newcastle Disease and Avian Flu Control Project (NDAFCP) is implementing vaccinations for Newcastle disease throughout sub-Saharan Africa, drastically reducing poultry morbidity and mortality associated with the disease in rural areas, and improving poultry productivity for village producers. Photo by David Bunn.

contribution of local chickens to the socio-economic status of village households, the social structure and relations within and among households, household perceptions of ND vaccination, and actions adopted or proposed locally for the sustainability of the program. This research brief presents the methodology utilized for the assessment, along with preliminary findings.

Methods. A survey instrument (questionnaire) was developed to conduct the assessment. The questionnaire was piloted for four days during the first week of July 2009 among 15 respondents in the Sangasanga village, which was selected for the pilot based on its location at the center of the seven villages where the NDAFCP was active. Feedback from the pilot led to questionnaire improvements for the launch of the main household survey activity.

Household surveys began in July 2009 and continued until September. The survey sample targeted a total of 180 household participants, including 26 from Sangasanga, 23 from Vikenge, 30 from Tangeni, 35 from Kimambila, 36 from Lubungo, 17 from Mafuru, and 13 from Changarawe. Following the survey, focus group discussions (FGD) involving eight participants were conducted for two weeks in each village, except for Mafuru and Changarawe where three FGDs were conducted.

Preliminary Findings

Preliminary findings from both the survey and FGDs show that households do recognize the importance of raising local chickens for certain socio-economic advantages, and that most of the households perceived the ND vaccination program as beneficial to their well-being. It was observed that chickens are used by respondents primarily for social purposes, both within and among households. For example, when hosting visitors, or when money is needed to solve household emergencies like sickness, chickens are considered valuable for helping families meet their obligations.

Despite the apparent advantages of ND vaccinations among the villages, deepened dependency on external support for assistance with ND vaccines continues to hinder independent development of local chicken production. Respondents indicated readiness to contribute monetarily for the vaccine, but their assumption that the project would continue to facilitate free vaccination raises questions about the sustainability of ND vaccinations following the conclusion of the NDAFCP.

Practical Implications

Findings from this study support the conclusions from the initial NDAFCP assessment by Knueppel (2009), that ND vaccinations are largely beneficial to the livelihoods of rural households. Along with the direct benefits obtained through decreased chicken morbidity and mortality achieved through the vaccinations, participants in the NDAFCP in Mzumbe ward have the potential to experience similar indirect advantages seen in Iringa, including diminished food insecurity and female

empowerment. Yet these advantages will remain short-term, unless issues surrounding the sustainability of ND vaccinations following the completion of the NDAFCP are resolved.

Sustainability of the ND vaccination program is a fundamental component in achieving improved avian influenza prevention and control, and is seen as critical for enhanced biosecurity (Msoffe and Cardona, 2008). While these objectives are viewed as intrinsically beneficial from a veterinary and public health perspective, it is possible that to rural households like those in Mzumbe and Iringa, this message requires additional reinforcement, which the socio-economic benefits can provide. As this study has shown, households participating in the ND vaccination program appear reluctant to contribute monetarily to continued vaccinations, a finding supported by Knueppel (2008), which reports that in Iringa, measurements of support for chicken vaccinations were lower in NDAFCP villages when compared to the unvaccinated control villages. While it is possible that following the completion of the NDAFCP in the villages, households deciding to terminate chicken vaccinations may be encouraged to continue at the first indication of elevated morbidity/mortality, or the first ND outbreak, this scenario is best avoided, especially from an avian influenza prevention and control perspective. Instead, it is recommended that alternative methods to support the continued involvement of households in the vaccination programs be explored, with greater emphasis on outreach and education, along with sharing the results of impact assessments like this study, which demonstrate the benefits of the program.

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Figure 2. A man markets his poultry in a local market in Tanzania. In rural areas, baskets like these are used to hold the chickens. Newcastle disease vaccinations provided to producers in rural villages in Tanzania are increasing incomes and improving well-being. Photo by David Bunn.

About the Author: Jacob Msuya is a graduate student in the Department of Rural Development at the Sokoine University of Agriculture in Tanzania, and a Global Livestock Collaborative Research Support Program Jim Ellis Award Recipient 2008-2009. Mr. Msuya's thesis, the subject of this brief, was conducted in collaboration with the Avian Flu School. He may be contacted by phone: +255 784 919592.

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Socio-economic Impact Assessment of the Newcastle Disease and Avian Flu Control Project in Selected Villages of Ufukoni Ward, Mtwara, Tanzania

Gibonce Kayuni, Jim Ellis Award Recipient 2008-2009, Sokoine University of Agriculture

Avian Flu School Project

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Ways and means to improve free range local chicken (FRLC) production through different programs and projects have been studied in Tanzania, but their socio-economic impact on rural households and communities is unknown. In response, this study was initiated to investigate the socio-economic impacts of the Newcastle Disease and Avian Flu Control Project's (NDAFCP) vaccination program on selected villages in the Ufukoni Ward, Mtwara, Tanzania. Findings demonstrate that NDAFCP interventions had a significant impact on local practices towards disease control and breeding, a change of knowledge in feeding, and a change in FRLC management practices. In addition, NDAFCP participants experienced an increase in total household income, and improved household food security due to increased production of FRLC and eggs when compared to a control. Furthermore, income derived from the increased productivity tended to remain under the control of women household members, the primary caretakers of FRLC. In conclusion, the vaccinations provided to FRLC through the NDAFCP had a positive impact on improving production, food security, and livelihoods of program participants. However, sustainability of vaccinations in the long-term continues to be an issue. Unless these communities can be convinced that the benefits of ND vaccination far outweigh the costs, the gains in livelihood enhancement, poverty alleviation, and women's empowerment may be lost, along with the considerable investments in research and resources by NDAFCP and Tanzanian personnel.

Background

In Tanzania, village chickens play an important role in the livelihoods of rural populations (Yongolo, 1996), and losses in poultry often negatively impact the livelihoods of the poor rural communities that rely on them for meat and eggs. Village free range local chicken (FRLC) production, common in the region, represents significant challenges to the implementation, effective prevention, detection, and outbreak response strategies for Highly Pathogenic Avian Influenza (HPAI), and for viscerotropic velogenic Newcastle disease (Mukiba-Muka, 1991). Newcastle disease (hereafter referred to as ND) is a complicating factor for the field diagnosis of HPAI (Minga et al., 1996), as clinical signs in chickens for ND and HPAI are similar (Beard and Hanson, 1990). Vaccinating for ND can increase chicken flock performance in terms of number and productivity, and make it easier to detect HPAI.

Newcastle disease control and its vaccination have long been implemented globally. In Tanzania, many efforts have been implemented to combat ND since the 1970's, including vaccinations using live lentogenic (LaSota, F strain), live mesogenic (Roakin, Kamarov, V4 and H vaccine), and velogenic-inactivated vaccines (Alexander, 2001). While attempts to control ND have received considerable attention in Tanzania, very little is known about their subsequent socio-economic impact, especially among communities that keep local chickens (Mtwara Urban District Council, 2005).

The Newcastle Disease and Avian Flu Control Project (NDAFCP), is a sub-project under the GL-CRSP funded Avian Flu School, researching improvements in poultry health and production, and improvements in avian flu control strategies in rural Tanzania. The NDAFCP is in line with various policies and ongoing government reform programs (Millennium Development Goals, the National Strategy for Growth and Reduction of Poverty, and the 2025 National Vision), which aim to improve the food security of households, alleviate household poverty through economic development, and empower and improve the livelihoods of women.

The NDAFCP initiated ND vaccinations in three project villages in the rural Iringa Region of Tanzania in 2007. An impact assessment conducted on the vaccination program in 2008 revealed that the program had a beneficial impact on the livelihoods of women, children, and resource-poor farmers, as households involved in the program kept more chickens than households in control villages, program households more frequently consumed eggs than those in control villages, and women in NDAFCP villages reported higher measures of empowerment along with a trend

towards less food insecurity (Knueppel, 2009). Through the NDAFCP, a series of vaccinations were also provided to villages in the Mtwara Region of Tanzania, where they were accompanied by trainings of livestock extension officers. Despite the success of ND vaccination project in the control of Newcastle disease in FRLC in Mtwara, there remained a death of information on the program's socio-economic impact. In response, this study was developed to assess community attitudes, benefits, and costs of vaccination, along with any changes in poultry production, and the general contribution of the campaign to changes in community livelihoods.

Findings

Profitability obtained from selling FRLC. Respondents sold their FRLC and eggs to middlemen, *mamalishe* (a local food vending site, also used to refer to women who work at such sites), the village market, and neighbors. Prices of FRLC and eggs varied according to location, season, size of the bird, and market channel. The average price for FRLC in the NDAFCP area was approximately Tanzanian Shillings (Tsh) 4,918 (USD 1.00 = app. Tsh 1,335), compared to Tsh 3,583 in the unvaccinated control area (Table 1), suggesting that respondents in the project area are conscious of the improvements in FRLC production and their subsequent production costs, and seem to have an improved knowledge of marketing. The majority of respondents (79%) also reported having more FRLC and eggs following their enrollment in NDAFCP, which is associated with improved FRLC production knowledge due to extension trainings, and maintaining the recommended disease vaccination pattern.

Effect of the project intervention on the respondents' knowledge, attitude, and practice towards FRLC production and sustainability. It was assumed that respondents' attitudes towards FRLC production, which included production for home consumption, production for petty cash, or production for commercial purposes, would influence FRLC management and eventually production. Study results, however, show that respondent attitudes towards FRLC production were not influenced by NDAFCP interventions; 85% of respondents (102) considered FRLC production as a supplementary enterprise, as opposed to a possible primary income-generating opportunity. However, the interventions did influence a change in practices towards FRLC production, as respondents shifted from a scavenging to the recommended combined scavenging and intensive system, demonstrating that the FRLC production improvement program had a significant impact on the acquired level of knowledge for FRLC management, and in improving knowledge of husbandry, disease control, and breeding. Program interventions did not improve the sustainability of vaccinations for FRLC against Newcastle disease.

Knowledge towards avian influenza and other diseases. Ninety-five percent (95%) of respondents (114) said that they were aware of avian influenza, having obtained information on NDAFCP seminars and the media. Findings also show that 60% (72) of respondents in the project area mentioned the occurrence of fowl pox primarily after using ND vaccines, while in the control area, fowl pox was not reported as a problem. Study investigations into fowl pox among respondent households in the NDAFCP villages revealed that young chicks (up to eight months) were the main affected group (Figure 1), implying that there may be a relationship between ND vaccination and fowl pox. This linkage may be caused by the inadvertent transfer of pox virus by ND vaccinators. When they touch the eye of a pox-infected chicken and then touch the eye of a naïve chicken during ND eyedrop vaccination, pox is transferred. This linkage suggests there is a need for additional biosecurity training for vaccinators.

Contribution of the Newcastle disease vaccination to household food security. In the study area, households kept more chickens and collected more eggs, mainly for household consumption. This interpretation is supported by self-

Table 1. Profitability of the NDAFCP in Ufukoni and Likombe wards, Tanzania.

Project Profitability			
Location (Village)	**Mean price (Tsh*)**	**Minimum price (Tsh*)**	**Maximum price (Tsh*)**
Project area (Ufukoni Ward)			
Naliendele	6,500.00	10,000.00	3,000.00
Mbae	4,250.00	6,000.00	2,500.00
Mkangala	4,000.00	5,500.00	2,500.00
Control area (Likombe ward)			
Mangambo	5,500.00	2,500.00	4,000.00
Mtawanya	4,500.00	2,500.00	3,500.00
Likombe	4,000.00	2,500.00	3,250.00

* USD 1.00 = approximately Tsh 1,335.00.

Figure 1. A chicken infected with fowl pox. Study findings show that 60% of respondents mentioned the occurrence of fowl pox after using Newcastle disease vaccines, with young chicks characterizing the main affected group. The linkage between ND and fowl pox may be caused by the inadvertent transfer of pox virus by ND vaccinators, who may touch the eye of a pox-infected chicken and then touch the eye of a naïve chicken during ND eyedrop vaccination, thus transferring the pox. This linkage suggests there is a need for additional biosecurity training for vaccinators. Photo by G. Kayuni.

reported household data, indicating a greater increase in egg production over the past year in the project area when compared to the control. With regard to the frequency of egg consumption, it was found that mothers consuming more chickens and eggs were associated with an increase in chicken and egg consumption among their children. There were also indirect benefits associated with NDAFCP interventions, such as the use of FRLC manure as feeds for fish and as manure in gardens, improved production in agriculture activities leading to improvement in family income, and in general, improved food security. Other indirect benefits reportedly obtained included the use of income generated from FRLC to buy other food items and agricultural inputs, which led to increases in production and improvements in overall farmer welfare. Therefore, improvements in FRLC production were associated with improved household food security as income and chicken and egg consumption increased.

Participation of men and women in the implementation of ND vaccinations. In the majority of study households (88.4% of NDAFCP households, and 87.3% of control households), women were reported as the primary caretakers of household chickens, though males tended to play a larger role in deciding whether to eat or sell chickens and eggs. Female heads of households in both project and control villages tended to keep income from chicken and egg sales.

Practical Implications

It is evident from this study that the NDAFCP has provided direct and identifiable benefits to program participants. The combination of disease vaccination and extension education programming has led to production improvements in free ranging local chicken production, along with improvements in management and marketing. Indirect benefits from the program seem to have also improved farm production. In addition, increased chicken and egg production associated with the program has positively impacted chicken and egg consumption among mothers and their children. Together, these changes drive a positive feedback loop leading to enhanced rural livelihoods through increased income and food security. These findings are supported by a similar impact assessment conducted on the NDAFCP program in the Iringa Region of Tanzania (Knueppel, 2009).

Despite these apparent advantages, however, respondents appear reluctant or uninterested in shifting FRLC from a supplementary livelihood activity to a primary income generating opportunity. It is possible that gender is a factor, as women are primarily responsible for poultry production in the study area yet do not control household income or decision-making over consumption and marketing. There is considerable potential for supporting the transition to more intensive poultry production throughout the study area, as NDAFCP participants have adapted management practices during program participation. Efforts addressing continued socio-economic benefits of ND vaccination should encourage the continued adoption of management improvements, along with encouragement of poultry production as a primary livelihood option, especially among female-headed households, whose control of poultry production and marketing could yield significant benefits to poverty alleviation and food security.

The primary objective of the NDAFCP was to introduce Newcastle disease vaccinations to improve avian influenza prevention and control to villages. Based on the relatively

stable vaccination pattern demonstrated in this study, along with the high reported awareness of avian influenza, the program has been a success. Yet as noted in the findings, sustainability of vaccinations in the long-term continues to be an issue. In a similar impact assessment of the NDAFCP in the Mvomero District of Tanzania by Msuya (2010), sustainability was also a concern, due to a deepened dependency on external support for assistance with ND vaccines that hindered independent development of local chicken production in the study area. Unless these communities can be convinced that the benefits of ND vaccination far outweigh the costs, the gains in livelihood enhancement, poverty alleviation, and women's empowerment may be lost, along with the considerable investments in research and resources by NDAFCP and Tanzanian personnel. While the documentation of NDAFCP benefits provided by this study and other assessments have provided a basis for education and outreach targeting adoption of ND vaccination by local communities, additional investments are required to ensure that NDAFCP progress is not lost upon the completion of the program.

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About the Author: Dr. Gibonce A. Kayuni is a graduate student in the Department of Rural Development at the Sokoine University of Agriculture in Tanzania, and a Jim Ellis Award Recipient 2008-2009. Dr. Kayuni's thesis, the subject of this brief, was conducted in collaboration with the Avian Flu School. He may be contacted by Email (kayunij@yahoo.com), Phone (+255 784 421010), or Post (P.O. box 320, Kyela, Mbeya, Tanzania).

Avian Flu School (AFS) was created to address the need for a train-the-trainer program to disseminate the knowledge necessary to minimize the health and economic impacts of H5N1 HPAI by improving the ability of a country, district or community to prevent, respond to, and recover from an outbreak. The project is led by Dr. Carol J. Cardona, University of California, Davis. Email: cjcardona@ucdavis.edu.

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GLOBAL LIVESTOCK CRSP

Enhancing Production of Local Chickens through Newcastle Disease I_2 Vaccine in the Techiman District of Ghana

Patrick Ahiabor, Jim Ellis Award Recipient 2008-2009, University of Ghana, Legon

Avian Flu School

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Vaccination trials were carried out to determine the spread and efficacy of the Newcastle Disease I_2 vaccine (NDV-I_2), a thermally stable vaccine option for rural communities which may lack cold chain capabilities and that can be administered by eye-drop. The trials were conducted in local chickens in the laboratory, and in scavenging chickens in the Techiman Municipality of Ghana. In the laboratory experiment, 40 young local birds were vaccinated with either NDV-I_2 or the LaSota vaccine, and comparisons of vaccinated, unvaccinated, and unvaccinated in contact with vaccinated birds were made. In the field study, 75% the chicken flocks were vaccinated in some households, while in others the entire flock was vaccinated. Results from the laboratory experiment show that there were differences in the mean titres of vaccinated (NDV-I_2 and LaSota) and non-vaccinated birds, indicating little lateral transmission or no spread of the vaccine virus from vaccinated to unvaccinated birds. In the villages, there was an outbreak of Newcastle disease (ND) during the study, resulting in mortality rates between 20 to 50% in birds of all ages. High rates of mortality were recorded in households with unvaccinated birds, while low mortalities occurred in households with unvaccinated birds that were in contact with the study vaccinated birds. There were no reported ND related deaths in households where entire flocks were vaccinated. Finally, traditional ethno-veterinary practices such as use of plants were found to be ineffective during the outbreak. In conclusion, vaccination with NDV-I_2 was found to be effective in reducing mortality associated with ND during the outbreak, with lateral transmission between the birds possible but limited possibly due to the low bird-to-bird contact in the free-range village setting. To ensure effective vaccine transmission and improved poultry health, it is recommended that ND vaccination is conducted for all birds once every three months from March to September, and that management improvements are implemented such as improved housing for greater potential lateral transmission, and anthelmintic treatments that may ensure greater antibody formation against ND.

Background

Local poultry (chicken, guinea fowl, ducks, and turkey) keeping is a very important agriculture activity in the developing world, providing support for livelihoods in the rural areas, especially women. In Ghana, it is estimated that about 60-80% of the country's total poultry population can be found in the rural and peri-urban areas (Ministry of Food and Agriculture, 2002; Gyening, 2006). These birds are usually produced under an extensive or backyard production system, where birds scavenge for their own food with little or no supplementation, housing, or veterinary care. The production of birds under this system is profitable as the level of inputs is low. However, the production of local chickens is hampered by the incidence of viscerotropic velogenic Newcastle disease (ND) especially in villages. ND causes massive mortality, especially in the dry season of the year, drastically reducing the number of birds with a harmful effect on local food production and income. An estimated 70-80% of unvaccinated chickens are lost to ND in developing countries (Awuni, 2002).

Yet Newcastle disease can be effectively controlled and managed through vaccinations. Vaccination of chicken against ND in Ghana over the past decade has been conducted primarily through the use of conventional vaccines like Hitchner B1 and LaSota (Aning and Brewoo, 2001). These vaccines, however, present several challenges when used in rural settings, particularly with regard to cost and storage, and render vaccination programs among extensive and backyard poultry operations very difficult to implement and support.

To address these challenges, an alternative vaccine, NDV-I_2, has been developed. NDV-I_2 was passaged to be thermally stable, requiring no cold chain in the field. Delivering vaccines to rural areas has been restrained by the cold chain: a network of refrigeration developed to maintain vaccines at an ideal temperature to avoid spoilage. Maintaining cold chains in rural areas is particularly difficult considering the often sporadic electrical infrastructure and long distances between sites, and is a significant obstacle in the implementation of health and development agency vaccination programs. The thermal stability of NDV-I_2, therefore, could render the cold chain irrelevant and greatly improve ND vaccination programs to the benefit of rural poultry producers and rural livelihoods in general.

However, there are mixed results in the effectiveness of NDV-I_2 in protecting rural chickens against virulent ND (Awuni et. al., 2006), along with doubts on another extolled attribute of the vaccine: its ability to spread from vaccinated to unvaccinated birds under typical conditions and thereby effectively protect birds with little effort by the manager or producer. However, this aspect requires further research, as it has not been extensively investigated. The aim of this study therefore, was to demonstrate the protection provided by NDV-I_2 to birds from ND, along with the ability of the vaccine to spread from vaccinated birds to unvaccinated birds. In addition, the study was intended to document the improved productivity of village chickens as a result of vaccination.

Methods

Two separate experiments were developed to assess the degree of protection provided by the NDV-I_2 vaccine, along with the vaccine's bird-to-bird transmission, and improved productivity.

Controlled Experiment. A controlled experiment was developed to test the capacity of locally available ND vaccine strains to spread from bird-to-bird after vaccination. In this experiment, five birds were selected from two separate groups of 15 birds, and were vaccinated with either the LaSota or NDV-I_2 vaccines. A third group of 10 non-vaccinated birds was used as a control. Vaccinations were given in week one and again in week three. The birds were bled and serum harvested for serology to determine antibody titre levels, a measure of developed immunity to the virus. Comparisons of vaccinated, unvaccinated, and unvaccinated in contact with vaccinated birds were then made. Additional technical details about the experiment may be obtained from the author.

Field Experiment. A vaccination trial was also conducted among extensive and backyard poultry operations in two villages in the Techiman Municipality (Fiaso and Forikrom) of Ghana to observe the effectivity of the NDV-I_2 vaccine under field conditions. In the experiment, 75% of the chickens in flocks from five households received the NDV-I_2 vaccine, while in four households, all the birds in the flock were vaccinated.

Preliminary Findings

Controlled Experiment. There were differences in the mean antibody titres of vaccinated (NDV-I_2 and LaSota) and non-vaccinated birds (Table 1 and Figure 1). The antibody levels recorded in chickens vaccinated with NDV-I_2 did not change significantly after both the first and second vaccinations, even though they were protective. There was also no significant change in the titres of the unvaccinated birds in contact with the NDV-I_2 vaccinated birds. Some birds died before the live virus challenge experiment. Post mortem examination of these birds indicated that death was a result of a *Salmonella* infection and worm infestation. The few birds that survived the challenge test were those that had been vaccinated with either NDV-I_2 or LaSota. Of the non-vaccinated birds, only two survived the challenge test. The results did not provide any indication of the lateral spread of LaSota or NDV-I_2 vaccines from the vaccinated to unvaccinated birds.

