Rats and Human Health in Africa: Proceedings of an international workshop on rodent-borne diseases and the RatZooMan research project

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http://www.nri.org/ratzooman

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Preface

The ratzooman workshop is the culmination of three and half years of research carried out by a large team of scientists operating in Europe and Africa. In many ways it has been a unique project by drawing together experts from various disciplines to holistically focus on the complex issue of rodent-vectored disease. From the outset of the project, it was clearly recognised that awareness about rodent-vectored diseases needed to be raised in the widest sense, and a practical workshop to disseminate results was considered to be an important step towards this goal. With more than 20 countries represented at the ratzooman workshop, I believe that we made a significant contribution towards improving knowledge provision on the rodent disease problems affecting individuals and communities throughout the world and particularly in Africa.

These proceedings are an attempt to capture and summarise some of the information that was formally presented at the workshop about the ratzooman project as well as from invited guests who made presentations on relevant subjects related to the overall theme of rodent diseases. Summaries of the discussion group sessions that involved all workshop participants are provided, and I hope do justice to the proficiency of proposed recommendations made by everyone's participation. These proceedings will be officially published as part of the ratzooman final report which will be abstracted and indexed for various citation search engines. My sincere thanks go out to all the presenters and participants for their contributions to the success of the workshop and their contribution to the ratzooman project.

Although rodent-borne diseases will continue to threaten people's lives for some time to come, our knowledge and understanding of rodent/disease eco-epidemiology is advancing. Even though the ratzooman project has officially ended, I'm sure ratzooman will serve as a baseline platform for future research initiatives on rodent-borne diseases.

Steve Belmain
Ratzooman technical coordinator
June 2006

Summary

Rodents are an important vector for zoonosis (diseases transmitted from animals to humans), and can act as reservoirs for more than 60 different diseases which can affect people. There is growing global concern about communicable diseases, particularly as climate change, urbanisation, and agricultural intensification may cause some zoonoses to spread – emerging in new areas or re-emerging in areas thought to be free of disease. As the world saw with SARS, new animal-borne diseases can emerge, and improved transport linkages from rural to urban settlements and international travel can lead to large zoonotic outbreaks when the disease is transmitted from person to person. Although we know rodent diseases are a problem, in most cases we do not know how severe a particular disease problem is for human health. For some diseases there is poor awareness among the general public, health care staff and clinicians. Awareness levels are complicated by the fact that the symptoms of some rodent diseases are similar to other better-known diseases, and through the difficulty in appropriately diagnosing the disease causing agents.

We can generally accept that rodent pest populations are worsening for a greater proportion of people living in Africa, through urbanisation and difficulties in providing basic standards for urbanised infrastructures (sewage, water, rubbish collection, rat-proof housing) Urban and peri-urban rodent populations generally increase with worsening sanitation, and urban slums are growing in and around many African cities. We also know that rural practices such as deforestation, agricultural intensification and other anthropogenic changes to the environment can change rodent species diversity, bringing people (or peri-domestic rodents and livestock) into contact with wild rodents. What people are doing in rural and urban areas of Africa is fundamentally encouraging conditions for the spread of rodent-borne diseases.

Diagnosis for many rodent-diseases is challenging and relies on specialised knowledge, expensive equipment and facilities. New diagnostic tools have been developed for some diseases, but they are not widely available. As rodent diseases are not routinely screened or diagnosed, we do not know how many people contract particular diseases. In other words, many African countries are reporting a growing proportion of cases of "Fevers of Unknown Origin". There is a major under-reporting of rodent diseases such as leptospirosis, and this makes it difficult to argue to the authorities that rodent diseases are, indeed, a problem. Surveillance for diseases of sporadic or unknown human cost is hard to justify. There are two broad categories of rodent borne diseases, which perhaps need to be treated in different ways with regard to policies and interventions. The first category is contagious diseases. These are diseases that then can spread from human to human after they have been initially picked up from animals. Plague and Lassa Fever fall into this category, and these require additional policies for their management to prevent human outbreaks (quarantine, barrier nursing, etc.). The second category of rodent diseases are those which are generally not contagious. This includes diseases picked up through contaminated food and water and often ultimately through rodent urine or faeces. In some circumstances these diseases can be spread from human to human (failing to wash hands), but they are generally of lower communicability status. These diseases can of course cause large scale outbreaks in communities which make use of common water and food sources which have become contaminated.

"If we don't look, we don't find it", appears to be an accepted course of action with regard to rodent diseases. The politics of rodent pests implies that providing government with new data which shows the true extent of rodent disease problems is not actively encouraged by most governments. The worry is that the figures will be alarming, cause panic, and add to the list of actions which must be taken. Increasing awareness of "unknown" diseases increases public calls for action against rodents and can be politically unpopular. This is particularly true when improving the management of rodent pests is intricately linked to housing conditions, service provision (sanitation, water) and active rodent pest control activities. Rodent pest control is not always assessed for its cost-benefits, leading to treatment failures, poor financial investments and widespread apathy among the authorities and the general public.

Rodents have caused human disease outbreaks in the past, and they will undoubtedly continue to do so in the future. We do not know if rodent disease problems are worsening. However, rodent pest populations are undoubtedly increasing with increasing human populations. Without improvements in

human living conditions, it seems self-evident that rodent disease problems will also increase. Clearly we need better information about rodent disease problems.

During the ratzooman workshop, a series of scientific presentations were made, covering aspects of current knowledge about rodent and disease ecology. These presentations showed that knowledge about the impact of rodent diseases on human health continues to be widely under-reported. Under-reporting arises from complex issues related to availability of diagnostics, confusion with other diseases, lack of surveillance and awareness, and resource constraints affecting staff, equipment and treatment facilities. These formal talks were followed by group discussions where five key constraints were elaborated in order to develop future strategies for improving the way in which people deal with rodent-borne diseases. The outputs of the workshop will be used to develop policy recommendations targeting decision makers at local, national, and international governing levels.

Session I: Introduction

Ratzooman overview