Field Experiment. During the period of the field study (i.e. August to early November 2009), there were outbreaks of ND in both the Fiaso and Forikrom villages. Infected birds showed typical signs of ND, and post mortem examination of dead birds showed characteristic lesions. Mortality as a result of the outbreak was between 20 to 50% and occurred in birds of all ages. There were no reported ND related deaths in households whose entire flocks had been vaccinated.

In the village of Fiaso, the outbreak of ND occurred at the beginning of the experiment, when birds from the selected households had been given the first vaccination. Further vaccinations were consequently withheld. It was observed that birds in households adjoining the selected households started dying as a result of the outbreak. Most of the households that had cases of ND were located in close proximity to rubbish dumps. Curiously, some of the vaccinated households reported no cases of mortality, while in others, low mortality rates were documented.

In Forikrom the outbreak of ND occurred after the second vaccination. As in Fiaso, households that reported occurrence of ND were located in close proximity to rubbish dumps. The mortality recorded for Forikrom

Table 1. Survival rates of chicken vaccinated twice at one week and two weeks after, and challenged three weeks after the second vaccination.

	Days post inoculation								
Groups	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**No. survived/ No. inoculated**	**% Mean level of protection**
NDV-I_2	100	100	75	62.5	37.5	37.5	25	2/8	62.5
LaSota	100	100	100	80	80	60	40	2/5	80
Control	100	100	100	86	37.5	28.5	28.5	2/7	68.6

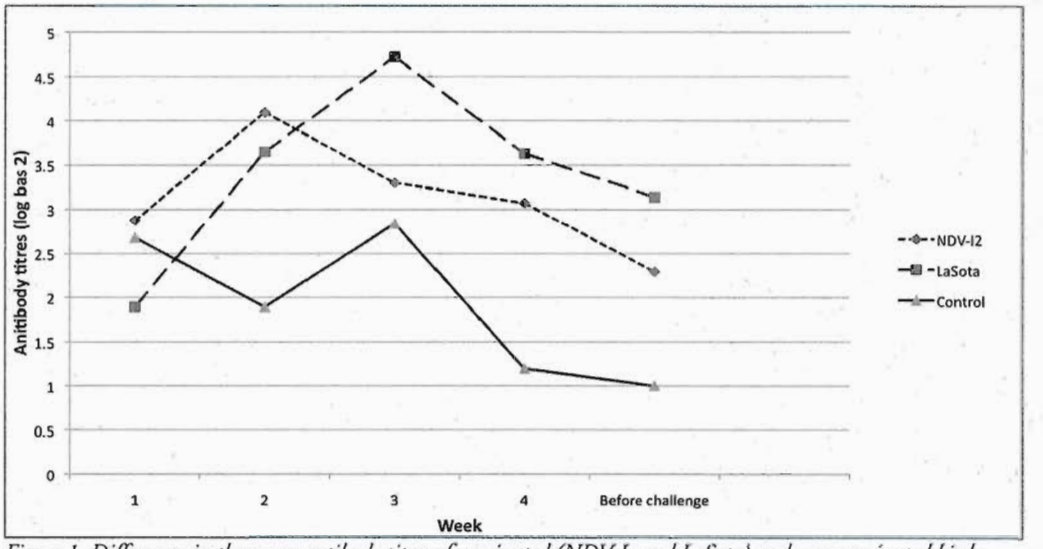

Figure 1. Differences in the mean antibody titres of vaccinated (NDV-I_2 and LaSota) and non-vaccinated birds from the controlled study.

ranged between 10-20%, primarily among unvaccinated birds that were in contact with the study's vaccinated birds. Some households not participating in the study reported mortalities up to 50%.

In both villages, there has never been any form of vaccination program against ND until the current study. In previous years, ND reportedly devastated the bird population with mortalities up to 80%. Traditional ethno-veterinary practices, particularly the bark of trees (mango) or pawpaw leaves, have been used to control and manage ND, but it is believed that they are largely ineffective. In other households, antibiotics such as ampicillin capsules were reportedly mixed in the drinking water as protection for birds against the virus. The effectiveness of this practice is unlikely and thus, was not considered by this study.

Practical Implications

Study results from the controlled experiment indicate that there was little lateral transmission of either the LaSota of NDV-I_2 vaccine virus. This situation is different from results of similar research conducted by Mgomezulu et al. (2009) in Malawi. In their study, the antibody levels of both vaccinated and unvaccinated chicken significantly increased after vaccination. The differences in the two study outcomes may be attributed to the immunosuppression of birds as a result of other pathogenic agents. Since 10 of the experimental birds died from *Salmonellosis* and worm infestation, which is unusual in birds with normal immune systems, this may be an indication of immune suppression. The presence of these additional pathogens may have hampered antibody formation against ND, as the immune system was dedicated to defending the birds against the other diseases, though there are no reports of this phenomenon in the literature (Personal Communication). It is also possible that the potency of the vaccines used in this experiment may have reduced, as antibody titres following vaccinations were low. Frequent electricity failures occurred during vaccine storage, and while NDV-I_2 is assumed to be thermally stable, this experiment was not designed to test this aspect of the vaccine. It is therefore important to repeat the preliminary experiments.

Findings from the field experiment, though still in progress, indicate that many of the birds may have high ND antibodies titres and were therefore protected against the virus. Brewoo and Aning (1999) found that local scavenging chickens had high protective antibody levels following a previous disease outbreak in Ghana. This possible protective immunity pre-vaccination may have accounted for the less than 100% mortality in the ND outbreaks during the study. While the lateral transmission of the vaccine virus in the village settings is possible, it was determined to be insignificant, as contact between birds was found to be low considering the truly extensive nature of production in the area and the subsequent lack of housing provided to birds in most households. Finally, traditional ethno-veterinary practices were found to be ineffective during the outbreak, positioning vaccination as the sole measure for protection against ND.

In conclusion, vaccination with NDV-I_2 was found to be effective in reducing mortality associated with ND during the outbreak, with lateral transmission between the birds possible but limited due to the low bird-to-bird contact in the free-range village setting. To ensure effective vaccine transmission and improved poultry health, it is recommended that ND vaccination is conducted for all birds once every three months from March to September, and that management improvements are implemented such as improved housing for greater potential lateral transmission, and anthelmintic treatments that may ensure greater antibody formation against ND.

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About the Author: Dr. Patrick Ahiabor is a graduate student in Veterinary Medicine in the Department of Animal Science at the University of Ghana, Legon, and Jim Ellis Award Recipient, 2008-2009. His thesis, the subject of this brief, was conducted in collaboration with the Avian Flu School. He may be contacted by email: ag_ri_patrick@hotmail.com.

Avian Flu School (AFS) was created to address the need for a train-the-trainer program to disseminate the knowledge necessary to minimize the health and economic impacts of H5N1 HPAI by improving the ability of a country, district or community to prevent, respond to, and recover from an outbreak. The project is led by Dr. Carol J. Cardona, University of California, Davis. Email: cjcardona@ucdavis.edu.

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GLOBAL LIVESTOCK CRSP

Evaluating and Managing Zoonotic Disease Risk in Rural Tanzania

Deana Clifford, University of California, Davis; Rudovick Kazwala, Sokoine University of Agriculture; Jonna Mazet, University of California, Davis; and Peter Coppolillo, Wildlife Conservation Society
Health for Animals and Livelihood Improvement (HALI) Project

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Daily workloads and livelihoods in rural communities depend heavily on the availability of natural resources. When water is scarce, workloads increase, as more distance must be traveled to acquire adequate supply for consumption, hygiene, and livestock. In addition, water limitation brings people, livestock, and wildlife together, increasing contamination of the limited water sources as well as the potential for disease transmission. Nowhere is the risk of waterborne illness and zoonotic disease more important than in the high HIV/AIDS (Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome) prevalence regions of East Africa. Assessing the impacts of zoonotic diseases like bovine tuberculosis (BTB) on health, economic livelihoods, and conservation requires a multi-disciplinary approach. Support from the Global Livestock Collaborative Research Support Program (GL-CRSP) is allowing an objective assessment of emerging zoonotic disease on health and livelihoods in pastoral communities within the sensitive Ruaha region of Tanzania. Project research has identified several pathogens including BTB in wildlife and livestock in the Ruaha area, along with low levels of zoonotic disease awareness among the pastoralist communities. Project results will inform management and policy to evaluate water quality for public safety and ecosystem health.

Background

Unprecedented human population growth and human-induced environmental changes have resulted in increased numbers of people living in close contact with wild and domestic animals, especially in developing countries. This increased contact together with changes in land use, including livestock grazing and crop production, have altered the inherent ecological balance between zoonotic pathogens (i.e. diseases that can be transmitted from animals to people and vice versa) and their human and animal hosts. In fact, zoonotic pathogens, such as avian influenza and tuberculosis, account for the majority of emerging infectious diseases in people (diseases that appear in a population for the first time or are increasing in prevalence or geographic distribution; Taylor et al., 2001).

Intimate linkages of human and animal health are not new nor are the serious consequences of zoonotic diseases, like plague and influenza. Nowhere is this more important than in the developing world, where availability of natural resources determines daily workloads and livelihoods. Water resources are perhaps most important, as humans and animals depend on clean water for health and survival, and sources of clean water are dwindling due to demands from agriculture and global climate change. As water becomes more and more scarce, animals and people are squeezed into smaller and smaller workable areas. Contact among infected animals and people then increases, facilitating disease transmission. When this situation is complicated by co-infection with HIV/AIDS (Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome), the results can be catastrophic to families and whole communities and ultimately, the environment through impacts on human capacity, natural resource management and land use (Ogelthorpe and Gelman, 2007).

Assessing the impacts of zoonotic diseases and resource limitation on health, economic livelihoods, and conservation requires a multi-disciplinary approach, uniting specialists from a wide variety of fields including medicine (veterinary and human), ecology and conservation, sociology, and economics. In 2006, the Health for Animals and Livelihood Improvement (HALI) project was initiated to find creative solutions to these problems by investigating the impact of zoonotic disease on the health and livelihoods of rural Tanzanians living in the water-limited Ruaha ecosystem. HALI addresses these complex disease and natural resources issues using the "One Health" paradigm, stressing that the health of domestic animals, wildlife, and people are inextricably linked to the ecosystem and natural resources on which all depend (Osofsky et al., 2005).

Project Rationale

The biologically diverse and economically important Ruaha ecosystem is seriously threatened by seasonal drying of the Great Ruaha River (GRR). Since 1993,

uncontrolled agricultural water diversions and intensive livestock grazing at the source have caused the normally perennial GRR to stop flowing for longer periods each year. The costs of water disruption are significant and far reaching. First, pastoralists that have traditionally used the GRR to water livestock have been forced to find other sources. Water restriction has decreased the area available for grazing and increased the concentration of livestock using dwindling water sources. Pastoralists suspect that this process has increased disease transmission at watering holes and has led to decreased forage quantity and quality. The effect of these factors on herd productivity, however, has not been quantitatively assessed. Another major cost of river drying has been the loss of wildlife tourism potential, both for Ruaha National Park (RNP) and for the village-managed Pawaga-Idodi Wildlife Management Area. Tourism in this part of Tanzania is concentrated in the dry season, when wild animals are visible near perennial water. The spatial distribution of surface water has declined over 60%, leading to a comparable decline in high-potential areas for tourism. This reduction in wildlife viewing area is particularly significant for village economies struggling to diversify their economic base beyond livestock and rice production.

In addition to direct impacts of restricted water flow, transmission of zoonotic diseases are likely to increase with reduced water availability, as people, wildlife, and livestock are increasingly forced to share dwindling and lower quality water sources. For example, in South Africa, buffalo herds with higher rates of bovine tuberculosis were more sensitive to drought, had higher numbers of endoparasites, and experienced more rapid loss of body condition during the dry season (Caron et al., 2003). With the drying of the GRR, the spatial distribution of buffalo has declined nearly 33% in the GRR portion of the Park (Wildlife Conservation Society-WCS, Aerial buffalo count, 19-20 October 2004, unpublished data), compressing herds into a smaller area where potential for disease transmission is higher and forage competition is more severe. The risk of disease is intensified as water quality is diminished through increased fecal contamination and stagnation of the remaining dry season watering holes. Previous research in the Rungwa-Ruaha ecosystem and in other regions of Tanzania illustrates that the area is a hot spot for zoonotic diseases of significant public health importance. In addition, the traditional practices of pastoralist groups in the region may put them at increased risk of infection.

A critical question that has only recently been explored is the role of bovine tuberculosis (BTB) in the current global human tuberculosis epidemic (Cosivi et al., 1998). Nearly 40,000 new cases of tuberculosis (human, bovine, or atypical strain) are diagnosed per year in Tanzania (NTLP - National Tuberculosis and Leprosy Programme, 1996), with anywhere from 21-77% of Tanzanian tuberculosis patients also infected with HIV (Range et al., 2001). The extra-pulmonary form of tuberculosis (EPTB) in humans is often associated with BTB infection from ingestion of animal products and has been documented in 17% of the tuberculosis cases in Tanzania (NTLP, 1996). Many pastoralist groups in Tanzania have practices that might increase their exposure to BTB (and other zoonotic diseases), including consumption of raw or fermented milk (prepared without boiling) or raw blood, eating un- or under-cooked meat, and housing livestock within human dwellings (Mfinanga et al., 2003).

The BTB strain is more commonly found in regions with a high ratio of cattle to people (Kazwala et al., 1993). Testing of cattle in and around the Ruaha ecosystem showed that 51% of herds had cattle reactive to BTB by intradermal skin tests, with reactor prevalence being highest in the hot dry lowland areas nearer to the park (Kazwala et al., 2001). Furthermore, the Usangu region adjacent to the park is a hot-spot, with over 80% of cattle skin-test positive for BTB (Iringa District Livestock Office, unpublished data). Bovine tuberculosis strains have also been isolated from milk samples from pastoral cattle in the region (Kazwala et al., 1998).

Although investigators know that BTB is present in livestock bordering the protected areas of the Ruaha ecosystem, nothing is known about the disease in the landscape's wildlife. Bovine tuberculosis has had population impacts on buffalo and lion in Kruger National Park, South Africa (Michel et al., 2006) and has emerged as a serious ecosystem-level health threat. This threat is compounded by the complete lack of knowledge regarding the impacts of BTB in local wildlife or their potential role as a reservoir for the disease.

The utilization of dwindling dry season watering holes by humans, livestock, and wildlife not only exacerbates the risk of BTB transmission among these populations, but exacerbates the transmission risk of other important zoonotic diseases, such as brucellosis and water-borne diseases (toxoplasmosis, cryptosporidiosis, giardiasis, and bacterial enteric pathogens). Information about the spatial, temporal, and demographic patterns of disease in human, domestic animal, and wildlife populations is needed to control and limit zoonotic agents of public health and economic importance. Additionally, the underlying land-use determinants of disease and the socioeconomic barriers to control and prevention must be explored (Patz et al., 2004).

Accordingly, the Health for Animals and Livelihood Improvement Project (HALI) was created to assess the impact of the interactions between water and disease in the Ruaha ecosystem by simultaneously investigating the biophysical, socioeconomic, and policy issues driving the

system. The research priorities for HALI were determined through a stakeholder meeting and informal interviews with affected pastoralist communities. An overwhelming consensus emerged from diverse stakeholders including pastoralists, multiple levels of government, non-profit organizations, and academia that a significant proportion of the rural population in the Ruaha landscape is affected by water-related diseases, and these diseases are affecting health, agricultural productivity, food security, and biodiversity in the region (See box below).

Considering the problems and needs as defined through the local community meetings and the stakeholder planning workshop, the HALI project seeks to: 1) assess the prevalence and transmission ecology of zoonotic diseases (BTB, brucellosis and water-borne pathogens) among wildlife, livestock, and pastoral and agropastoral communities; 2) assess the effects of water (river and other water bodies) management on the presence, abundance, and severity of disease impacts; 3) assess how water management and disease affect the health and livelihoods of agropastoral and pastoral communities; and 4) strengthen the zoonotic disease education and research capacity of the Faculty of Veterinary Medicine at Sokoine University of Agriculture, Morogoro, Tanzania.

HALI stakeholders agreed that the highest priority diseases for study were pathogens that:

1) Are impacted by water use issues
2) May severely affect human health (especially individuals with HIV/AIDS)
3) Adversely affect livestock health and productivity
4) Threaten the persistence of endangered species

HALI project team members are accomplishing these goals by testing wildlife, livestock, and their shared water sources for disease; interviewing pastoralist households; introducing new diagnostic techniques for disease detection; and training Tanzanians of all education levels about zoonotic disease.

Preliminary Findings

Research activities from the first year of the project have already yielded significant findings. Researchers have discovered bovine tuberculosis present in wildlife inside the community wildlife management area bordering Ruaha National Park and are continuing to sample wild animals to determine which species are most affected and the geographic distribution of infection in the ecosystem. They are sampling pastoral livestock with partnering households to determine the current prevalence of BTB in agricultural animals and to assess whether or not disease in livestock is related to water limitation or proximity to wildlife. Investigators have isolated disease causing bacteria and parasites that can be passed between animals and people from sampled water sources and are gathering information about how people use these water sources. Preliminary findings from wet season surveys of pastoralist households indicated that 68% of 70 participating households did not believe illness in their families could be contracted from livestock, while 40% of these households also did not believe illness in their families could be transmitted from wildlife. Additionally, 75% of these households did not believe sharing water sources with livestock or wildlife was a disease risk.

Practical Implications

Preliminary results showing that BTB is present in both wildlife and livestock in the Ruaha ecosystem indicates that these species have interacted in the past. The Ruaha ecosystem is at the juncture of the East and southern African faunal zones and is one of the largest intact conservation areas remaining in Africa. An accurate assessment of the diseases that could threaten the persistence of key species, such as buffalo and lion, is essential for conserving the region's unique biodiversity and its ecotourism earning potential.

Perhaps more importantly, it is crucial to recognize that these diseases are present at the local level, as people depend on meat and milk from potentially infected animals for their food. Determining the prevalence of these and other zoonotic diseases affecting livestock will guide subsequent disease prevention efforts aimed at improving livestock productivity through improvement of health and the protection and expansion of trade and food security.

Second, education regarding zoonotic diseases is urgently needed in pastoralist communities. Collecting detailed data regarding food consumption and water use habits, illness in livestock and people, and access to healthcare will help tailor disease education efforts. In the meantime, team members are educating livestock owners at each project household. Tuberculin skin tests are administered and interpreted with the owners present, and households with positive reactor cattle are advised on disease prevention.

Finally, findings from this project will be used by the Rufiji Basin Water Office to evaluate water quality for public safety. HALI data will aid in the development of water management strategies that maximize water flow for people, livestock, and wildlife, thereby improving the health and livelihoods of local people, as well as habitat for wildlife and ecotourism.

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About the Authors: Dr. Deana Clifford is the HALI Project Coordinator and postdoctoral researcher at the Wildlife Health Center in the School of Veterinary Medicine, University of California, Davis. Email: dlclifford@ucdavis.edu. Prof. Rudovick Kazwala is a Professor in the Department of Veterinary Medicine and Public Health at Sokoine University of Agriculture. Email: kazwala@suanet.ac.tz. Dr. Peter Coppolillo is an Associate Conservation Ecologist and was the Project Director of the Wildlife Conservation Society Ruaha Landscape Program at the time of writing. He is currently the Coordinator of the Yellowstone Rockies Program. Email: PCoppolillo@WCS.org. Dr. Jonna Mazet is a Professor of Wildlife Epidemiology and Co-Director of the Wildlife Health Center at the University of California, Davis. Email: jkmazet@ucdavis.edu.

The Health for Animals and Livelihood Improvement (HALI) project was established in 2006 and is a stakeholder-driven research and capacity-building program to assess the effects of zoonotic disease and water management on animal health, biodiversity, and livelihoods in the Ruaha ecosystem, Tanzania. The project is led by Dr. Jonna Mazet, University of California, Davis. Email: jkmazet@ucdavis.edu.

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GLOBAL LIVESTOCK CRSP

The Unintended Consequences of Development Assistance: The Case of Usangu in Tanzania

Peter Coppolillo, Wildlife Conservation Society;
Deana Clifford and Jonna Mazet, University of California, Davis
Health for Animals and Livelihood Improvement (HALI) Project

Research Brief 08-02-HALI November 2008

Three smallholder rice irrigation schemes were established with development assistance in Tanzania in the 1980s and early 90s aimed at improving agricultural livelihoods in the region. The projects did not accomplish their stated goals, but more problematically, they precipitated a cascade of unintended consequences. The primary effect was that legal channelization of water catalyzed illegal diversions and satellite farms surrounding the rice schemes. The resultant loss of water was (and remains) the central driver in a cascade of unintended environmental and socioeconomic effects including: a 77% reduction in the area of the Ihefu swamp, the important wetland habitat of the Great Ruaha River; over 60% loss of dry-season habitat in Ruaha National Park; the collapse of fisheries in Mtera Reservoir; increased potential for transmitting zoonotic disease; and the loss of electricity produced by the Mtera Hydroelectric Plant. The social and economic costs of these unintended consequences remain untallied, but the power crisis alone likely cost the Tanzanian economy approximately one billion U.S. dollars. This case highlights the need for development assistance to control the genesis and propagation of unintended consequences which could vastly outweigh the benefits of the assistance program. Furthermore, the perception that developing countries, like Tanzania, are not financially able to manage water sustainably should be replaced by the idea that those countries cannot afford the consequences of unsustainable water resource management.

Background

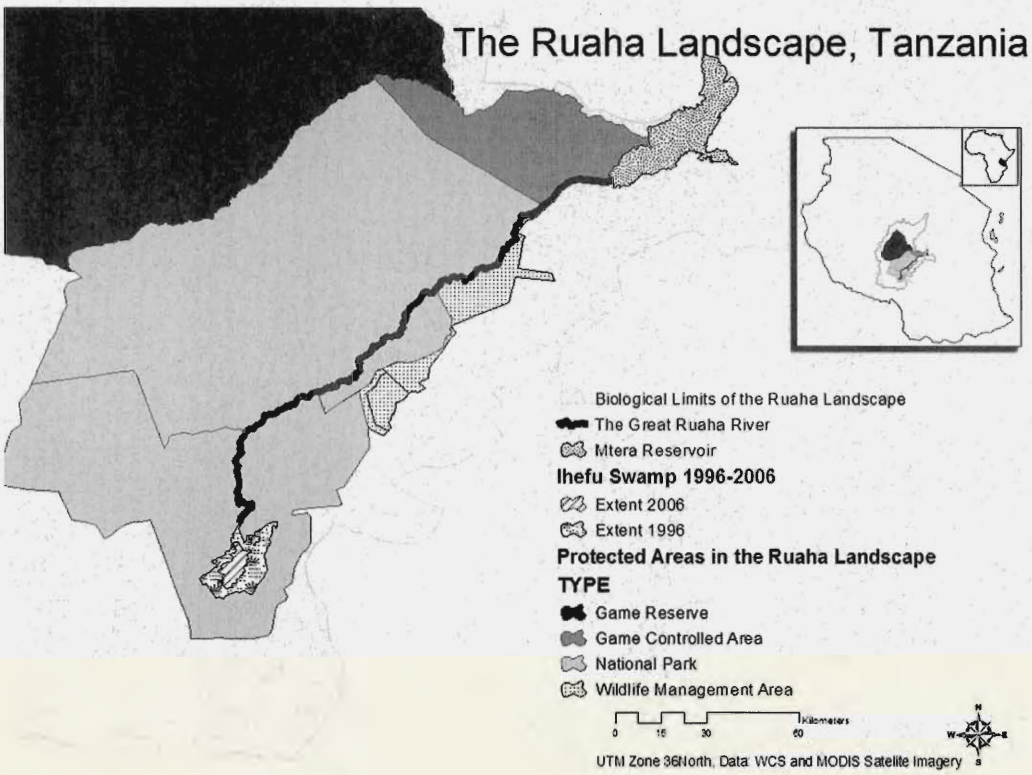
Tanzania is among the world's poorest countries, ranking 159th out of 177, according to the Human Development Indices' calculations. This need, combined with abundant land and natural resources, a peaceful and relatively well-governed political environment and a rapidly growing economy make Tanzania an attractive recipient for bi- and multi-lateral development assistance. Assistance in 2005 amounted to around $US 1.5 billion or about 12% of GDP (gross domestic product) in Tanzania (SIDA-Swedish International Development Cooperation Agency, 2006). In many cases, this support has led to significant improvements in livelihoods, environmental outcomes and quality of life, but the net effects of development assistance are not universally positive. Here, researchers examine a case where the unintended negative consequences of development assistance vastly outweigh the positive benefits and attempt to identify practical ways to avoid similar outcomes in the future.

The Usangu Plains of central Tanzania had fertile soil, abundant sunshine and natural wetlands that supported both rain-fed and traditionally irrigated rice systems. Starting in the mid 1980s with support from the British, Dutch, and Chinese governments as well as the World and African Development Banks, these traditional systems were "improved" through provision of cement-lined delivery canals and industrial-scale paddies parceled out to smallholders. The idea was to use modern irrigation techniques to grow more rice overall, more rice per hectare, and to do so more efficiently in terms of water use (SMUWC-Sustainable Management of the Usanga Wetland and its Catchment, 2001).

Unfortunately, the irrigation projects never realized any of these goals (Lankford, 2004; Lankford et. al, 2004). Far more destructively, by channeling the water, the schemes made it possible to divert much larger proportions of the rivers feeding into the Usangu Plains. As a result – in the dry season of 1993 and for the first time in living memory - the Great Ruaha River stopped flowing.

The cessation of flow was totally unanticipated, having serious implications for downstream irrigators and effects on other costs, both ecological and economic. Specifically, Ruaha National Park (now Tanzania's largest national park) was impacted because the Great Ruaha River was the principal water source for the southern half of the Park. The Great Ruaha also carries over 60% of the water flowing into Mtera Reservoir, which supports central Tanzania's only significant fishery; generates 80 Megawatts (MW) of electricity; and provides storage for Kidatu Hydroelectric Plant, which generates 200 MW. Combined, Mtera and Kidatu provide over 70% of Tanzania's electricity.

Recognizing the potential costs, DFID (the UK Department for International Development) funded



the Sustainable Management of the Usangu Wetland Catchment program, a four million dollar research initiative. Numerous hydrological studies documented the amounts of water diverted, but little attention was paid to the areas outside the internationally-funded irrigation schemes. Economic studies established that Great Ruaha River water was eight times more valuable for hydropower than for rice, but the DFID funded research did little to improve the flow of the Great Ruaha River, and hence reverse some of the negative impacts of the irrigation projects on the surrounding ecosystem and its inhabitants.

In 2003, the severity of the drying of the Great Ruaha continued to intensify. The effects of the drying on ecosystem services and flow requirements, however, remained un-quantified making it impossible to apply Tanzania's Water Policy, which gives "Environmental Flows" priority over economic activities (and behind domestic water use). In response, the Wildlife Conservation Society (WCS) Ruaha Program set out to identify the flow regimes necessary to sustain the ecosystem services provided by the Great Ruaha, namely, provision of hydropower and maintenance of dry-season wildlife habitat (which supports ecotourism, now Tanzania's largest economic sector).

Major Findings

Quantifying the ecological effects of river drying showed that over 60% of dry season habitat in the Ruaha National Park was eliminated as the Great Ruaha River dried. The effects, however, were not just downstream. The Ihefu Swamp—where the Great Ruaha flows from the Usangu Plains—lost 77% of its surface area and was fragmented into three sections. Not only was its hydrological function threatened, but its decline represents a significant loss of wetland habitat.

In re-examining the factors contributing to river drying, more unanticipated results were uncovered. Most analyses of diversions focused on the sanctioned rice schemes, which intended to divert around 20-30% of the Great Ruaha's flow. Receiving far less (if any) attention were the illegal diversions feeding a proliferation of smaller 'satellite farms' surrounding the developed farms. These satellite farms substantially increased the area flooded. A satellite image analysis comparing illegally flooded areas in satellite farms to those in the irrigation schemes revealed a ratio of 50:1, respectively. Furthermore, very few of the satellite farms were properly leveled, requiring constantly flowering water to keep rice wet. Worse still, almost none of the satellite farms have canals to return river water after irrigation. The small scale satellite farms thus consume significantly more water than the large scale irrigation systems but have been ignored in research and policy discourses.

The hydrological effects of livestock were also examined, along with the social and political drivers affecting pastoral land use and land tenure. In the course of these discussions, pastoralists argued that the loss of water sources forced

The flowing Great Ruaha riverbed in December (left) and the dry riverbed in October (right). The drying of this normally perennial river may increase disease transmission among people, livestock, and wildlife, as all are forced to share diminishing dry season water sources. Flowing Ruaha photo by Deana Clifford. Dry Ruaha photo by Peter Coppolillo.

livestock to move further seasonally and to be compressed during the dry season. These two factors, they argued, substantially increased the transmission of diseases among livestock herds and between livestock and wildlife, which were increasingly forced to use the same water holes. Now, over a decade after river drying, secondary consequences of rice development appeared. In 2006, Wildlife Conservation Society, University of California, Davis and Sokoine University of Agriculture initiated the HALI project (Health for Animal and Livelihood Improvement) to better understand how zoonotic disease was affecting livestock, human and wildlife health. The HALI project is now investigating the health and economic consequences of water shortage on livestock and pastoralists in the Ruaha ecosystem.

Other secondary effects are also affecting human and wildlife health. Stagnant water can be poisoned, and the concentration of wildlife at water holes means that many animals can be poisoned at a single point. With the drying of the Great Ruaha River, illegal "hunters" have resorted to poisoning water holes and selling the meat in villages. The HALI project is examining the socioeconomics of protein availability in target villages to understand whether this kind of threat can be alleviated by increasing the availability of animal-source protein in villages.

While the problems outlined above had significant economic and ecological effects locally, the unintended consequences of rice development in Usangu were scarcely recognized outside the local context. In 2006, however, on the heels of a prolonged drought, low flows and the drying of the Great Ruaha River forced the complete closure of the Mtera Hydroelectric Plant and a 50% reduction of hydropower generation at Kidatu. These reductions reportedly cost TANESCO (Tanzania's Parastatal electricity utility) around $US 200,000 each day. The aggregate costs to Tanzanian economy from the loss of electricity were estimated between $US two-nine million each day. HALI researchers know of no published estimates of the total cost of the overall economic loss from the power crisis, but simple extrapolation of the daily estimates yields losses between $US 360 million and 1.6 billion. This higher figure exceeds the estimated amount of all bi- and multi-lateral aid flowing into Tanzania each year.

In summary, the details of the Usangu case make it clear that the economic value of rice development, even if the projects' goals had been realized, was swamped by a cascade of unintended and negative consequences arising from the projects themselves.

Practical Implications

It is tempting to view the Usangu Rice Development projects as unmitigated failures, given that they achieved none of their stated goals and have had catastrophic effects on the local environment and livelihoods throughout Tanzania. Dismissing the case in this way, however, abdicates responsibility and misses an important opportunity to learn from and rectify the mistakes made.

A number of clear practical lessons are apparent. First, establishment of the Usangu Rice projects focused on technical issues of agronomic efficiency and economic yields, without sufficient attention to enforcement and regulation. In a country like Tanzania, where resource use is often regulated by technological and practical constraints, the existing institutions were not prepared to deal with the scale and magnitude of use made possible by channelizing water. Because of this, 15 years after the initiation of projects, the unanticipated burden on water resources stemming from illegal channeling continues to threaten the sustainable management of local livelihood activities as well as habitat conservation efforts.

More directly related to HALI, the unintended consequences and their economic and ecological effects are still being recognized 15 years after the first year of drying. While this underscores the inadequacy of the initial environmental impact assessments (EIAs), it is also clear that more significant investment in more responsible EIAs probably would not have anticipated all the problems observed today. Like Usangu, most parts of the developing world have great and immediate needs, and background data are generally lacking. More significant and integrative EIAs will undoubtedly reduce the incidence of similar cascades in the future, but environmental assessment of development assistance projects must not end at the initiation of the projects. Instead, donor countries must ensure that monitoring and adaptive management of unintended environmental, social, and economic consequences are built into the implementation and operation stages of assistance projects. Such regulation is imperative to ensure effective and ethical development assistance.

Finally, rural livelihoods and zoonotic diseases remain broad, weakly defined issues for which "baseline" data rarely exist. Yet, the Usangu Case highlights how development assistance can affect rural people, their livestock and ecosystem health through indirect pathways. Monitoring alone cannot anticipate all of the unintended consequences of development assistance. Only through integrative and multi-year research will the development community understand and ultimately improve the efficacy and responsibility of development assistance to countries like Tanzania.

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About the Authors: At the time of writing, Dr. Peter Coppolillo was Director of the Ruaha Landscape Program for the Wildlife Conservation Society. He is currently the Coordinator of the Yellowstone Rockies Program. Email: PCoppolillo@WCS.org. Dr. Deana Clifford is the HALI Project Coordinator and postdoctoral researcher at the Wildlife Health Center in the School of Veterinary Medicine, University of California, Davis. Email: dlclifford@ucdavis.edu. Dr. Jonna Mazet is a Professor of Wildlife Epidemiology and Co-Director of the Wildlife Health Center at the University of California, Davis. Email: jkmazet@ucdavis.edu.

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GLOBAL LIVESTOCK CRSP

Innovative Approaches to Evaluate Household Health and Livelihoods in Pastoral and Agropastoral Communities

Michel Masozera, Jon Erickson, University of Vermont;
Deana Clifford, University of California, Davis;
Peter Coppolillo, Wildlife Conservation Society;
and Mariam Nguvava, Research Assistant
Health for Animals and Livelihood Improvement (HALI) Project

Research Brief 08-03-HALI November 2008

The emergence and spread of infectious diseases at the interface of humans, livestock, and wildlife are increasingly recognized as critical issues by health specialists, disease ecologists, conservation biologists, wildlife managers, and protected area managers throughout the world. Addressing the causes and consequences of disease requires investigation of links between various biological, environmental, agricultural and socioeconomic factors that cross disciplines, including at the least epidemiology, veterinary sciences, environmental science, public health, and economics. The Health for Animals and Livelihood Improvement (HALI) project has been designed to investigate these complex issues in the Ruaha landscape of Tanzania. The project uses an integrated approach to understand the drivers of disease transmission across the landscape and to generate preventive measures and interventions. This research brief provides an overview of the methods used to investigate health and livelihood strategies in pastoral and agropastoral communities near Ruaha National Park. Methods include household surveys and diaries, focus groups, choice modeling, and village economy models. Resulting analysis will estimate the impact of zoonotic diseases and water scarcity on household health and livelihoods across ethnic, economic, and gender groups, and make recommendations to reduce risk of diseases, better manage scarce water resources, and conserve wildlife in the Ruaha Landscape.

Background

Protected areas throughout the world are key for conserving biodiversity and provide a host of other services including watershed protection, carbon sequestration and regulation of vectors that transmit disease. Many protected areas, however, especially in developing countries, are experiencing increasing pressure due to population growth, expansion of cultivation, land degradation and widespread poverty limiting their capacities to perform these functions. As a result, people and wild and domestic animals are coming into close proximity, which can increase risks of predation and disease transmission that can compromise human, livestock and wildlife health. In the arid and semi-arid dry lands of East Africa, where the predominant production and livelihood system is agropastoralism, competition for scarce grazing and water resources is increasing, and the potential for interspecies disease vectors is growing as pastoralists move into new areas and/or live in the vicinity of protected areas.

The emergence and spread of infectious diseases at the interface of humans, livestock, and wildlife are increasingly recognized as critical issues by health specialists, disease ecologists, conservation biologists, wildlife managers, and protected area managers (e.g. Kock, 2004; Patz et al., 2004). Addressing these complex issues requires an integrated and transdisciplinary approach to detect problems and generate long-term solutions. Collecting information on these interface issues presents many challenges, especially in rural communities in developing countries where literacy and record-keeping are limited. The nomadic life of pastoralists is particularly challenging. For these reasons innovative approaches are needed.

The Health for Animals and Livelihood Improvement (HALI) project uses an integrated approach to understand the social, economic and ecological drivers of disease transmission in the landscape and to generate preventive measures and solutions. This research brief provides an overview of methods and multiple approaches used to capture the complexity of health and livelihood systems in the pastoral and agropastoral communities around Ruaha National Park.

Approach

The Ruaha landscape of southern Tanzania provides an ideal case study to investigate the interface of human, livestock, and wildlife health and the impact of zoonotic disease on economic livelihoods. Communities bordering the Ruaha National Park include traditional pastoralists and agropastoralists practicing subsistence living and traditional husbandry practices. The environment is characterized by unpredictable and variable rainfall resulting in prolonged periods of drought.

As human and livestock populations have grown with subsequent demands for agriculture and grazing lands, there has been increasing pressure on water resources for livestock grazing and irrigation of rice and other crops. Wetlands that previously provided year-round flow to the Great Ruaha River have been particularly impacted. The river stopped running year-round in 1993 and has dried up each year since. As a consequence, people, livestock and wildlife are forced into small isolated areas where water is still available during the dry season, increasing the risk for disease emergence and transmission between animal species (Clifford et al., 2008).

There is growing evidence that human-induced land use changes drive a range of infectious disease outbreaks and modify the transmission of endemic infections (e.g., Patz et al., 2004). Previous research in the East Africa has demonstrated that bovine tuberculosis (BTB) is a disease of particular importance to the health of water buffalo in Uganda (Woodford, 1982) and baboons in the Masai Mara of Kenya (Tarara et al., 1985). In Tanzania, a recent study by Cleaveland et al. (2005) confirmed the presence of tuberculosis (BTB) in multiple wildlife species in Tarangire and the Serengeti. However, little is known about the effects of water limitation on disease transmission, herd productivity and agricultural productivity in the Ruaha landscape or similar semi-arid regions; nor has the applicability of these effects more generally to wildlife conservation efforts, veterinary public health, and poverty reduction strategies been widely considered.

The socioeconomic research within the larger HALI project employed a combination of qualitative and quantitative research approaches to assess the impacts of zoonotic diseases and water scarcity on health and economic livelihoods of pastoral and agropastoral communities in the Ruaha ecosystem.

Overview of research methods

Table 1 highlights the mix of survey instruments utilized, including a long survey and paired sample short surveys between wet and dry seasons, as well as village economic sector inventories and household diaries. The resulting socioeconomic profile includes information on household production and consumption, family and animal health, husbandry practices, demographic characteristics, and water use behavior.

Household Surveys. A household survey was designed and administered to 159 households over a one-year time period. A sub-sample of 30 households participated in a repeated short survey to evaluate seasonal variations of livelihood strategies, health, income, expenditures, and changes in capital assets (livestock, land and crops). The questionnaire was aimed at estimating the livestock population and assessing the dynamic of stock variation throughout the year, the health of livestock, source of illness and the costs related to livestock health. In addition, information related to water and sanitation, household structure, labor and health, agriculture and other income generating activities was collected.

Results from both the long survey and the wet-dry season paired survey are currently being analyzed and will be summarized thematically in future HALI research briefs, including a brief detailing the research results on issues surrounding gender roles and participation.

Focus Group Research and Choice Modeling. Qualitative methods including semi-structured interviews and focus group discussions were used along with the survey data described in the previous section to inform a workshop and choice modeling exercise held in August 2008. Initial interviews were conducted with village leaders followed by a series of focus group discussions with the aim of identifying the most critical issues for their communities by economic sector. The focus group meetings were organized at both village and district levels.

Discussions were focused on identifying the three most critical issues in each economic sector, and issues were ranked by economic sector. In addition, participants in the focus group meetings were asked to identify

Table 1. Summary of quantitative data collection approaches

Type	Number	Objectives
Long household surveys	159	To obtain a socioeconomic profile of household production and consumption, measure attitudes towards diseases and diseases management, and assess household health and economic livelihood.
Short repeated household surveys	30	To assess seasonal variations of household production and consumption, health, and livestock population.
Village government economy inventory	20	To identify different economic activities existing in each village, number of people involve in each sector and the contribution of different actors to the village economy.
Household diaries	18	To quantify in monetary terms all income and expenditures at the household level and to better understand daily household and livestock fluctuations.

other economic activities or livelihood strategies that exist in the villages. Key findings are summarized in Table 2. The results of focus group discussions were used to develop and design a choice modeling exercise based on a conjoint analysis survey.

Conjoint Analysis. Conjoint techniques are well suited for soliciting and analyzing the preferences of stakeholders in environmental decisions that frequently involve tradeoffs between costs and benefits which are not efficiently represented in market transactions. A conjoint survey was developed with five attributes – infrastructure investment in water, health and education, tourism, farmer cooperatives, and extension services – with high and low levels of investment described for each. Two participants – the village executive officer and one other stakeholder – from each of the 21 villages were invited to participate in an all-day workshop. Ultimately, 38 of the 42 invitees attended the workshop; 26% of attendees were women. By ranking the discrete bundles of attributes, the importance values of each can be determined and compared to stakeholder position, gender, income level, village, etc. Asking respondents to make choices between alternatives mimics the real choices that managers must make, and provided stakeholders with a starting point for discussing complex tradeoffs and preferences in a workshop setting. Results from the conjoint analysis are currently being analyzed by the HALI team.

Table 2. Summary of most important issues by economic sector identified by focus group meetings at local and district levels.

Village level	District level	Overall
Agriculture		
Insufficient and poor irrigation system	Inaccessibility to the market	Insufficient and poor irrigation system
	Lack of skills	
	Poor irrigation system	
Education		
Insufficient infrastructure for teachers and classrooms	Insufficient number of teachers	Insufficient infrastructure for teachers and classrooms
	Poor infrastructures	
	Lack of awareness of the importance of education	
Health		
Lack of health care facilities	Limited number of medical staff	Lack of health care facilities
No access to clean and safe drinking water	Lack of health care facilities	
Limited number of medical staff	Poor sanitation	
Poor sanitation		
Livestock		
Lack of access/insufficient watering points	Lack of education in current husbandry practices	Lack of access/ insufficient watering points
Lack of dipping areas	Lack of access/insufficient watering points	

Village Economy Models. The direct impact of water management and diseases on livelihoods of pastoral and agropastoral communities can be studied quantitatively with household survey data and qualitatively with interviews with key informants. The indirect (or multiplier effects), however, are at least as important as the direct impact. For example, impacts of water scarcity on pastoralist livelihoods will also impact other households and village or regional industries that supply inputs to or are dependent on livestock production systems. Changes in income of pastoralists will also impact spending on household goods and services, further impacting the village economy. Both the direct and indirect economic impacts of water scarcity and disease emergence can be assessed using a social accounting matrix approach (SAM). Social accounting is an extension of input-output analysis, an analytical tool that models the interrelationship among different sectors of an economy. The SAM model shows the flow of income and expenditure among household production activities.

To aid in the construction of the village SAMs, 18 household diaries were used in a small sample of pastoralist and agropastoralists from different wealth categories: three relatively poor households and three relatively wealthy households from each of the three ethic groups were surveyed. A representative of the family or enumerator was selected and trained to record the information related to daily household expenditures, household earnings, household consumption, household health and livestock changes on a daily basis for four weeks. In addition, household enumerators made an inventory of all household supplies at the start of the surveys.

The SAM is based on the assumption that production activities are endogenous and demand-driven. Direct impacts introduced into the village economy produce changes in the flows of resources among sectors within

the village. The magnitude of these impacts (multipliers) depends upon the strength of the linkages between the sectors. In order to investigate the effect of some exogenous shocks and policies on village production, income, capital and labor allocation, a few scenarios will be investigated including: increasing demand for village output, investment in non-agricultural sectors, irrigation and water use efficiency improvements, general water scarcity, and costs of health care for both livestock and humans.

Practical Implications

The analysis of collected data will help to estimate the impact of zoonotic diseases and water scarcity on health and economic livelihoods across different ethnic groups, socioeconomic levels, distance to water sources, and degrees of wildlife interaction. The HALI team will combine survey, workshop, and model results to make recommendations for designing policies and strategies to reduce risk of diseases and address water issues in the Ruaha landscape.

While this research brief was primarily meant to summarize the socioeconomic methods used in HALI, findings from this research will be used by development agencies, non-governmental organizations, Tanzania National Parks, and village governance to develop strategies that improve the health and livelihoods of local communities. Information collected on perceptions and attitudes of local communities will also be used by veterinary, human health and agriculture extension officers as well as conservation outreach officers to develop extension programs that will educate people to minimize the risks of disease transmission between wildlife, livestock and local population and reduce conflicts between park and local communities.

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About the Authors: Michel Masozera is a Jim Ellis Mentorship Program Fellow and a Ph.D. student in the Rubenstein School of Environment and Natural Resources at the University of Vermont. Email: michel.masozera@uvm.edu. Dr. Jon Erickson is an Associate Professor in the Rubenstein School of Natural Resources and Environment at the University of Vermont. Email: jon.erickson@uvm.edu. Dr. Deana Clifford is the HALI Project Coordinator and a postdoctoral researcher at the Wildlife Health Center, University of California, Davis. Email: dlclifford@ucdavis.edu. Mariam Nguvava is a HALI project research assistant. Email: mariamnguvava@yahoo.com. Dr. Peter Coppolillo is an Associate Conservation Ecologist and at the time of writing was the Project Director of the Wildlife Conservation Society Ruaha Landscape Program. He is currently the Coordinator for the Yellowstone Rockies Program. Email: PCoppolillo@wcs.org.

The Health for Animals and Livelihood Improvement (HALI) project was established in 2006 and is a stakeholder-driven research and capacity-building program to assess the effects of zoonotic disease and water management on animal health, biodiversity, and livelihoods in the Ruaha ecosystem, Tanzania. The project is led by Dr. Jonna Mazet, University of California, Davis. Email: jkmazet@ucdavis.edu.

The Global Livestock CRSP is comprised of multidisciplinary, collaborative projects focused on human nutrition, economic growth, environment and policy related to animal agriculture and linked by a global theme of risk in a changing environment. The program is active in East and West Africa, Central Asia and Latin America.

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GLOBAL LIVESTOCK CRSP

Landscape Factors Associated with Livestock Disease Deaths in Idodi and Pawaga Divisions, Tanzania

Peter Coppolillo[1], Deana Clifford[2], Amy Dickman[3], Michel Masozera[4], Mariam Nguvava[5], Rudovick Kazwala[5], Jon Erickson[4], and Jonna Mazet[2]
[1]Wildlife Conservation Society, [2]University of California Davis, [3]Oxford University, [4]University of Vermont, [5]Sokoine University of Agriculture
Health for Animals and Livelihood Improvement Project

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In sub-Saharan Africa, livestock deaths due to disease have large impacts on household income and nutrition. As part of the larger Health for Animals and Livelihood Improvement (HALI) project assessing the impact of zoonotic disease and water scarcity on rural livelihoods, the authors examined the association between landscape factors and livestock deaths attributed to disease in pastoralist households living near Ruaha National Park, Tanzania. Preliminary results suggest that households located farther from the center of the village and farther from water sources suffered greater livestock losses due to disease. Livestock disease losses were greater in Pawaga than in Idodi Division, underscoring the importance of localized factors that may influence disease. The presence of wildlife and close proximity to roads were not associated with livestock disease losses. However, that is not to say the perception of disease from wildlife is not important, nor can it be said that interactions in the opposite direction (from livestock to wildlife) are not important. These assessments will require further investigation, which is currently underway. Study data also support the importance of water availability for livestock health and productivity. In conclusion, both local and regional strategies to increase livestock productivity should consider within-village disease variation and ensure that more remote households have access to extension and veterinary services.

Background

Livestock disease is a critical economic issue for pastoralists (livestock keepers deriving the majority of their subsistence from their herds), as it strongly affects herd productivity, which in turn affects (among others) household income and nutrition, along with herd dynamics, including mortality in drought and growth in good years. Disease is also an ecological issue, with zoonoses (diseases that can be transmitted between animals and people) affecting human populations, and the exchange of disease between livestock and wildlife affecting conservation and livelihood outcomes. Disease interactions, or more aptly, perceived disease interactions are also socio-political considerations, with both protected area managers and pastoralists citing the others' animals as reservoirs of disease and threats to their own existence, a scenario with important implications for the mitigation of regional conflict.

These issues are clear throughout savanna Africa and most rangeland ecosystems, and Pawaga and Idodi Divisions, adjacent to Ruaha National Park in central Tanzania, are no different. Here, where rainfall ranges from 200-550 mm/year, rain-fed agriculture is marginal at best. Pastoral and agropastoral livelihoods are widespread and are the only viable subsistence strategies outside areas where irrigated agriculture is possible. Because both Pawaga and Idodi Divisions border Ruaha National Park, disease at the wildlife-livestock interface is at once a political issue and a potential threat to wildlife populations and livelihoods.

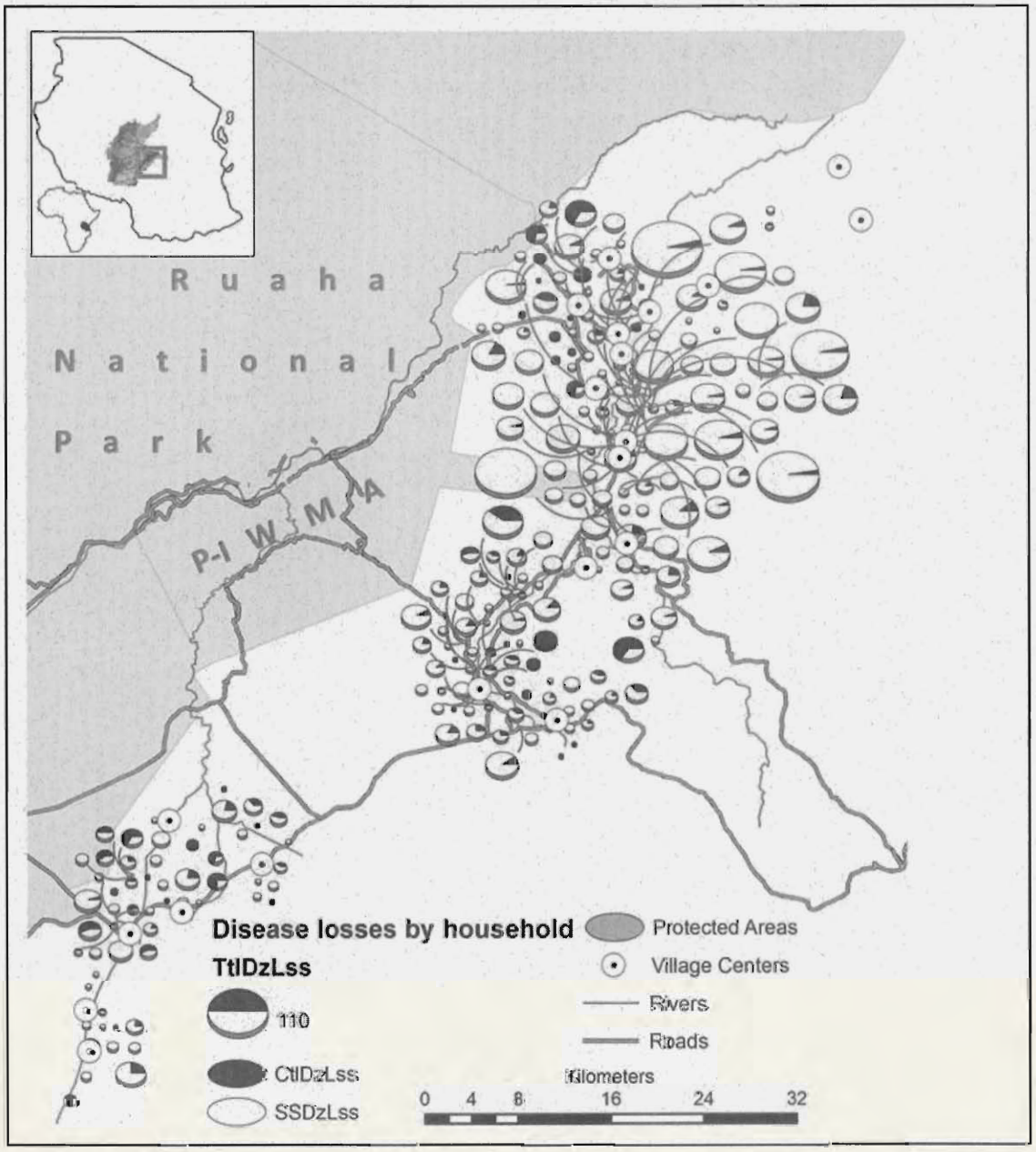
Recognizing these issues and their importance, the Health for Animals and Livelihood Improvement (HALI) project, initiated in 2006, sought to quantify livestock disease prevalence and distribution of livestock losses to disease in the area. In this research brief, the authors present reported livestock disease losses from household surveys in Pawaga and Idodi Divisions. Data from the HALI project were also combined with reported disease loss data from carnivore conflict surveys, which examined all livestock losses, including disease, theft, and losses to carnivores.

Preliminary Findings

The most striking finding to date is that, despite huge political significance and widespread perceptions that wildlife pass diseases to livestock, there was no evidence of such an interaction. Neither pastoralists living closer to park boundaries, nor those living in areas with higher wildlife densities (as measured by aerial surveys and foot transects) had higher losses attributed to disease. In fact, for small stock (sheep and goats), a negative relationship was found with households living at higher wildlife densities having lower disease losses.

A second important negative result was that households living closer to roads and the associated diseases introduced by itinerant livestock showed no increase in livestock losses. In contrast, households located at greater distances from the village centers were more

Figure 1. Reported disease losses in Idodi and Pawaga Divisions adjacent to Ruaha National Park and Pawaga-Idodi Wildlife Management Area (PI-WMA), Tanzania (area of detail shown in inset). Pie charts are sized according to total losses, with cattle losses in black and small stock in white.

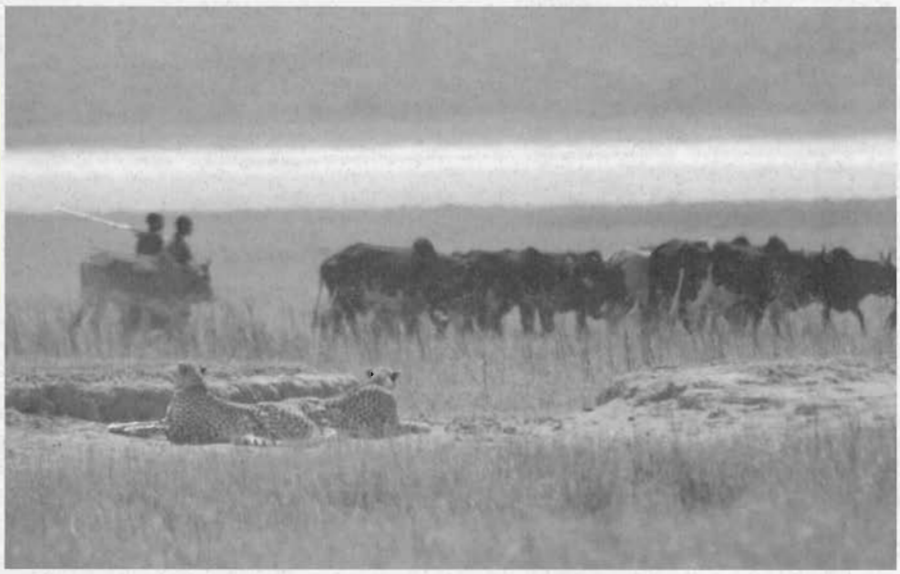


likely to suffer greater losses of both cattle and small stock, suggesting that limited access to veterinary supplies and livestock extension may exacerbate livestock losses. Information may also be limiting, as those living farther from villages may be less aware of disease outbreaks and consequently less able to vaccinate or treat stock sooner.

Households living farther from surface water also reported more losses. This may reflect poorer water sources (with greater contamination, higher densities of use), or the effects of increased nutritional stress on livestock from having to walk herds farther, or less frequent watering. The final important result was the marked differences between Idodi and Pawaga Divisions themselves. Losses for all stock were greater in Pawaga Division, possibly reflecting the area's dryness (there is a west to east rainfall gradient), or the effects of the 2007 Rift Valley Fever outbreak in small ruminants (though cattle losses were higher in Pawaga as well).

Practical Implications

A number of practical issues arise from these preliminary results. First, the relationship between disease losses and distance to village centers suggests that access to veterinary care, markets for veterinary supplies, and information on livestock husbandry may be important factors in mitigating disease losses. Both local and regional strategies



Cheetah keep a close eye on cattle escorted by Maasai herders. The HALI project is investigating disease transmission in this landscape, where livestock, humans, and wildlife share critical resources and often come into close contact. Photo by Jonna Mazet.

to increase livestock productivity should consider within-village variation and ensure that more remote households have access to extension and veterinary services.

Exposure to wildlife was not an important factor driving livestock disease losses in sampled households. However, that is not to say the perception of disease from wildlife is not important, nor can it be said that interactions in the opposite direction (from livestock to wildlife) are not important. Additionally, diseases transmitted between wildlife and livestock that result in illness or decreased production, but not necessarily death of the animal, may be overlooked when assessing deaths due to disease. This assessment will require more wildlife sampling, which the HALI project has already begun in collaboration with the Tanzanian National Parks. It is also conceivable that a wildlife reservoir spreads disease evenly across the whole study area, so comparisons with other livestock producing areas lacking wildlife may be useful.

The data also revealed significant spatial differences between the two divisions. The differences are not wholly attributable to the Rift Valley Fever outbreak in 2007 (which was more severe in Pawaga), and it is not clear whether the same pattern will persist through time. It is clear however, that livestock extension and veterinary interventions should be keenly aware of local variation in disease losses and target their efforts accordingly.

Maasai herders and their livestock pass by a herd of Zebra. Extensive grazing is critical to livestock nutrition and livelihoods in pastoral management systems, and often brings herders, their households, livestock and wildlife into close proximity as resources like water and pasture are shared. This proximity increases the potential for the transmission of zoonotic diseases like tuberculosis.
Photo by Jonna Mazet.

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About the Authors: Dr. Peter Coppolillo is an Associate Conservation Ecologist and former director of the Ruaha Landscape Program for the Wildlife Conservation Society (WCS). He is currently coordinator for the WCS Yellowstone Program. Email: PCoppolillo@WCS.org. Dr. Deana Clifford is the HALI Project Coordinator and postdoctoral researcher at the Wildlife Health Center in the School of Veterinary Medicine, University of California, Davis. Email: dlclifford@ucdavis.edu. Amy Dickman is the Kaplan Senior Research Fellow in Wild Cat Conservation at Oxford University. Email: amydickman@gmail.com. Michel Masozera is a PhD Candidate and Borlag-LEAP Fellow at the University of Vermont. Email: Michel.Masozera@uvm.edu. Mariam Nguvava served as the HALI Project Socieconomic Research Assistant and currently is a teaching assistant at Sokoine University. Email: mariamnguvava@yahoo.com. Dr. Rudovick Kazwala is a Professor of Veterinary Medicine and Public Health at Sokoine University. Email: kazwala@suanet.ac.tz. Dr. Jonna Mazet is a Professor of Wildlife Epidemiology and Co-Director of the Wildlife Health Center at the University of California Davis. Email: jkmazet@ucdavis.edu.

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GLOBAL LIVESTOCK CRSP

Building Human Capacity to Solve Ecosystem-Health Challenges in Developing Countries

Deana Clifford[1], Rudovick Kazwala[2], Val Beasley[3], Kirsten Gilardi[1], Elizabeth VanWormer[1], Harrison Sadiki[2], and Jonna Mazet[1]
[1]University of California Davis, [2]Sokoine University of Agriculture, [3]University of Illinois
Health for Animals and Livelihood Improvement Project

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The Envirovet Summer Institute is an established, yet unique and annually adapted opportunity to train the next generation of professionals in the rapidly emerging area of ecosystem health. In 2008, the GL-CRSP sponsored Health for Animals and Livelihood Improvement (HALI) project partnered with Envirovet to design and direct the Envirovet Summer Institute Developing Country Session in Tanzania. From July 17th through August 5th, 2008 twenty-four veterinary professionals and exceptional veterinary students from six nations studied cross-cutting themes relating to health at the wildlife-livestock-human interface, conservation, zoonotic diseases, and freshwater and marine ecosystem health at multiple locations in Tanzania through a combination of hands-on activities, field visits and presentations. Linking ongoing research from the HALI program with Envirovet created a win-win partnership, enabling HALI to fulfill the goal of increasing local capacity for disease diagnosis and surveillance, and expanding each organization's impact by helping to create a cadre of scientists working on issues relevant to improving health and livelihoods in developing countries.

Background

There is a paucity of veterinary educational and training opportunities in wildlife and ecosystem health that facilitate the application of veterinarians' comparative medicine and problem-solving skills to benefit wildlife and ecosystems. In developing countries, veterinary training is basic and emphasizes food animal medicine. However, veterinarians in these countries who assume responsibility for the health of free-ranging wildlife within and outside protected areas generally have very little opportunity for training and education in diseases at the domestic animal-wildlife interface, zoonoses, environmental toxicology, land and water management, conservation, and other key components of ecosystem health.

Since 1991, the Envirovet Summer Institute has been providing knowledge, skills, and mentors necessary to catalyze environmentally-focused careers for veterinarians. Envirovet illustrates many ways by which veterinarians can contribute to improvement of ecosystem integrity across a spectrum of landscapes, with special attention to the interface between wild areas and areas intensively managed by humans. The course is designed to guide participants towards matching their aims and resources to an educational plan and career in wildlife and ecosystem health. Because of careful selection of its faculty members, including specialists from academia, industry, government, non-governmental organizations, and the private sector, Envirovet students gain exposure to a broad range of perspectives and guidance from world-class role models.

The goal of the Envirovet Summer Institute is to create a force of scientists with unique perspectives, knowledge, skills, and expertise required to implement an efficient approach to ecosystem repair that will enable synchronous gains in wildlife, domestic animal, human, and economic health. To meet this goal, Envirovet provides seven weeks of intensive lecture, laboratory, and field experiences to approximately 25 veterinarians, veterinary students and wildlife professionals in terrestrial and aquatic wildlife and ecosystem health, addressing both developed and developing country issues.

The Envirovet course is divided into two sessions. The first session is entitled "Terrestrial and Aquatic Wildlife and Ecosystem Health Issues and Techniques for the Developed World with Outreach to Developing Countries." Components of this session take place in Florida and Georgia. The second session is entitled "Terrestrial and Aquatic Wildlife and Ecosystem Health Issues and Techniques for the Developing World" and takes place in a developing country. Because of the zoonotic disease and ecosystem health research activities comprising the Global Livestock Collaborative Research Support Program's (GL-CRSP) Health for Animals and Livelihood Improvement (HALI) project, the resulting network of local partnerships, and commitment to training and capacity building, team members from the GL-CRSP HALI project were offered the chance to design the curriculum for and direct the 2008 Envirovet developing country session for the first time in Tanzania.

Principal Outcomes

From July 17th through August 5th, 2008, Envirovet participants studied cross-cutting themes in ecosystem health through a combination of hands-on activities, field visits and presentations at various locations throughout Tanzania. Envirovet participants explored the first theme, "Health and Conservation at the Wildlife-Livestock-Interface" by discussing case studies presented by researchers who are actively working to mitigate these problems. They visited sites of wildlife-human conflict and spent an afternoon talking with pastoralists living near a wildlife-protected area. They actively participated in ongoing HALI project research activities, learning how to test cattle for bovine tuberculosis and sample river water for pathogens in order to evaluate risks of zoonotic diseases at the interface between populations of humans and their domestic animals, and wildlife.

During a visit to the Sokoine University of Agriculture's Faculty of Veterinary Medicine participants toured the veterinary school and participated in activities focused on the second theme, "Challenges with Diagnosis, Surveillance and Control of Zoonotic and Emerging Infectious Diseases in Developing Countries". During hands-on laboratories, participants learned how to properly handle, test, and necropsy chickens in the case of a highly pathogenic avian influenza outbreak; how to assess toxicoses in fish using biomarker assay methods; and were familiarized with methods for characterization of water-borne disease agents and tuberculosis. Lectures and discussions focused on Rift Valley fever and climate change, bovine tuberculosis in animals and people, animal welfare in the developing world, the role of private and public veterinary medicine in Tanzania, and the complex issue of bushmeat. Research and locally appropriate methods being developed in Tanzania for disease diagnosis and surveillance were highlighted with a visit to the Apopo Project, which uses giant Gambian rats for detection of tuberculosis.

Envirovet Tanzania Goals

- Produce globally aware wildlife and ecosystem health professionals able to solve problems in diverse cultural contexts.
- Develop participant understanding of the conditions and constraints relevant to addressing health and conservation issues in developing countries.
- Allow participants to develop a professional network of colleagues and exchange ideas in a supportive environment.

Participants learned about the third theme, "Challenges to Wildlife Health and Conservation in Protected Areas," by participating in projects addressing disease issues in Mikumi and Ruaha National Parks, including a giraffe immobilization (see picture below) and disease field survey. Additionally, participants learned about new initiatives that have created community-based wildlife management areas and worked on wildlife tracking, plant identification, and fish sampling field exercises inside the newly created Pawaga-Idodi community-based Wildlife Management Area. The pros and cons of community-based conservation initiatives were addressed during lively discussions. Challenges and recent success in the conservation of Zanzibar's indigenous forests and mangroves were highlighted in a visit to Jozani Chakwa Bay Conservation Area.

Finally, "Threats to Tropical Marine and Freshwater Systems" were addressed. Participants closely studied the 15-year conservation crisis of the Great Ruaha River. The history and consequences of the drying of the Great Ruaha River were presented in a detailed case study, and participants visited various sites along the river and its tributaries to: 1) see examples of irrigation and water diversions, 2) assess fish species diversity, and 3) sample

Working with a team of Tanzanian wildlife veterinarians, Envirovet students monitor and collect vital samples from an immobilized giraffe as part of an ear disease investigation in Mikumi National Park. By linking Envirovet with the HALI project, students were able to gain hands-on experience in research focused on ecosystem health. Photo by Elizabeth VanWormer.

Table 1. Output and impact of the Envirovet Summer Institute in Tanzania.

Output	Impact
A total of 180 hours (average of 9.5 hr/day for 19 days) of training in the form of lectures, laboratory exercises, field experiences, group discussions.	Veterinarians versed in the complexities and multidisciplinary nature of wildlife and ecosystem health through immersion training.
24 veterinarians and veterinary students who have new knowledge and mentors to facilitate focused careers on wildlife and ecosystem health.	Greater capacity among veterinarians at institutions worldwide for addressing wildlife and ecosystem health challenges.
A cohort of like-minded veterinary professionals with mutual awareness and the shared experience of Envirovet.	A true network of global animal health and conservation professionals addressing ecosystem health challenges with the greater synergy and cooperation that such networks make possible.

for pathogens in the water. Pollution problems and the latest research in freshwater and marine ecosystems were emphasized through discussions and field exercises at Sokoine University of Agriculture and the Institute for Marine Sciences on Zanzibar. Coral health and innovations in mariculture were also highlighted through lectures, and field visits to women's cooperatives for sustainable seaweed farming and half-pearl jewelry production.

Practical Implications

In just 19 days, Envirovet Tanzania provided approximately 180 hours of instruction, laboratories, and field activities from 38 instructors at six sites across Tanzania and the island of Zanzibar. By linking HALI and Envirovet, students assisted in ongoing research projects, gaining first-hand experience in problem solving when faced with the challenges of health research in a developing country.

Additionally, participants had access to areas not frequented by tourists, enabling them to hear unique perspectives from pastoralists and village leaders in addition to non-governmental organization staff, academicians and government employees. Christina Ploog, an Envirovet participant and veterinary student from the University of Illinois with a background in social work commented, "It [Envirovet Tanzania] was truly amazing and it really changed my perception of veterinary medicine, myself, my world, my country. I knew veterinary medicine was powerful before Envirovet, but the work all of you are doing is truly inspiring to me and more than ever I am thrilled that I will soon be a part of it all."

Directing Envirovet in Tanzania has also expanded the HALI project's collaborative relationships within Tanzania. Five organizations (Sokoine University, Tanzania National Parks, University of California Davis, Wildlife Conservation Society Ruaha Landscape Program, and the Institute for Marine Studies, Zanzibar) worked together as hosts and instructors for the course. Bringing instructors from different organizations together for the course also fostered new research collaborations.

To date, the Envirovet Summer Institute has trained 339 individuals from 38 nations, including: Canada, the United States, Mexico, Costa Rica, Panama, Colombia, Bolivia, Brazil, Argentina, Nigeria, Ethiopia, Kenya, Tanzania, Uganda, Zimbabwe, Botswana, South Africa, the United Kingdom, France, Norway, Italy, Hungary, Germany, Lithuania, Pakistan, India, Thailand, Mongolia, Japan, Taiwan, Sri Lanka, and New Zealand. Many Envirovet alumni are working to help wildlife, domestic animal, and public health around the world each day. Most of these individuals have some role at the interface of domestic animal-wildlife-public health, with many serving in prominent positions in government, academia and non-governmental organizations.

Dr. Ayebazibwei Christostom, veterinarian and GL-CRSP supported Envirovet participant from Uganda wrote, "I take this opportunity to thank you for the support to attend Envirovet 2008. I have really benefited so much, beyond my expectation. The course exposed me to a new arena of ecosystem health, encompassing livestock-wildlife-human beings and environment in any aspect of research and development. The training has exposed me to a number of professionals and colleagues who can help me to network and collaborate on a number of issues. I have conviction that the knowledge I have gained will further support development in my country and over the globe."

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About the Authors: Dr. Deana Clifford is the HALI Project Coordinator, postdoctoral researcher, and director of the Envirovet Tanzania course. Email: dlclifford@ucdavis.edu. Dr. Rudovick Kazwala is Professor of Veterinary Medicine and Public Health at the Sokoine University of Agriculture. He co-directs Envirovet Tanzania and is Co-Principal Investigator for HALI Project. Email: kazwala@suanet.ac.tz. Dr. Val Beasley is Professor of Veterinary, Wildlife and Ecological Toxicology at the University of Illinois and the Executive Director of the Envirovet Summer Institute. Email: val@illinois.edu. Dr. Kirsten Gilardi is a Senior Wildlife Veterinarian at the University of California, Davis Wildlife Health Center and co-director of Envirovet Summer Institute. Email: kvgilardi@ucdavis.edu. Dr. Elizabeth VanWormer is a PhD Candidate in Epidemiology at the University of California, Davis and assistant coordinator for the Envirovet Tanzania course. Email: evanwormer@ucdavis.edu. Dr. Harrison Sadiki is the HALI Project Field Coordinator and logistics coordinator for Envirovet Tanzania. Email: hsadily@yahoo.com. Dr. Jonna Mazet is a Professor of Wildlife Epidemiology and Director of the Wildlife Health Center at the University of California Davis. Email: jkmazet@ucdavis.edu.

The Health for Animals and Livelihood Improvement (HALI) project was established in 2006 and is a stakeholder-driven research and capacity-building program to assess the effects of zoonotic disease and water management on animal health, biodiversity, and livelihoods in the Ruaha ecosystem, Tanzania. The project is led by Dr. Jonna Mazet. Email: jkmazet@ucdavis.edu.

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Edited by David Wolking and Susan L. Johnson

GLOBAL LIVESTOCK CRSP

Capturing Women's Voices: Socioeconomics and Gender-Roles in Pastoralist Households in the Ruaha Landscape, Tanzania

Mariam Nguvava[3], Deana Clifford[1], Michel Masozera[2], Peter Coppolillo[4], Harrison Sadiki[3], Jonna Mazet[1], and Jon Erickson[2]
[1]University of California Davis, [2]University of Vermont, [3]Sokoine University of Agriculture, [4]Wildlife Conservation Society
Health for Animals and Livelihood Improvement Project

Research Brief 09-03-HALI May 2009

Pastoralists in East Africa face a multitude of challenges relating to land ownership, environmental concerns and access to government services. These difficulties may disproportionately affect women due to traditional gender roles within pastoralist society. HALI project team members conducted an assessment of gender-roles in pastoralist households during a longitudinal survey of study households and focus group meetings in an effort to include women's voices in socioeconomic research investigating interactions between disease and water scarcity, and to identify challenges to empowerment facing these women. Findings revealed that women's participation in decision making in pastoralist households within the Ruaha landscape is limited to traditional socially assigned gender roles, most often child care; water collecting; animal and household husbandry; construction; food preparation; and production of milk, eggs and chickens; a finding consistent with other GL-CRSP research on gender roles and pastoralism conducted in Ethiopia and Kenya. In addition, women in Ruaha are often less likely to attend school. At the community level, women's participation in decision making remains low, as they are often reluctant to speak freely and confidently in the presence of men and community leaders. Despite these obstacles, experiences from HALI project research suggest that women's participation in decision-making in the study area is increasing as they are becoming active in women's associations and small enterprises, entities that enable women to collectively voice their concerns and foster greater social and economic independence, and that should be further evaluated as potential strategies to improve development efforts focused on women and children. The authors conclude, however, that a more detailed gender assessment is warranted, as the roles, constraints and experiences of women vary, and too little is understood about the role of these women's associations and microfinance groups.

Background

Pastoralists in East Africa face a multitude of challenges relating to land ownership, environmental concerns and access to government services. In traditional pastoralist societies, including those in the Ruaha landscape, land is not owned but 'belongs' to a group linked by descent or cultural affiliation. Despite the fact that pastoralism is the predominant production and livelihood system in the arid and semi-arid dry lands of East Africa, its value to household food security and national economic development is hardly considered (Coppolillo and Dickman, 2007). Policy makers tend to demonstrate little regard for pastoralism and pastoralist interests (Odhiambo, 2006). This lack of appreciation for the contribution of pastoralism to national economies and poor access to education and medical and veterinary services has further marginalized pastoralists, with women in particular being severely affected. This is especially true for women's contributions to pastoral systems. In this research brief, the authors consider gender roles and their implications for development among three ethnic groups living in the Ruaha Landscape, Tanzania.

Gender Roles in Pastoralist Societies. Understanding the role of gender in traditional livestock production systems is essential for effective research, development and policy formulation. In Tanzania, gender roles differ in the management and ownership of cattle, goats, chickens and other animals. Gender dynamics also vary among pastoralists, agropastoralists (permanent settlement with crops and animals) and intensive production systems (high population density, crop-oriented systems with animals playing a supplementary role). Each has developed different ways to control resources, divide labor, and make decisions that are often poorly understood by outsiders. In traditional pastoralist systems, for example, almost all cattle belong to men, and women control only cattle allocated by men. Household management and decisions about animals are usually made by older men with young men responsible for herding, while women are responsible for the milking of cows and care of young animals. For agropastoralist communities, management of livestock is usually done by men, with the processing and marketing of milk and butter primarily performed by women. Although women may own some animals through inheritance and may purchase more through income earning activities, they still consult with husbands regarding livestock decisions. Generally, in intensive systems, men control land and livestock, but women control food crops and are responsible for the management of poultry. Unlike

pastoral livestock systems, men also may be more likely to consult with their wives regarding major decisions.

Why Women's Voices Matter. The Global Livestock CRSP (GL-CRSP) Health for Animals and Livelihood Improvement (HALI) project is investigating the effects of water limitation and disease on the health and economic well-being of pastoralist and agropastoralist households, as well as assessing people's attitudes toward disease, disease management and livestock/wildlife extension in order to identify strategies to more effectively address zoonotic disease and development at the human/livestock/wildlife interface. In this high conservation-value but water-restricted ecosystem, competition for scarce grazing and water resources is increasing. In addition, potential for disease transmission among human, wildlife and livestock are growing as pastoralists, agropastoralists and their livestock are forced to share common dwindling water sources with each other and wildlife. Given the differential effects that health and water scarcity may have on pastoralist women, it was essential that women's perspectives be heard in HALI project research activities, and that varying gender roles be considered. For example, perceptions about disease and actual disease risk may differ by gender; men make most livestock management decisions (including health care) but women often attend to daily husbandry needs (milking, calf management, tick removal). Accordingly, women may be more at risk for health problems and important sentinels for recognizing livestock disease, as they may be able to more rapidly recognize livestock changes and may be exposed more frequently to animal-source disease because of their more regular and close contact with livestock and animal products (mostly milk, meat, fat and occasionally blood). Furthermore, water scarcity may disproportionately affect women and children, who are primarily responsible for collecting water for household needs. Here the authors report on efforts to include women's voices in HALI project socioeconomic research, the challenges faced, and the initial observations on gender roles based upon findings from surveys and focus group meetings.

Methods. From December 2006 through November 2007, HALI team members interviewed 160 pastoralist and agropastoralist households among Maasai, Sukuma and Barabaig ethnic groups to assess the impact of water and disease on the health of the household, its livestock, and the household economy. The team collected information concerning livestock, water and sanitation; household structure; labor and health; agriculture; and other income generating activities performed by members of the household (see Research Brief 08-03-HALI for more survey details). At each household, the survey administrator made efforts to incorporate women into the interview process. Women's participation, the types of questions women answered, and the interactions between women and men were noted during the interviews. Information regarding gender division of labor and education level was captured in the questionnaire. In addition to household-level surveys, data was collected on health, water and economic issues at the village level by soliciting information from village leaders, in particular village executive officers and village chairmen. The number of village leaders that were female was recorded. Village focus groups were also conducted. Groups consisted of five to 12 members representing leaders of various groups such as women's associations, pastoralist associations, water users associations, village leadership, small business owners and religious leaders. Data concerning problems and challenges encountered with respect to agricultural activities, livestock, health and education in each village were collected. These meetings were led by a female administrator (Nugavava) with occasional assistance from other male HALI team members (Masozera and Sadiki). Women's opinions and the degree of women's participation in these meetings were monitored.

Preliminary Findings

Efforts and challenges of including women's voices in household surveys. Consultation with women on survey questions was challenging in pastoral communities. Most commonly, data were collected from men, and when they were unavailable, women often declined to be interviewed. Sometimes when the male head of house was absent and his wife and their children were present, the wife would invite a son to respond to the survey. Most wives would explain that they have no authority to talk to strangers. When the male head of household was present and a request was made to talk with the wife or wives in front of the husbands, most women tended to talk very little. When women did participate in the absence of their husbands, most gave more detailed information than male respondents, especially with respect to water and sanitation and household health. In general, the male interviewer reported more difficulties in obtaining information from women.

Observed gender roles in household interviews and village meetings. During the household interviews, wives were most often some distance away from the conversation area. For questions concerning family structure, most husbands gave information about the name, age, education and health of each member of the family. However in some instances, particularly for households of the Sukuma tribe, husbands invited their wives to answer these questions, indicating that the wives knew this information better. In contrast, husbands in Maasai and Barabaig households were typically the only respondents and answered most questions about the family.

Among the heads of household interviewed, 29% (47/160) had more than one wife. Polygamy tends to be

more common in Sukuma than in Maasai and Barabaig households. The average family size for interviewed households was 15 (including members of the extended family). Sukuma and Maasai households who had large families also tended to have large herds of cattle. Among the Sukuma, large families were due to the tendency of a father, his wives, his sons and their wives and the grandchildren to stay together in the same household. Conversely among the Maasai, a large family size was due to the head of household having many wives and hence many children and other live-in relatives. Barabaig men interviewed were more likely to have only one wife, hence the average number of people in their families (7.9), was lower than Maasai (11.25) or Sukuma (13.2). Barabaig tended to be more strictly nomadic, and smaller families are likely easier to organize and mobilize for frequent movement. Survey questions regarding education revealed that boys are more commonly selected to go to school and girls generally remain at home. There remains a high illiteracy rate among women and girls. This was attributed primarily to maintenance of traditional gender roles, lack of family resources and distance from households to schools. A higher proportion of children in Sukuma and Maasai households attended school compared to Barabaig households. Sukuma and Maasai households were settled closer to the villages and potentially had better access to schools.

At the village level. Preliminary results from focus group meetings and village leader interviews show that most economic activities are conducted and owned by men. Women do participate in activities such as chicken husbandry, operation of local restaurants and selling of local alcoholic brews. Women have also started creating and becoming involved in agriculture associations, which are mainly sponsored by the government. In regards to governance, only 9.5% (2/21) of participating villages were led by women.

During the village focus group meetings, most participants were men, and even when women attended, they did not talk or participate much. Encouraging women to speak was challenging, and when they responded, most times they repeated what the men had said. The women who attended these meetings were often members of women's associations. Sometimes these women tried to explain the problems they were having in their associations, especially their need for capacity building to enable them to more effectively utilize funds from donors, as well as their own return contributions.

Practical Implications

Findings from the HALI project preliminary gender assessment show that women's participation in decision making in pastoralist households is limited to socially

Sukuma women preparing food for a wedding ceremony in a village in Pawaga Division, Tanzania. Women's participation in decision making in this area is restricted to traditionally assigned gender roles. Research by the HALI project, however, shows that their participation may be increasing, due in part to the presence of women's associations and small enterprises. Photo by David Wolking

assigned gender roles, most often child care; water collecting; animal and household husbandry; construction; food preparation; and production of milk, eggs and chickens; a finding consistent with other GL-CRSP research on gender roles and pastoralism conducted in Ethiopia and Kenya (McPeak and Doss, 2006; Ngari, 2008). At the community level, women's participation in decision making remains low despite evolving roles in community activities supported by governments and donors. Furthermore, the experiences and knowledge accumulated by women are rarely acknowledged or utilized.

Despite these challenges, initial findings and experiences suggest that the position of pastoralist women in the Ruaha landscape has improved slightly in recent years, as evidenced by women being allowed to leave the household more frequently. Despite this improvement, pastoralist women remain far from "empowered," and they most often have to get their husband's permission to attend community meetings, and rarely have the confidence to speak. However, women are becoming active in the women's associations that now exist in most of the study villages, and in some cases even contribute money, which in many instances is used for microfinance development activities for members. Accordingly, there is a need to increase education and confidence-building opportunities for these women to enable them to make decisions more effectively, and to encourage consideration of profitable

activities that will optimally benefit their households and villages, a role that can be supported to a much greater extent in the study area by government agencies and development organizations.

Addressing gender equality issues in pastoralist communities is a continuing challenge, as traditional gender roles are very much entrenched and there are few experts on gender issues in the area. There is a need to involve gender experts in projects such as HALI, but such experts should either be from the area or have a very good understanding of east African pastoral societies. In conclusion, though the current assessment did identify several gender-related issues and challenges in the study area, a more detailed gender assessment is warranted, as the roles, constraints and experiences of women vary, and too little is understood about the role of the women's associations and microfinance groups. It is clear from this preliminary assessment however, that the evolution of these women's groups as the nucleus for gendered empowerment should be evaluated as a key strategy to improve development efforts focused on education, household health, food security, and poverty reduction.

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About the Authors: Mariam Nguvava served as the HALI project Socio-economic Research Assistant and currently is a teaching assistant at Sokoine University. Email: mariamnguvava@yahoo.com. Dr. Deana Clifford is the HALI Project Coordinator and postdoctoral researcher at the Wildlife Health Center in the School of Veterinary Medicine, University of California, Davis. Email: dlclifford@ucdavis.edu. Michel Masozera is a PhD Candidate and Borlag-LEAP Fellow at the University of Vermont. Email: Michel.Masozera@uvm.edu. Dr. Peter Coppolillo is an Associate Conservation Ecologist and former Director of the Ruaha Landscape Program for the Wildlife Conservation Society (WCS). He is currently Coordinator of WCS's Yellowstone Rockies Program. Email: PCoppolillo@WCS.org. Dr. Harrison Sadiki is the HALI Project Field Coordinator at Sokoine University of Agriculture. Email: hsadily@yahoo.com. Dr. Jonna Mazet is a Professor of Wildlife Epidemiology and Co-Director of the Wildlife Health Center at the University of California Davis. Email: jkmazet@ucdavis.edu. Dr. Jon Erickson is an Associate Professor of Ecological Economics at the University of Vermont. Email: jon.erickson@uvm.edu.

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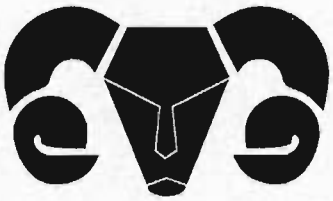

New Medicine for Emerging Zoonoses: Reducing Disease Risk at Human-Animal-Environment Interfaces in Tanzania Using a One-Health Approach

J.A.K Mazet[1], D.L. Clifford[1], P.B. Coppolillo[2], J.D. Erickson[3], and R.R. Kazwala[4]
[1]University of California, Davis; [2]Wildlife Conservation Society; [3]University of Vermont; [4]Sokoine University of Agriculture, Tanzania
Health for Animals and Livelihood Improvement Project

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When livestock and wildlife are in close proximity, diseases can have severe impacts on livelihoods, biodiversity, and even human health. Using a transdisciplinary ecosystem approach rooted in the "One Health" paradigm, an increasingly important prism through which governments, non-governmental organizations, and practitioners view human health, we are addressing disease transmission and its impacts on livelihoods in water-limited, rural Tanzania. Critical information gaps targeted for data collection included disease testing in animals and water, human health and socioeconomic surveys, and evaluation of wildlife and livestock demography and land usage. The resulting data were used to assess risk of transmission of the bovine tuberculosis, brucellosis, and waterborne pathogens identified in the area and to identify science-based interventions likely to be implementable in the current economic and cultural contexts. The HALI platform has reinforced the importance of the One Health concept and provided lessons for the development of a new approach to global health. Effective surveillance, assessments, and interventions are only possible by crossing the organizational gaps between local citizens and institutions studying and managing wildlife, livestock, water, and public health. Collecting detailed data regarding land use and agricultural practices, food consumption, and water use habits, illness in animals and people, and access to healthcare will help appropriately tailor education efforts for priority diseases and pandemic prevention. Though strong science is an excellent foundation on which to base recommendations, interventions can succeed only if stakeholders are involved in the characterization of the problem and are willing to make the tradeoffs necessary to balance their short-term economic needs with those of the long-term health of the ecosystem. Finally, the donor community should be encouraged to transcend disciplinary conventions and invest in holistic health projects that have the best chance of affecting change.

Background

Every day thousands of children and adults die from under-diagnosed diseases that have arisen at the human-animal-environment interface, especially diarrheal and respiratory diseases in developing countries. Explosive human population growth and environmental changes have resulted in increased numbers of people living in close contact with wild and domestic animals. Unfortunately, this increased contact together with changes in land use, including livestock grazing and crop production, have altered the inherent ecological balance between pathogens and their human and animal hosts. In fact, zoonotic pathogens account for the majority of emerging infectious diseases in people. Nowhere in the world are these health impacts more important than in developing countries, where daily workloads are highly dependent on the availability of natural resources. Water resources are perhaps most crucial, as humans and animals depend on safe water for health and survival, and sources of clean water are dwindling due to demands from agriculture and global climate change. As water becomes more scarce, animals and people are squeezed into smaller workable areas, increasing contact among infected animals and people, and facilitating disease transmission (Clifford et al., 2008).

These conditions are particularly prevalent in rural Africa and near remaining wildlands. Rapid population growth and consequent demands for natural resources are making African wildlands increasingly vulnerable to conversion to other land-uses, such as logging, agriculture, and pastureland. A recent analysis by Wittemyer et al. (2008) found that average annual population growth rates were higher in buffers to protected areas than in rural areas in Africa and Latin America. Protected areas provide some of the last supplies of ecosystem goods and services for expanding human populations, yet their porous edges provide refuge for the vectors of zoonotic disease transmission.

The interconnectedness of human, animal, and environmental health is at the heart of 'One Health,' an increasingly important prism through which governments, non-governmental organizations, and practitioners view human health. An important implication of the One Health approach is that integrated policy interventions which simultaneously and holistically address multiple and interacting causes of poor human health – unsafe and scarce water, lack of sanitation, food insecurity, and close proximity between

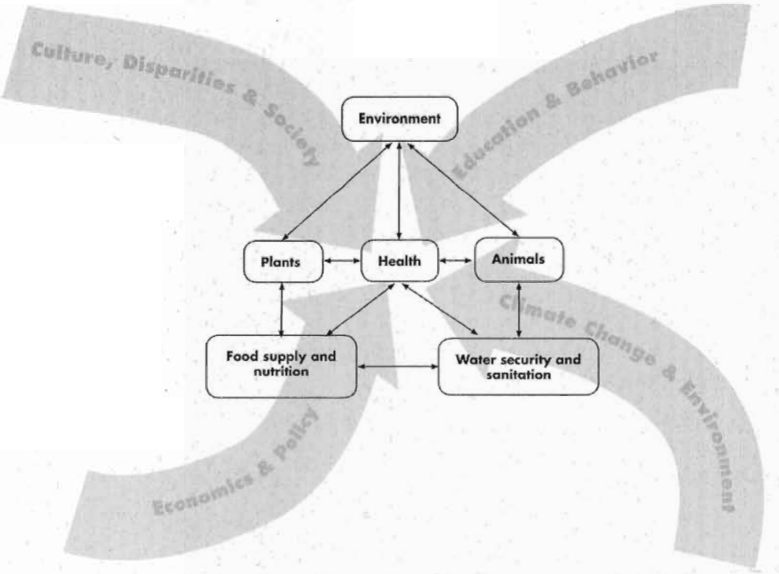

Figure 1. Local and global influences impacting human health, including the interdependence of people, animals, plants, and the environment, and associated food and water availability, safety, and security.

animals and humans – will yield significantly larger health benefits than policies that target each of these factors individually and in isolation. By its very nature, the One Health approach is trans-disciplinary, since it is predicated on working collaboratively to improve and promote both human and animal health. Figure 1 depicts the interdependent relationships and influences that interact to affect human health. This complexity necessitates professionals from multiple disciplines to collaborate on the design of effective interventions.

In 2006, the Health for Animals and Livelihood Improvement (HALI) project was initiated to test the feasibility of the One Health approach in rural Tanzania and to find creative solutions to these problems. HALI is investigating the impact of zoonotic disease on the health and livelihoods of rural Tanzanians living in the water-limited Ruaha ecosystem, one of Tanzania's largest wild areas, where virtually all communities depend entirely on the natural resource base and where livestock are central to traditional natural resource management. The HALI approach recognizes that the health of domestic animals, wildlife, and people are inextricably linked to the ecosystem on which all depend (Clifford et al., 2008).

Zoonotic diseases known to be of public health importance, like rabies and Rift Valley Fever, are present in wildlife, domestic animals, and people in Tanzania; however, the role of under-diagnosed disease, like bovine tuberculosis (BTB), has only just begun to be characterized. Nearly 40,000 new cases of tuberculosis (human, bovine, or atypical strain) are diagnosed per year in Tanzania, with anywhere from 21-77% of Tanzanian tuberculosis patients also infected with HIV. The extra-pulmonary form of tuberculosis (EPTB) in people, often associated with BTB infection from animals, accounts for 20% of the reported cases in Tanzania. Therefore, bovine tuberculosis became a focal disease for the HALI project due to its high livestock prevalence, wildlife data paucity, and the large, susceptible HIV/AIDS-infected human population living in close association with livestock and wildlife. Additional priorities for HALI were determined through gender-balanced interviews with affected communities. Through these interviews and stakeholder meetings, an overwhelming consensus emerged:

A significant proportion of the rural population in the Ruaha Landscape is affected by diseases impacted by water supply, and these diseases are affecting health, agricultural productivity, food security, and biodiversity in the region.

Accordingly, HALI is assessing the impact of the interactions between water and disease in Ruaha by simultaneously investigating the medical, ecological, socioeconomic, and policy issues driving the system.

Achievements

The map in Figure 2 illustrates our multi-level approach which includes: testing of wildlife (n=70), livestock (n=1350 in 102 households), and their water sources (10 sources sampled monthly for two years) for zoonotic pathogens and disease; environmental monitoring of water quality, availability, and use (with above); assessing wildlife population health and demography (surveys in association with Wildlife Conservation Society, Tanzania National Parks, and the local community managing wildlife); evaluating livestock and human disease impacts on livelihoods of pastoralist households (n=159 household surveys examining economic and disease transmission risk factors, including gender differences, subset resampled seasonally); examining land and water use impacts on daily workloads and village economies (n=18 detailed diaries); introducing new diagnostic techniques for disease detection (technology transfer between University of California, Davis and Sokoine University of Agriculture); training Tanzanians of all education levels about zoonotic disease (over 950 local people by outreach programs, 24 game scouts and technicians, four Honors Bachelor and Extern Projects, two Masters theses, one Rwandan PhD); and developing new health and environmental policy interventions to mitigate the impacts of zoonotic diseases (currently underway). Perhaps most importantly, HALI is

examining these issues in a common framework with specific emphasis on the interactions between them, instead of attempting to isolate a single issue.

The HALI project has identified bovine tuberculosis and brucellosis in livestock and wildlife in the Ruaha ecosystem and is using this information to identify geographic areas with varying water availability where risk of transmission between wildlife, livestock, and people may be high. In addition, *Salmonella, Escherichia coli, Cryptosporidium,* and *Giardia spp.* that can cause disease in humans and animals have been isolated from multiple water sources used by people and frequented by livestock and wildlife. These data are now being used to examine spatial and temporal associations between landscape factors and disease and to identify risk factors and health impacts that may be mitigated through policy changes and outreach. Preliminary findings also indicate that more than two-thirds of participating pastoral households do not believe that illness in their families can be contracted from livestock, and nearly half believe the same of wildlife. Furthermore, when HALI began working in this region, 75% of households did not consider sharing water sources with livestock or wildlife a health risk, illustrating the need for effective community education.

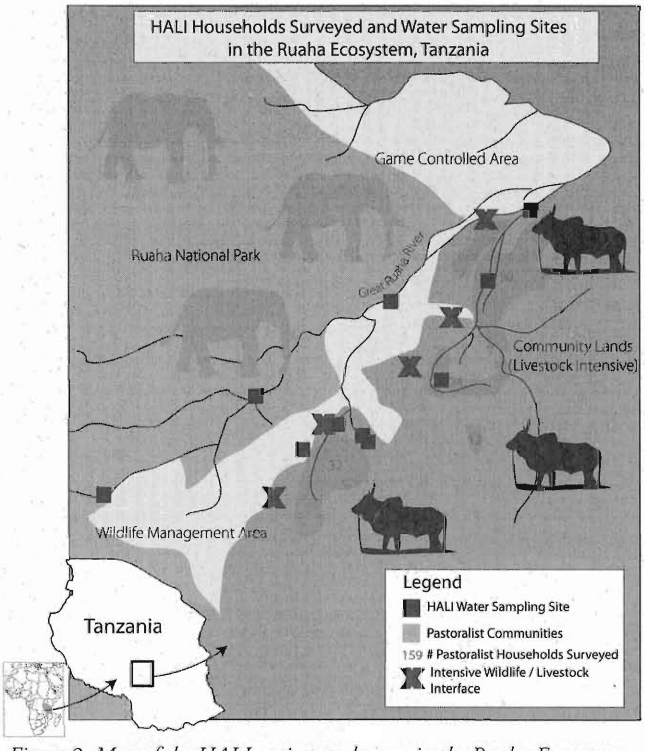

Figure 2. Map of the HALI project study area in the Ruaha Ecosystem, Tanzania.

The HALI project is currently focusing efforts on continued disease surveillance, health education and outreach, and collaboration with the Tanzanian medical community to better integrate animal and human health in rural areas of Ruaha. In 2009, HALI research in Ruaha formed a key component in obtaining a competitive research award of up to $75 million over five years to host a new USAID Emerging Pandemic Threats program entitled *PREDICT: Building a global early warning system for emerging diseases that move between wildlife and people.* PREDICT, now underway, is a research and capacity strengthening program working to improve disease surveillance and detect new and emerging diseases in wildlife that threaten humans in infectious disease hotspots around the world, like Ruaha. The PREDICT consortium is led by HALI Lead PI Dr. Jonna Mazet, and hosted within the UC Davis School of Veterinary Medicine's new One Health Institute.

Lessons Learned

The HALI platform has reinforced the importance of the One Health concept and provided lessons for the development of a new approach to global health. First, it is crucial to recognize that zoonotic pathogens are present and emerging in rural communities and that their emergence is spatially and temporally variable within these communities. Most people living in high risk areas are not aware of the danger or what can be done to reduce it. In addition, transmission can be exacerbated by common animal husbandry and food and water handling practices. Therefore, data collection strategies should include the evaluation of spatial, temporal, and demographic patterns of pathogen prevalence and disease in human, domestic animal, and wildlife populations in likely hotspots for disease emergence. The underlying water and land-use determinants of disease and the social, economic, and cultural barriers to control and prevention must be explored. While local stakeholders and international institutions actively involved in animal health, conservation, and livelihood assessment and improvement were quick to engage in HALI, physicians and public health experts (local and international) have been slower, likely due to competing demands on time and resources already dedicated to addressing malaria and tuberculosis of human origin. Concerns over the financial escalation of projects directly measuring pathogens in human subjects was also an obstacle to engaging medical professionals for these neglected diseases.

Second, the role of water in disease transmission and zoonosis emergence should be further explored. Water scarcity increases work stress, especially in women and children, and brings animals and people together more frequently, increasing the likelihood of water contamination and transmission of infectious diseases. Likewise, the manner in which water is used for agricultural and animal production affects worker health, food safety, and the health of those who drink and bathe in it. Improving water safety

and security, including sanitation, in ecologically appropriate ways that reduce disease risk will require a transdisciplinary approach in which economists, ecologists, epidemiologists, and engineers play important roles with public and animal health practitioners.

Finally, the determinants and consequences of zoonotic diseases, as well as the interventions to mitigate their deleterious effects, are all cross-sectoral. Effective surveillance, assessments, and interventions are only possible by crossing the organizational gaps among institutions studying and managing wildlife, livestock, water, and public health. It is clear that education in global health, especially emerging zoonotic diseases, is urgently needed at all levels from research institutions to pastoralist communities. Collecting detailed data regarding land use and agricultural practices, food consumption, and water use habits, illness in animals and people, and access to healthcare will help appropriately tailor education efforts for priority diseases and pandemic prevention. While strong science is an excellent foundation on which to base recommendations, interventions can succeed only if stakeholders are involved in the characterization of the problem and are willing to make the tradeoffs necessary to balance their short-term economic needs with those of the long-term health of the ecosystem. The donor community should be encouraged to transcend disciplinary conventions and invest in holistic health projects that have the best chance of affecting change.

Further Reading

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About the Authors: Dr. Jonna Mazet is a Professor of Epidemiology and Wildlife Health and Director of the Wildlife Health Center in the School of Veterinary Medicine, University of California, Davis. Email: jkmazet@ucdavis.edu. Dr. Deana Clifford is a veterinary epidemiologist with the California Department of Fish & Game. Email: dlclifford@ucdavis.edu. Dr. Peter Coppolillo is an Associate Conservation Ecologist and the Coordinator of the Yellowstone Rockies Program. Email: PCoppolillo@wcs.org. Dr. Jon Erickson is an Associate Professor in the Rubenstein School of Natural Resources and Environment at the University of Vermont. Email: jon.erickson@uvm.edu. Professor Rudovick Kazwala is a Professor in the Department of Veterinary Medicine and Public Health at Sokoine University of Agriculture. Email: kazwal@suanet.ac.tz.

The Health for Animals and Livelihood Improvement (HALI) project was established in 2006 and is a stakeholder-driven research and capacity-building program to assess the effects of zoonotic disease and water management on animal health, biodiversity, and livelihoods in the Ruaha ecosystem, Tanzania. The project is led by Dr. Jonna Mazet. She can be contacted via post at Wildlife Health Center, One Shields Ave., School of Veterinary Medicine, University of California, Davis, CA 95616, USA, or via email: jkmazet@ucdavis.edu.

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Edited by David Wolking & Susan L. Johnson

GLOBAL LIVESTOCK CRSP

Integrating the Management of the Ruaha Landscape of Tanzania with Local Needs and Preferences

M. Masozera[1], J.D. Erickson[1], D.L. Clifford[2], P. Coppolillo[3], M. Nguvava[4], H. Sadiki[4], and J.A.K. Mazet[2]
[1]University of Vermont; [2]University of California, Davis; [3]Wildlife Conservation Society; [4]Sokoine University of Agriculture, Tanzania
Health for Animals and Livelihood Improvement Project

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Sustainable management of landscapes with multiple competing demands requires balancing the diverse preferences and needs of stakeholder groups. Conservation and development organizations have often made unwarranted assumptions about what is desired by, or good for local people without engaging local stakeholders. This study uses conjoint analysis to assess the preferences of representatives from three stakeholder groups—local communities, district government officials, and non-governmental organizations (NGOs)—to identify potential competing conservation and development priorities facing local communities in the Ruaha Landscape of Tanzania. Representatives of local agricultural communities place high importance on investments in farmer's cooperatives that increase accessibility to supplies, loans, and capacity development. In contrast, district government officials and NGOs perceive investments to improve health, education, and tourism infrastructure as highest priorities for the region. Analysis suggests a need for incorporating issues deemed important by these various groups into a development strategy that aims to promote conservation of the Ruaha Landscape while improving the livelihoods of local communities. To be successful, future projects, whether conservation or development, must reconcile objectives at local to global scales and across sectors.

Background

The establishment of more than 44,000 protected areas, covering nearly 14 million square kilometers (km^2) across virtually every country of the world may well be one of the most stunning conservation successes of the 20th century. However, conventional management strategies such as a 'fences and fines approach' that prohibit access to protected areas have escalated conflicts between local communities and management authorities in developing countries. These conflicts are more pronounced where communities were once dependent on these areas for their subsistence needs. Growing populations are also increasingly drawn to the borderlands of protected areas to access ecosystem goods and services, including firewood, bush meat, clean water, medicinal plants, and refuge areas during civil strife. Wittemyer et al. (2008) found that average annual population growth rates were higher in buffers of protected areas than in rural areas of the same country in Africa and Latin America.

Africa's long history of conservation has been dominated by management strategies that exclude human use of resources in protected areas. Post-colonial African governments have continued to embrace these strategies. Because many protected areas have been proposed on lands that are legally or customarily occupied and managed by local people, it has often been impractical, or impossible, to consider these lands off-limits to human use. Furthermore, in countries where remote populations endure social and economic marginalization, protected areas have further restricted livelihood options. As a result, the protectionist approach has caused skepticism and even hatred between protected area managers and surrounding communities. There is a growing consensus among conservationists that the traditional protectionist approach will not ensure land and wildlife sustainability over the long run in Africa.

In many parts of Africa, and specifically in Southern Africa, different models of community based conservation programs have been undertaken in recent years that seek to link conservation with the alleviation of rural poverty, as well as encouraging community participation. Community based conservation (CBC) stresses the need to include local people either directly in protected area management or politically in the conservation policy process. However, the literature suggests that first generation CBC approaches have failed to achieve their goals. Songorwa (1999) notes that the main reasons were the failure to meet communities' expectations and the unwillingness of national governments to devolve ownership and management responsibility to local communities. In addition, the lack of community infrastructure and capacity to manage CBC projects has also been found to be an obstacle to success. In many cases, CBC approaches have been unable to address the complex and diverse interests of the people and institutions with claims to land and resources in and around protected areas.

Perhaps the lack of success of some CBC initiatives has been due to the characterization of community resource management needs by outside experts instead

of the knowledge and priorities of local people. A major challenge for the next generation of CBC is to find more effective ways to engage people whose livelihoods, interests, and future are linked to those of a protected area while effectively engaging those with relevant jurisdiction or substantial local influence (e.g. community leadership; local, regional, and national government; wildlife and protected area management agencies; research and development organizations; and churches). There have been few systematic attempts to help stakeholders identify and then make informed choices between competing priorities in conservation or development.

This research brief reports on the use of conjoint analysis (CA) to identify similarities and differences in perceptions of different stakeholder groups – non-governmental organizations (NGOs), village government, agro-pastoralists, and agriculturalists – regarding root causes and potential solutions for challenges related to balancing conservation and development needs in the Ruaha Landscape of Tanzania. Identifying stakeholder priorities and evaluating trade-offs before implementation of management can reduce the framework for successfully engaging multiple stakeholders at the local, regional, national, and international scales.

Study Area. The Ruaha Landscape covers over 45,000 km^2, including the 10,300 km^2 Ruaha National Park (RNP), four Game Reserves, two forest reserves, and the Pawaga-Idodi Wildlife Management Area (WMA), and is an area of southern Tanzania with outstanding biodiversity and significant potential for livelihood improvement through ecotourism, hunting, and the provision of ecosystem services. It is situated within one of the World Wide Fund for Nature's 'Global 200' ecoregions, and encompasses two Audubon Society Important Bird Areas and two proposed Ramsar sites. The area harbors an intact large carnivore fauna, including the continent's third largest population of African wild dogs, and is part of a priority 'hotspot' for African carnivore conservation.

While conservation activities have the potential to improve local livelihoods, wildlife is an under-developed resource in the southern portion of the landscape. Less than 10% of the Ruaha National Park is developed for photographic tourism, and communities are poorly integrated into the wildlife economy, with fewer than 2% of local residents involved in or deriving revenues from tourism. Recognizing similar patterns throughout Tanzania, legislation was established to allow villages to directly benefit from wildlife by establishing WMAs in village lands surrounding protected areas. As part of the WMA process, villages must establish and adopt land use plans so that conservation and development objectives are balanced at the village level and the necessary governance structures are established. WMAs are designed with the joint objectives of conservation and development, but the necessity of making tradeoffs between these are also apparent at the village and national levels. The low rainfall in this portion of the Ruaha landscape makes decisions over land use and tenure for dryland agriculture and livestock production especially contentious.

To better understand village-level priorities, this study applied a combination of focus group meetings and a conjoint survey workshop with representatives of the villages of Idodi and Pawaga divisions, the gateway communities to the Ruaha National Park. We also surveyed government, business, and NGO organizations at the regional level to analyze their preference alignment with village priorities.

Conjoint Analysis. Conjoint analysis (CA) is a technique for establishing the relative importance of different attributes in the provision of a good or service. Often referred to as choice modeling, CA has its origin in market research where it has been used to identify factors influencing the demand for commodities. In a typical CA study, individuals are asked to rank hypothetical scenarios composed of different levels of important attributes in the provision of a good or service.

A four phase analytical strategy was used to develop the choice modeling exercise in the current study. First, focus group meetings were conducted at both the village and district levels where representative stakeholders identified critical problems facing local communities – identified problems included agriculture, livestock, education, and health issues. Representatives included agriculturalists and agro-pastoralists, religious leaders, tribal leaders, local government representatives, business owners, and representatives from water users' associations and women's groups, with particular attention paid to gender representation. At the district level, key stakeholders were selected based on their relationship with or involvement in the four economic sectors identified, including representatives of government at the district level, non-governmental organizations (NGOs), and business operators.

Second, attributes were formulated to address community needs and concerns. They included investment in farmers' cooperatives, water infrastructure, tourism infrastructure, extension services, health, and education. These attributes were formulated as potential solutions to address the major problems identified in focus groups, and each attribute had a mix of two or three possible levels of investment.

Third, a conjoint ranking survey was designed to solicit preferences for the five attributes and various levels. Ten alternatives, each depicting a unique bundle of attribute levels, were designed for participant ranking based on an orthogonal design that allows estimation of linear and

quadratic main-effect components over the entire range of 108 possible alternatives with the least number of trials. To complete the conjoint survey, two participants – the village executive officer and one other stakeholder – from each of 21 villages from Pawaga and Idodi divisions were invited to participate in an all-day workshop (with 38 of 42 ultimately attending, including 26% women). Each participant was asked to individually rank 10 alternatives provided in Kiswahili on index cards by sorting and stacking them in order from most to least preferred alternative. Respondents also answered a series of attitudinal and demographic questions. Subsequently 11 district-level representatives completed the survey. Finally, an ordered probit model (a popular specification for a binary response model) was used to identify differences in preferences for potential solutions to address the problems identified in Phase 1.

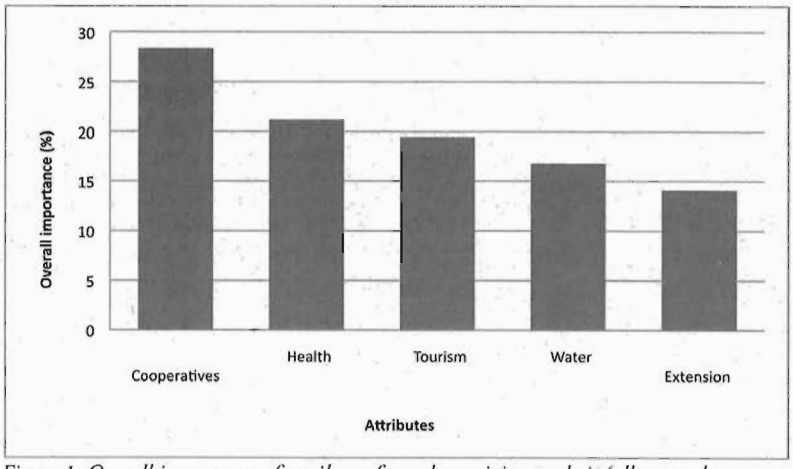

Figure 1. Overall importance of attributes from the conjoint analysis (all respondents: village and district representatives).

Findings

Figure 1 shows the relative importance of attributes when considering all respondents together. Overall, investment in farmers' cooperatives was the most important attribute with a relative importance score of 28%, followed by investments in health, tourism, water infrastructure, and livestock extension services.

When considering differences in priorities among groups, investment in farmers' cooperatives was the most important attribute for the agro-pastoralist and agriculturalist respondents, with relative scores of 33% and 37%, respectively. The lack of emphasis on water and livestock extension services may be explained by the low participation of pure pastoralists in the conjoint workshop. The results from district government employees and NGO respondents show that investment in health and education was the most important attribute with relative scores of 35.5% and 29.9%, respectively. Investment in tourism infrastructure was the second most important attribute for district government representatives. However, tourism was given low priority amongst village representatives and was rarely mentioned as an economic activity during village focus group discussions, representing a key disconnect between district-level and local-level priorities.

Results of the focus group research and conjoint analysis revealed some differences in key priority areas for development. Differences revolve around short-term versus long-term actions to address the issues facing village districts along the edge of the Ruaha National Park and other protected areas. In general, the local stakeholder participants preferred immediate income-generating actions, while district stakeholders preferred longer-term investment, such as improvement of health, education, and tourism sectors. Goals around tourism development in village-controlled WMAs showed a considerable disconnect between village-level and district-wide priorities. This likely comes from the high expectations from local communities of the financial benefits from the WMA, which have not materialized. Most of the revenues from the WMA come from investors through royalties and taxes, and this money goes mainly into community development projects (i.e. school, health facilities, roads, and water) but with little perceived direct impact on household incomes and livelihoods. In addition, there is a perception of lack of transparency and accountability in the management of the WMA.

Practical Implications

Sustainable management of landscapes with multiple competing demands, such as in the Ruaha Landscape, is complex due to the diverse preferences and needs of stakeholder groups involved. Finding a management strategy that integrates community preferences at the local level with those of other stakeholders at the district, national, and international levels is of paramount importance.

Over the last few decades land use in the Ruaha Landscape has been increasingly shaped by an approach akin to that of the problem-isolation paradigm, which breaks down a complex problem into a suite of small, easy-to-understand elements. From the biodiversity conservation perspective, the problem-isolation paradigm has proved unsatisfactory because biodiversity cannot be contained within the confines of a protected area, nor can people be easily kept out of areas required for biodiversity conservation. From the rural development perspective, the problem-isolation paradigm has also proved a particularly unsatisfactory model to shape land use, because the definition of the problem

and the identification of the solution have tended to be top-down and centralized. For instance, the Usangu rice schemes upstream of the focal villages examined here, were conceived to create opportunities for expanding crop agriculture, but because they were planned and implemented in isolation, they had the unintended consequences of undermining Tanzania's hydroelectric capacity and ecotourism industries. To be successful, future projects, whether conservation or development, must reconcile objectives at local to global scales and across sectors.

Acknowledgements

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About the Authors: Dr. Michel Masozera was a Jim Ellis Award Recipient 2006-2007, Norman E. Borlaug LEAP Fellow Fall 2007, and is currently the Director of Payment for Ecosystem Services at the Wildlife Conservation Society (WCS). He can be contacted by email at mmasozera@wcs.org. Dr. Jon Erickson is an Associate Professor in the Rubenstein School of Natural Resources and Environment at the University of Vermont. Email: jon.erickson@uvm.edu. Dr. Deana Clifford has been the HALI project Coordinator based at the Wildlife Health Center in the School of Veterinary Medicine, University of California, Davis and is currently a Veterinary Epidemiologist with the California Department of Fish & Game. Email: dlclifford@ucdavis.edu. Dr. Peter Coppolillo is an Associate Conservation Ecologist and former Director of the Ruaha Landscape Program for the Wildlife Conservation Society (WCS). He is currently Coordinator for the WCS Yellowstone Program. Email: PCoppolillo@wcs.org. Mariam Nguvava served as the HALI project socioeconomic Research Assistant and currently is a Teaching Assistant at Sokoine University of Agriculture in Tanzania. Email: mariamnguvava@yahoo.com. Dr. Harrison Sadiki is the HALI project Field Coordinator and Veterinarian at Sokoine University of Agriculture. Email: hsadily@yahoo.com. Dr. Jonna Mazet is Professor of Wildlife Health and Epidemiology and Co-Director of the Wildlife Health Center at the University of California, Davis. Email: jkmazet@ucdavis.edu.

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GLOBAL LIVESTOCK CRSP

Fecal Pathogen Pollution in Surface Waters of the Ruaha Ecosystem, Tanzania

W.A. Miller[1], D.L. Clifford[1], R.R. Kazwala[2], A. Kitime[2], A. Kitambi[2], and J.A.K. Mazet[1]
[1]University of California, Davis; [2]Sokoine University of Agriculture
Health for Animals and Livelihood Improvement Project

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The Health for Animals and Livelihood Improvement (HALI) project undertook a two-year capacity building and water quality testing study in the Ruaha ecosystem of south-central Tanzania. New diagnostic procedures for enumerating standard indicator bacteria, as well as detecting and characterizing zoonotic fecal bacterial and protozoal pathogens of public health concern, were instituted at Sokoine University of Agriculture and in the field. Water quality of surface waters used by human and animal populations for drinking, cooking, and bathing was found to be poor throughout the year and at all study sites. Indicator bacteria levels exceeded regulatory water quality criteria more than 50% of the time at upstream sites and 25-50% of the time at downstream sites where more tributaries have fed into the main waterways. Salmonella, Cryptosporidium, *and* Giardia *were detected at sites used predominantly by humans and their livestock, as well as at sites used predominantly by wildlife. Considering the relatively poor water quality, and the heavy use of water resources by human and animal populations, it is quite likely that untreated waters represent significant public health risks. This study highlights the need for efforts to prevent contamination of surface waters with fecal wastes, as well as the importance of utilizing point-of-use water treatment practices to minimize health risks to humans and animals in this dynamic ecosystem.*

Background

Water quality and quantity issues shape societies and civilizations around the world. In East Africa, specifically in Tanzania, water quality studies conducted outside of the major coastal townships are rare. The lack of effective sewage treatment and fecal management programs for human and animal populations throughout the continent, along with the high rate of diarrheal diseases, suggest that fecal pathogen pollution is a critical problem that needs to be addressed (Mohammed, 2002). As part of the Health for Animals and Livelihood Improvement (HALI) project, we sought to characterize ambient water quality in the Ruaha ecosystem of Tanzania, where water management and climate change factors have contributed to the annual drying of the Great Ruaha River, and thus forced human and animal populations to share and compete for diminishing water resources. A second but equally important goal of this study was to build in-country capacity to conduct diagnostic testing for fecal bacteria and protozoa at university and government laboratories,

To achieve these goals, HALI staff conducted monthly sampling of 10 riverine study sites along the Great Ruaha River and its tributaries. Sites were selected based on their use either by human populations and their associated livestock, or by wildlife populations, or both (Figure 1). Field collections began in February 2007 and were completed in January 2009. Water samples from the 10 river and one downstream reservoir (Mtera) were screened for a suite of indicator bacteria that represent fecal contamination, zoonotic bacterial pathogens, zoonotic protozoal pathogens, and other standard water quality parameters. This research brief presents preliminary findings pertaining to indicator bacteria and pathogens detected in surface water samples from the Great Ruaha and Little Ruaha River systems in south-central Tanzania, and discusses possible next steps for the monitoring and mitigation of fecal pathogen pollution in Tanzania.

Findings

The HALI water quality investigation identified *Escherichia coli (E. coli)*, an indicator of fecal contamination, at levels exceeding regulatory water quality criteria at all study sites and in all months. Figure 2a shows the mean *E. coli* levels by study site, and Figure 2b shows the mean *E. coli* levels by month. A horizontal line indicates the U.S. Environmental Protection Agency (EPA) recommended maximum level of 298 *E. coli* per 100 milliliters (ml) for ambient recreational waters receiving moderate use (EPA, 1986). Statistical analyses showed that high *E. coli* levels were three times more likely to be detected in water samples collected in the early dry season (June, July, August) when water bodies are shrinking, than in the early wet season (December, January, February) when water levels are increasing. High *E. coli* levels exceeding regulatory criteria were also twice as likely to be detected at upstream sites compared to samples from Mtera Reservoir, likely due to the large

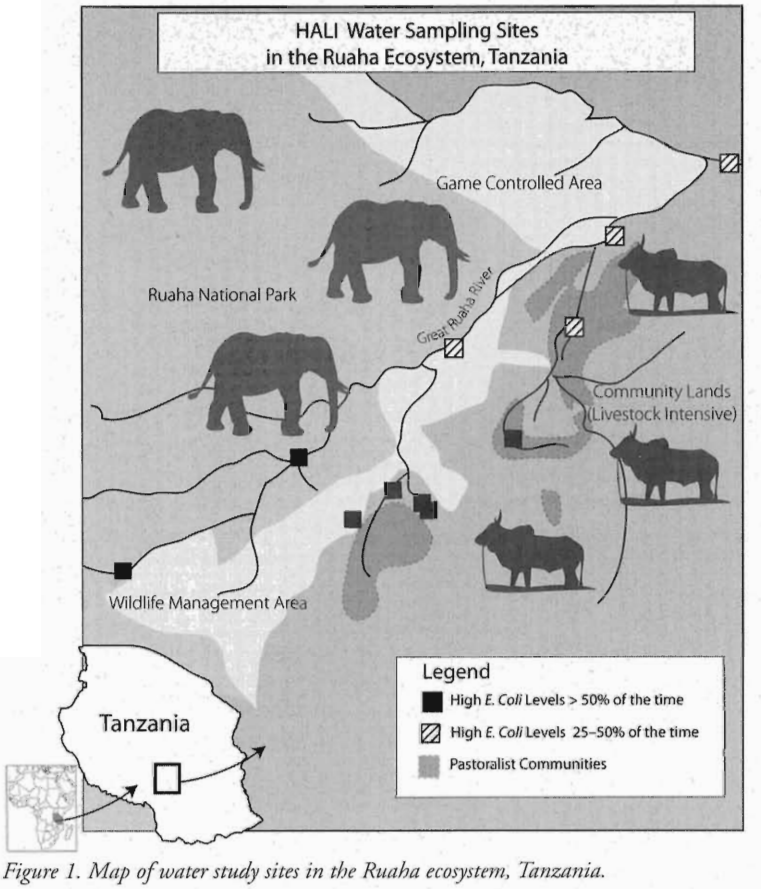

Figure 1. Map of water study sites in the Ruaha ecosystem, Tanzania.

dilutional effect of the reservoir receiving waters. Figure 1 shows the seven upstream sites where *E. coli* levels exceed regulatory criteria more than 50% of the time, as compared to the four sites downstream of joining tributaries where criteria were exceeded 25-50% of the time. It is unclear at this time whether the exceedingly poor water quality at upstream sites was due to increased fecal inputs from human and animal sources compared to fecal inputs at downstream sites, or whether the difference was due to larger water volumes present at downstream sites diluting the bacterial concentrations and perhaps associated health risks. Regardless, these findings provide critical data that should raise awareness of water quality problems and will hopefully stimulate discussions of approaches to better manage water quality and quantity issues in the region.

Fecal pathogen distribution patterns in space and time support the indicator bacteria findings. *Salmonella* bacteria were detected at 91% (10/11) of the study sites and were detected throughout the year, while the fecal protozoal pathogens *Cryptosporidium* and *Giardia* were detected in water samples at 25% (3/12) of study sites and were only detected in the wet season. Pathogens were detected at sites used predominantly by humans and their associated livestock, as well as at sites used predominantly by wildlife species, and there was no statistical difference between pathogen detection based on the human/animal use factor. *Salmonella* was nine times more likely to be detected in water samples collected during the late wet season (March, April, May) as compared to the early wet season (December, January, February), and was twice as likely to be detected at upstream sites compared to downstream sites. Molecular characterization efforts are currently underway that may shed additional light on the diversity, genotypes, and potential virulence of study isolates.

Practical Implications

Fecal pathogen pollution is a problem worldwide, and lessons can be learned from both developed and developing countries when it comes to water quality and managing fecal wastes. Our findings regarding indicator bacteria confirm that fecal contamination identified more than a decade earlier in south-central Tanzania persists; *E. coli* levels ranging from 2,900 - 4,400 bacteria per 100 ml were reported for river samples (Jiwa et al., 1991). Considering that the EPA recommended upper limit for recreational waters with moderate use is 298 bacteria per 100 ml, and the fact that our study sites receive heavy use from human and animal populations who use the water for drinking, cooking, and bathing, it is quite likely that untreated waters represent significant public health risks.

There are several different approaches to be considered for minimizing health risks from fecal pathogens in our study system. Fecal wastes are often categorized into point and non-point sources, where point sources are identifiable foci of human or animal waste such as sewage outfalls, while non-point sources represent more diffuse sources such as agricultural runoff, stormwater, or leaking septic fields. Managing point sources of fecal waste to minimize contamination of receiving waters may include implementing sewage treatment practices that can be centralized in a large wastewater treatment facility (Mbwele et al., 2003), or de-centralized as many small domestic on-site wastewater purification projects (Oladoja and Ademoroti, 2006). Reducing the transport and health risks due to fecal pathogens from non-point sources requires a different approach, as the concentration may be lower but the volume of contaminated runoff higher. Two promising principles are to mechanically filter out and to sediment pathogens from runoff using barriers such as vegetated filter strips between fecal sources (e.g. animal populations or fields fertilized with manure) and downstream waterways (Miller et al., 2007), or by channeling contaminated waters through wetlands to improve water quality (D'Arcy et al., 2007). Of course there are costs associated with implementing sewage treatment practices or other Beneficial Management Practices (BMPs), but the

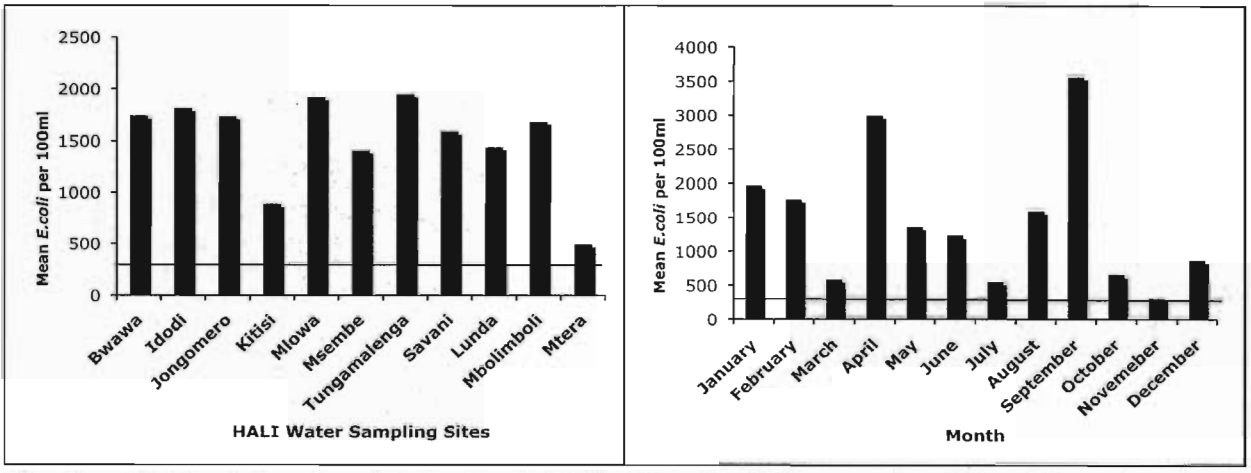

Figure 2a and 2b. Mean indicator bacteria Escherichia coli *(MPN per 100 ml) by HALI water study site (left); and Mean indicator bacteria* Escherichia coli *(MPN per 100 ml) by month (right). All sites exceeded the EPA recommended upper limit for ambient recreational waters with moderate human contact (298* E. coli *per 100 ml, shown with a horizontal line).*

costs of improvements must be weighed against benefits of reducing health risks, and against the costs of healthcare to treat illnesses due to fecal pathogens in the human and animal populations.

An attractive alternative or even complementary approach to reducing inputs of fecal waste into ambient waters is to encourage point-of-use treatment to improve water quality and reduce health risks at the household level. Point-of-use (POU) water treatment methods include boiling, chlorination, coagulation, SODIS (solar disinfection using transparent polyethylene bottles), ceramic filters, and biosand filters (Jenkins et al., 2009; Sobsey et al., 2008). Studies in Africa are now starting to investigate the effectiveness of these approaches for use on drinking water (Tiwari et al., 2009), as well as for water that may be needed for other uses such as irrigating vegetables to be consumed raw (Keraita et al., 2008). POU BioSand filtration, for example, was successfully implemented among pastoral and agro-pastoral communities in the River Njoro watershed, Kenya by the Global Livestock CRSP Multidisciplinary Research for the Sustainable Management of Rural Watersheds (SUMAWA) project. Through SUMAWA's POU program, rural health improvements were achieved through the reduction in diarrheal disease prevalence among BioSand filter users (Jenkins et al., 2009).

These point-of-use approaches may provide insights into possible treatment of water supplies that would prevent health risks in domestic animals as well. For example, another SUMAWA project intervention in the upper River Njoro watershed focused on supplying clean drinking water to livestock in troughs set back from the actual waterway to prevent stream-bank erosion, to reduce the loading of livestock feces into the waterway, and to reduce losses due to livestock illness from waterborne pathogens (Kyalo et al., 2010). Despite the abundance of solutions and possible interventions, however, it will take creative and interdisciplinary efforts to effectively evaluate and implement improved water management approaches in rural communities where people are struggling to make a living, and may not have the means to easily treat their water sources or improve their management of human and animal fecal wastes.

Figure 3. Dr. Annette Kitambi, a graduate student supported by HALI, trains local government personnel to read water quality test results during a field collection day. Photo by D. Clifford.

Further Reading

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About the Authors: Dr. Woutrina Miller is an Assistant Adjunct Professor at the School of Veterinary Medicine, University of California, Davis. Email: wamiller@ucdavis.edu. Dr. Deana Clifford has been the HALI project Coordinator based at the Wildlife Health Center in the School of Veterinary Medicine, University of California, Davis and is currently a Veterinary Epidemiologist with the California Department of Fish & Game. Email: dlclifford@ucdavis.edu. Dr. Rudovick Kazwala is a Professor of Veterinary Medicine and Public Health at Sokoine University of Agriculture. Email: kazwala@suanet.ac.tz. Mr. Ally Kitime is Senior Laboratory Technician in the Department of Veterinary Medicine and Public Health, Sokoine University of Agriculture. Email: kitimeally@yahoo.co.uk. Dr. Annette Kitambi completed her Masters at Sokoine University of Agriculture (SUA), and is currently a District Veterinarian. Email: annettekitambi@yahoo.com. Dr. Jonna Mazet is a Professor of Epidemiology and Wildlife Health and Co-Director of the Wildlife Health Center in the School of Veterinary Medicine, University of California Davis. Email: jkmazet@ucdavis.edu.

The Health for Animals and Livelihood Improvement (HALI) project was established in 2006 and is a stakeholder-driven research and capacity-building program to assess the effects of zoonotic disease and water management on animal health, biodiversity, and livelihoods in the Ruaha ecosystem, Tanzania. The project is led by Dr. Jonna Mazet. She can be contacted via post at Wildlife Health Center, One Shields Ave., School of Veterinary Medicine, University of California, Davis, CA 95616, USA, or via email: jkmazet@ucdavis.edu.

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GLOBAL LIVESTOCK CRSP

Public Health and Rural Livelihoods under Water Scarcity in the Ruaha Landscape, Tanzania

M. Masozera[1], J.D. Erickson[1], D.L. Clifford[2], P. Coppolillo[3], R. Kazwala[4], H. Sadiki[4], and J.A.K. Mazet[2]
[1]University of Vermont; [2]University of California, Davis; [3]Wildlife Conservation Society; [4]Sokoine University of Agriculture, Tanzania
Health for Animals and Livelihood Improvement Project

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A combination of irrigated agriculture, uncontrolled water diversions, and intensive livestock grazing of wetlands has resulted in dramatic decreases in both water quantity and quality in Tanzania's vast Ruaha Landscape. This has directly impacted human livelihoods and wildlife populations that depend on the multitude of ecosystem services provided by the Ruaha River watershed, and has indirectly influenced the transmission of disease between humans, livestock, and wildlife. This study assesses the socioeconomic and environmental factors influencing human and livestock health. Results show that reported wealth, cattle sickness, consumption of raw cow blood, and limited accessibility to surface water sources increased the probability of reported chronic diseases in the household. Household wealth and walking distance to surface water were also found to affect cattle health. These findings remind us that health issues should not only be seen in relation to health services, but as being intimately connected to the state of: 1) ecosystems and the services they provide; 2) social institutions for land use planning, settlement and social services; and 3) culture and traditions (diet, nutrition and husbandry practices).

Background

Accessibility to water and land resources for agriculture and grazing areas are key factors for sustainable agriculture development and sustainability of rural livelihoods in Africa, particularly in the arid and semi-arid regions of Africa characterized by widespread food insecurity exacerbated by persistent droughts, erratic rainfall, and increasing human populations. Adaptations of pastoralists and agro-pastoralists in arid zones include keeping diverse species of livestock, movements of species-specific and production-specific livestock herds over large areas, emigration out of the pastoral system until perturbations pass, economic diversity, and seasonal and drought-induced nutritional stress allocation among community members. However, the potential for movement between and access to alternative seasonal pastures is increasingly limited. While pastoral and agricultural populations throughout Africa have grown, pastoralists have been unable to expand livestock holdings due to factors such as disease epidemics, recurring droughts, and intertribal raiding. In addition, traditional dry season ranges with water access have been lost to intensive agriculture (both colonial and African agriculturalists), to game parks, and to conservation areas.

A consequence of these changes in pastoralist communities is the enhancement of disease vectors at the human-livestock-wildlife interface. In particular, loss of access to water sources has forced pastoralists and their livestock to move further seasonally and to be more concentrated during the dry season. The combination of greater migration and concentration can contribute to the transmission of diseases among livestock herds, as well as between humans, livestock, and wildlife as they are forced to share dwindling water sources. More than 75% of human diseases are zoonotic – shared between human and other animal species – with links to wild and domestic animals. In East Africa, zoonotic diseases are presenting significant simultaneous threats to human health, livestock productivity, and wildlife conservation, and can no longer be addressed as separate problems within isolated disciplines. An investigation of the underlying drivers of zoonotic disease under increasing water scarcity, with emphasis on bovine tuberculosis, has been the focus of the Health for Animals and Livelihood Improvement (HALI) project of the Ruaha Landscape, Tanzania.

This brief reports on household survey research of the HALI project aimed at addressing the impact of increasing water scarcity in the Ruaha Landscape on household and livestock health. This study was conducted in the villages of the Idodi and Pawaga divisions adjacent to the Pawaga-Idodi Wildlife Management Area (WMA), an area recently transitioning out of grazing land to a village-controlled hunting range adjacent to the south-eastern border of the Ruaha National Park in southwest Tanzania. In other research briefs the HALI team has described the underlying causes of the recent seasonal drying of the Great Ruaha, evaluation of disease risk, the design of our socioeconomic studies, landscape factors behind livestock disease loss, and gender roles in pastoralist households (See Further Reading). Here we report on the analysis of the household survey data.

Findings

To assess socioeconomic and environmental factors influencing human and livestock health, as measured by reported chronic disease in the household and sickness in both cattle and small stock (goats and sheep), we estimated logistic regression models. The explanatory variables used to explain a household's health included: wealth class (determined by Tropical Livestock units (TLUs) and land), reported livestock sickness in the herd, reported household drinking of raw blood (a custom prevalent amongst traditional pastoralists), reported household treating of drinking water, walking distance to surface water sources, access to piped water for drinking and cooking, age of the household head (or the respondent), and walking distance to the nearest village health care center. Table 1 shows the results of the regression model for reported household health. In this model, many explanatory variables have the expected effects on household health. Not surprisingly, wealth was among the factors explaining variation in reported household health in this region. Households in the poor category were two times more likely to report chronic diseases than households in the wealthy category, when holding other variables constant, suggesting that wealthier families are more likely to invest more in health prevention.

Also, households reporting sick cattle were three times more likely to report chronic diseases than households without sick cattle. Similarly, there was a positive correlation between reported blood consumption, a zoonotic disease transmission risk factor, and the probability of reporting chronic diseases in the household. Households reporting drinking raw blood were found to be at least four times more likely to report chronic diseases than households who do not. There was a significant difference between ethnic groups in terms of raw blood consumption with a higher proportion of Maasai households reporting drinking blood than the Barabaig and Sukuma. These results suggest a key linkage to the livestock sampling portion of the HALI project. For households who reported cattle sickness in their herds and for whom livestock were tested for possible brucella and bovine tuberculosis (BTB), 15% of cattle tested positive for BTB and 8% were suspected to be positive, while 46% tested positive for brucella. These results are suggestive of a critical link between human and livestock health and the transmission of zoonotic diseases.

The variable walking time to surface water was found to be positively correlated to household health, suggesting that households farther away from surface water sources have greater reported health problems. This result suggests that limited access to surface water sources due to distances and time involved in water collection result in use of volumes inadequate to support basic personal hygiene and marginally adequate for human consumption.

Similarly, factors determining livestock health were assessed. Results demonstrated that wealth positively correlated to cattle sickness suggesting that wealthy households are associated with sick cattle. The probability of reporting sick cattle was two times greater for wealthy households than for the poor. For pastoralists and agro-pastoralists, wealth is measured in part by the number of animals owned; thus having a large herd size may increase the probability of reporting sick cattle in the herd. Livestock health is also dependent upon access to adequate water for consumption. The results indicate the odds of households reporting cattle sickness in the herd increase by a factor of 1.7 for every additional hour walked to surface water sources. This demonstrates that lack of livestock watering sources caused by drought and exacerbated by drying of rivers and streams affects the health of cattle, and therefore may contribute to the decline of their productivity.

Reporting of the presence of wildlife in the same water sources used by livestock (a zoonotic disease risk) had no effect on reported health of cattle. However, identification of pathogens in water samples taken from a variety of water sources used by humans only, livestock and humans, or livestock, humans, and wildlife within the HALI project will allow for a more unbiased investigation of these potential pathways.

Finally, a comparison between wet and dry seasons revealed that households consumed less meat per week in the dry season than in the wet season, and that there were more reported human and livestock health problems in the wet season than the dry season. In particular, reported cases of diarrhea and fever were significantly higher in the wet season. For diarrhea, the main water quality risk is the microbial load (e.g. *E. Coli* and total coliform) from human and animal excreta. Water quantity plays a role because more water allows for increases in washing of hands, food, and clothes and in many situations allows for more effective removal of waste via drainage and sewers, all leading to decreases in diarrhea and lower rates of mortality. However, too much water leading to flooding can also be a problem for water-related diseases such as diarrhea. For villages in the Ruaha region, only 1% of households surveyed reported using improved latrines, while 43% used traditional pit and 56% used the bush as a toilet facility. Thus, it is not surprising to record more reported cases of diarrhea in the wet season. Similarly, households surveyed reported significantly more malaria cases in the wet season. Malaria is a water-related disease which is spread through insect vectors, especially *Anopheles gambiae* in East Africa that breeds in water. The risk of a malaria epidemic is associated with anomalous temperatures in the months preceding and during the rainy season. Rainfall, in general, affects the availability and suitability of disease habitats, while temperature affects the rate of vector and pathogen development. For livestock health, there were also

Table 1. Estimated coefficients and odds ratios for the logistic regression household model.

Parameter	Estimate	Standard Error	Wald Chi-Square	Odds ratio
Intercept	0.1559	0.7686	0.0411	1.169
Wealth	-0.7434*	0.4333	2.9439	0.475
Sick cattle	0.9800**	0.4355	5.0636	2.665
Sick shoats	0.2849	0.4393	0.4204	1.330
Blood consumption	1.3783***	0.4381	9.8974	3.968
Water treatment	-0.2231	0.4200	0.2822	0.800
Walking time to surface water	0.4641**	0.2400	3.7401	1.591
Distance to health center	-0.2521	0.2225	1.2839	0.777
Piped water sources	0.3642	0.6022	0.3659	1.439

Asterisks (*) denote the level of significance: *p<0.10, **p<0.05, and ***p<0.01.

significantly more reported sickness and death of cattle, goats, and sheep in the wet season. The reported sickness and death of livestock (especially goats) can be attributed to the outbreak of Rift Valley Fever (RVF) which is in general associated with heavy rainfall and localized flooding (Wilson, 2003).

Practical Implications

A combination of irrigated agriculture, uncontrolled water diversions, and intensive livestock grazing of wetlands has resulted in dramatic decreases in both water quantity and quality of Tanzania's vast Ruaha Landscape. This has impacted human livelihoods, livestock productivity, and wildlife populations that depend on the surface water and associated ecosystem services of the Greater Ruaha River. Understanding the dynamics of zoonotic disease agents in human, livestock and wildlife populations and how they relate to land use change and environmental management is critical to developing mitigation strategies at multiple scales, including the often overlooked landscape scale.

These findings highlight some of the most important issues identified by focus group meetings at local and district levels during this study, including lack of health care infrastructure, limited access to clean and safe drinking water, insufficient watering points for livestock, and traditional husbandry practices as important problems at the local level. To assist local communities to break poverty cycles and reduce risks of disease contamination, there are key areas that need particular attention. These include improving accessibility to water sources for livestock and domestic consumption, investing in human health and veterinary care facilities and their personnel, developing an outreach program on hygiene and sanitation to address cultural barriers, and increasing accessibility to the market for agricultural and livestock products.

The findings also suggest that pressure to utilize land and water resources to expand economic development through increased agriculture production is in conflict with the health of pastoralist and agro-pastoralist households and their livestock. Efforts to address water scarcity and its impact on pastoral and agro-pastoral communities' health and livelihoods should be coordinated at the watershed scale and evaluated against other landscape level goals such as irrigation, ecotourism, and hydroelectricity production. There is a need for an integrated sectoral collaboration between government agencies, and coherence in inter-sectoral policies. Rural development programs should not only pay attention to the increased production of food but also to an integrated approach to management of rangelands, wetlands, and other habitats.

Lastly, these findings remind us that health issues should not only be seen in relation to health services, but as being intimately connected to the state of: 1) ecosystems and the services they provide; 2) social institutions for land use planning, settlement and social services; and 3) culture and traditions (diet, nutrition and husbandry practices). While these preliminary results point to the relationship between water scarcity in the Ruaha Landscape and health and livelihoods of pastoral and agropastoral communities, data from disease sampling of wildlife and livestock, and pathogen prevalence in water samples are needed to better understand the dynamics of zoonotic diseases, to confirm our findings, and to draw some policy implications. The HALI project with its integrated approach provides a novel platform to understand these dynamics. However, long term transdisciplinary research partnerships and diagnostic capacity building need to be forged to enhance our ability to understand how human actions affect land use and land cover, along with the consequences of these changes on human, livestock, and wildlife health.

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About the Authors: Dr. Michel Masozera was a Jim Award Recipient 2006-2007, Norman E. Borlaug LEAP Fellow Fall 2007, and is currently the Director of Payment for Ecosystem Services at the Wildlife Conservation Society (WCS). He can be contacted by email at mmasozera@wcs.org. Dr. Jon Erickson is an Associate Professor in the Rubenstein School of Natural Resources and Environment at the University of Vermont. Email: jon.erickson@uvm.edu. Dr. Deana Clifford has been the HALI project Coordinator based at the Wildlife Health Center in the School of Veterinary Medicine, University of California, Davis and is currently a Veterinary Epidemiologist with the California Department of Fish & Game. Email: dlclifford@ucdavis.edu. Dr. Peter Coppolillo is an Associate Conservation Ecologist and former Director of the Ruaha Landscape Program for the Wildlife Conservation Society (WCS). He is currently Coordinator for the WCS Yellowstone Program. Email: PCoppolillo@wcs.org. Dr. Rudovick Kazwala is a Professor in the Faculty of Veterinary Medicine, Sokoine University of Agriculture. Email: kazwala@suanet.ac.tz. Dr. Harrison Sadiki is the HALI project Field Coordinator and Veterinarian at Sokoine University of Agriculture. Email: hsadily@yahoo.com. Dr. Jonna Mazet is Professor of Wildlife Health and Epidemiology and Co-Director of the Wildlife Health Center at the University of California Davis. Email: jkmazet@ucdavis.edu.

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GLOBAL LIVESTOCK CRSP

Calf Diarrhea and Public Health: Herd and Household Exposure to Cryptosporidium and Giardia in the Ruaha Landscape, Tanzania

D.J. Wolking[1,2], D.L. Clifford[2], H. Sadiki[3], E. Kamani[3], W.A. Miller[2], R.R. Kazwala[3], and J.A.K. Mazet[2]
[1]Jim Ellis Award Recipient 2007-2008; [2]University of California, Davis; [3]Sokoine University of Agriculture, Tanzania
Health for Animals and Livelihood Improvement Project

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In the arid Ruaha Landscape, pastoral livestock production is an important subsistence and livelihood strategy for many people, and calf health is a critical component of traditional husbandry practices. Despite this importance, however, little attention has been paid to calf illness in disease surveillance activities in the area, especially regarding calf diarrhea, one of the leading causes of calf morbidity and mortality worldwide. Following the identification of the protozoal pathogens Cryptosporidium *and* Giardia *in Ruaha, and in consideration of the expected high susceptibility of calves to infection, we investigated the prevalences of diarrhea,* Cryptosporidium, *and* Giardia *among calves in pastoral herds, along with the intensity of pathogen shedding and subsequent environmental contamination. Results show that diarrhea, along with protozoa, are prevalent in pastoral calf herds, and that some diarrheic calves are shedding the pathogens in relatively large proportions with regards to the infective dose. The presence of* Cryptosporidium *and* Giardia *in association with calf diarrhea is of public health importance, as diarrhea may increase the likelihood for pathogenic environmental contamination. In response, managers should interpret symptomatic calf diarrhea as potentially indicative of pathogen shedding or other infection and should counter with appropriate treatments and control measures to protect their herds and households from infection.*

Background

The Ruaha Landscape represents a critical interface for the interaction of wildlife, livestock, and humans, and is recognized as a potential "hotspot" for zoonotic disease transmission (diseases that can be transmitted between animals and people), as livestock and humans share grazing lands and water resources with wildlife, and humans closely interact with animals though traditional husbandry practices. In Ruaha, where rainfall ranges from 200-550 millimeters per year, pastoral and agro-pastoral livestock production represents the sole viable subsistence and livelihood strategy in areas lacking access to irrigated agriculture. As the viability of any livestock production system is dependent upon the successful raising of calves for herd replacement, calf health is a critical component of traditional husbandry practices. Considering the close interaction between calves and their caretakers, infections in the calf population may be particularly risky from a zoonotic perspective. Despite this importance, however, little attention has been paid to calf illness in disease surveillance activities in the region, especially in regards to calf diarrhea, one of the leading causes of calf morbidity and mortality worldwide and a major source for several pathogens of zoonotic importance.

Cryptosporidium parvum is one of these protozoal pathogens, with public health significance due to its zoonotic potential. It is associated with intense but short-lived diarrhea, nausea, abdominal pain and severe long-lasting infection that can be life-threatening in those with compromised immune systems, including people with HIV, children, and young animals (Fayer and Xiao, 2008). In addition, *Giardia lamblia*, another enteric parasite, has been identified as infecting a wide range of wildlife, livestock, and human populations globally, and can contribute to poor growth and nutritional disorders, particularly in young children (Hunter and Thompson, 2005). The Health for Animals and Livelihood Improvement (HALI) project has been monitoring adult cattle in pastoral and agro-pastoral herds throughout the Ruaha landscape for *Cryptosporidium* and *Giardia* since 2006. Although neither protozoan was detected in fecal samples from adult cattle, both *Cryptosporidium* and *Giardia* were successfully isolated in water samples obtained from surface water monitoring points in the ecosystem, indicating that animal or human shedding of these parasites into surface water sources was occurring (Miller et al., 2010).

Following the identification of the pathogens *Cryptosporidium* and *Giardia* in Ruaha and in consideration of the expected high susceptibility of calves to infection, this study was developed to investigate the prevalences of diarrhea and both protozoal pathogens among calves in pastoral herds. In addition, we investigated the intensity of pathogen shedding and subsequent environmental contamination to assess the potential public health significance of diarrheic animals to the household.

Methods

A two-stage sampling procedure was used to select study households and animals from among households participating in the HALI project. First, households were selected from the HALI sampling frame to increase the probability of targeting households and herds with reported diarrheal disease. Second, calves from each herd were selected at random. Sampling was designed to identify the prevalences of diarrhea and both protozoa at the herd level; having even a single infected animal in a herd presents a significant disease risk because one animal can be infectious to people and other animals in the herd. In addition, households manage their livestock herds as a unit, requiring the entire herd to be disease free for elimination of the risk of continued disease transmission.

At each household, following herd sampling, the head of household or main caretaker of young livestock was interviewed with a standardized questionnaire including questions about general livestock management practices, management practices specific to the calf herd, and potential risk-factors for disease such as calf housing, water sources, household interaction and contact with the animals, and household hygiene and sanitation behavior.

Immunoflourescent antibody testing to detect *Cryptosporidium* and *Giardia* in calf fecal samples was conducted at the Sokoine University of Agriculture. Technical details on laboratory and field methods may be obtained from the author (Wolking). A bivariate analysis was also conducted to assess factors associated with increased risk of diarrhea, and the increased risk of shedding *Cryptosporidium* oocysts and *Giardia* cysts—an indication of pathogen infection.

Findings

At the herd level, 42.3% and 75.0% of the 52 participating herds contained at least one animal shedding *Cryptosporidium* oocysts or *Giardia* cysts, respectively (Table 1). Furthermore, 53.9% of sampled herds had at least one calf in the herd with clinical diarrhea. Larger herds (herds with more than 125 animals), larger calf herds (calf herds with more than 25 calves), herds with smaller calf *bomas* (calf pens measuring less than 500m^2), and herds observed with clinical diarrhea or reporting diarrhea in the past month had higher prevalences of both protozoal pathogens.

In order to assess shedding intensity and the potential environmental contamination associated with a single animal, each calf was classified as either a high or low "shedder" based on the quantification of *Cryptosporidium* oocysts and *Giardia* cysts detected in the fecal sample. Shedding intensity estimates showed a range for

Table 1. Prevalence of diarrhea and the protozoa at the herd level.

Herd Level Prevalence (%)	
Cryptosporidium (n=22*)	42.3
Giardia (n=39*)	75.0
Cinically apparent diarrhea (n=28*)	53.9

N = 52; *n = Number of herds

Cryptosporidium of between 15 and 121,625 oocysts per gram feces (mean = 8,578.5), while *Giardia* ranged significantly higher, up to 217,188 cysts per gram (mean = 19,837.5). Mean fecal loading was estimated at 19,837,500 oocysts per calf and 43,642,500 cysts per calf per day for *Cryptosporidium* and *Giardia*, respectively.

With regard to household level practices undertaken to prevent disease transmission, nearly all respondents (96%) indicated that hand washing is a consistent household practice when working with animals. However, only 80% reported hand washing as an activity practiced prior to milking. Washing cow udders prior to milking, practiced by 64% of respondents, emerged as a practice associated with reduced risk of *Cryptosporidium* shedding for calves, as well as with lower prevalences of both protozoal pathogens and diarrhea, and may be a more reliable estimate for washing prior to working with animals.

Results from the bivariate analysis showed that moving the *boma* or livestock pen, small calf *bomas*, and clinically apparent diarrhea (detected during sampling) were significantly associated with shedding *Cryptosporidium* oocysts. Movement of the *boma* (livestock pen) is a practice reportedly associated with manure management implemented when the *boma* becomes full, and is also practiced in response to precipitation and rainfall, as moisture in the fecally-contaminated *boma* was reported by respondents to be associated with greater risk for a variety of livestock diseases. Study results, however, suggest that movement of the *boma* is in fact associated with increased likelihood of shedding of *Cryptosporidium*. It is therefore suggested that movement of the *boma* may be a response to disease by managers, indicative of possible endemic infection in the herds, or of an awareness and preventive action for disease control. Small sized calf *bomas* (often resulting in high stocking density) and environmental contamination may play a role in increased risk of protozoal infection, as high stocking density elevates the potential for fecal contact between and among animals due to a larger population in a restricted area. Larger adult herds and smaller *bomas* were also associated with increased risk for diarrhea.

Factors associated with shedding *Giardia* cysts were providing water for calves in buckets or storage containers at the household, observed diarrhea, reported diarrhea

Figure 1. A Barabaig herder holding his calf. Calves in traditional pastoral husbandry systems are a highly valued component of the herd, and constant interaction and contact between calves, their caretakers, and other household members is common. This relationship serves to protect calf health and development, but can pose a risk to human health as calves (like many animals) may transmit zoonotic diseases like Cryptosporidium *and* Giardia. *Photo by D. Wolking.*

in the herd the month preceding sampling, and surface water as the primary livestock water source. Sharing water through containers may be especially risky from a public health perspective, considering the low percentage of respondent households reporting water treatment, and the isolation of both *Cryptosporidium* and *Giardia* from water sources used by humans and livestock in the study area (Miller et al., 2010).

Practical Implications

While other studies have focused on *Cryptosporidium* in traditional livestock systems in Tanzania, this study is the first that we know of investigating the prevalence of both *Cryptosporidium* and *Giardia* in herds among primarily pastoral livestock producers. It is evident from the high herd level prevalences that *Cryptosporidium* and *Giardia* are present and endemic in livestock in Ruaha. The relatively high prevalence of infected herds in this study may indicate that pastoral and agro-pastoral herds function as reservoirs for infection in the region, or are exposed and at higher risk due to proximity to conservation areas and presence of other reservoirs in contaminated water sources.

Furthermore, the extensive grazing nature of herds in the region is conducive to herd-herd transmission, potentially allowing for the protozoa to be endemic in cattle alone, though this requires further investigation to determine other possible sources of infection among wildlife and among the human population in the area, as there is constant contact between the livestock and human populations. As *Cryptosporidium* and *Giardia* share similar transmission pathways via a fecal-oral route, it is possible that the higher prevalence of *Giardia* in this study is more representative of the actual protozoa disease burden in these herds. Given the relatively high quantities of observed fecal material within and surrounding the livestock holdings of the calves, the high susceptibility of calves to infection, and the estimated high pathogen shedding intensities, there is a relatively high risk of environmental contamination from diarrheic animals. The long survival time and low infectious dose for both *Cryptosporidium* and *Giardia*, which can be as low as 10 oocysts or cysts (Dupont et al., 1995; Ortega et al., 1997), demonstrate the public health significance of this threat in the pastoral context, where humans and animals frequently interact, and where sick animals are often brought into the household for shelter, care, and protection.

It is recommended that managers should interpret symptomatic calf diarrhea as indicative of shedding or other infection, and respond with appropriate treatments and control measures to protect their herds and household members from infection. These measures should include isolating diarrheic animals from the herd until subsidence of symptoms, separation of household and herd water sources, and active manure management to contain the pathogenic material. In addition, greater emphasis on protective behaviors (e.g. handwashing when contacting animals and water treatment) must be included in outreach and educational programs targeting disease awareness, prevention, and surveillance throughout Ruaha.

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Further Reading

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About the Authors: David Wolking, Jim Ellis Award Recipient 2007-2008, received his MS in International Agricultural Development at the University of California, Davis in November 2009. He is currently Lead Writer and Editor for the GL-CRSP. Email: djwolk@gmail.com. Mr. Wolking's thesis, a component of which provides the content for this brief, was conducted in collaboration with the HALI project. Dr. Deana Clifford has been the HALI project Coordinator based at the Wildlife Health Center in the School of Veterinary Medicine, University of California, Davis and is currently a Veterinary Epidemiologist with the California Department of Fish & Game. Email: dlclifford@ucdavis.edu. Dr. Harrison Sadiki is the HALI project Field Coordinator in Tanzania. Email: hsadily@yahoo.com. Enos Kamani is a Research Assistant working with the HALI project. Email: ekamani2002@yahoo.com.sg. Dr. Woutrina Miller is an Adjunct Assistant Professor in the School of Veterinary Medicine, University of California, Davis. Email: wamiller@ucdavis.edu. Dr. Rudovick Kazwala is a Professor of Veterinary Medicine and Public Health at Sokoine University of Agriculture, Tanzania. Email: kazwala@suanet.ac.tz. Dr. Jonna Mazet is a Professor of Wildlife Epidemiology and Co-Director of the Wildlife Health Center at the University of California Davis. Email: jkmazet@ucdavis.edu.

The Health for Animals and Livelihood Improvement (HALI) project was established in 2006 and is a stakeholder-driven research and capacity-building program to assess the effects of zoonotic disease and water management on animal health, biodiversity, and livelihoods in the Ruaha ecosystem, Tanzania. The project is led by Dr. Jonna Mazet. She can be contacted via post at Wildlife Health Center, One Shields Ave., School of Veterinary Medicine, University of California, Davis, CA 95616, USA, or via email: jkmazet@ucdavis.edu.

The Global Livestock CRSP is comprised of multidisciplinary, collaborative projects focused on human nutrition, economic growth, environment and policy related to animal agriculture and linked by a global theme of risk in a changing environment. The program is active in East and West Africa, and Central Asia.

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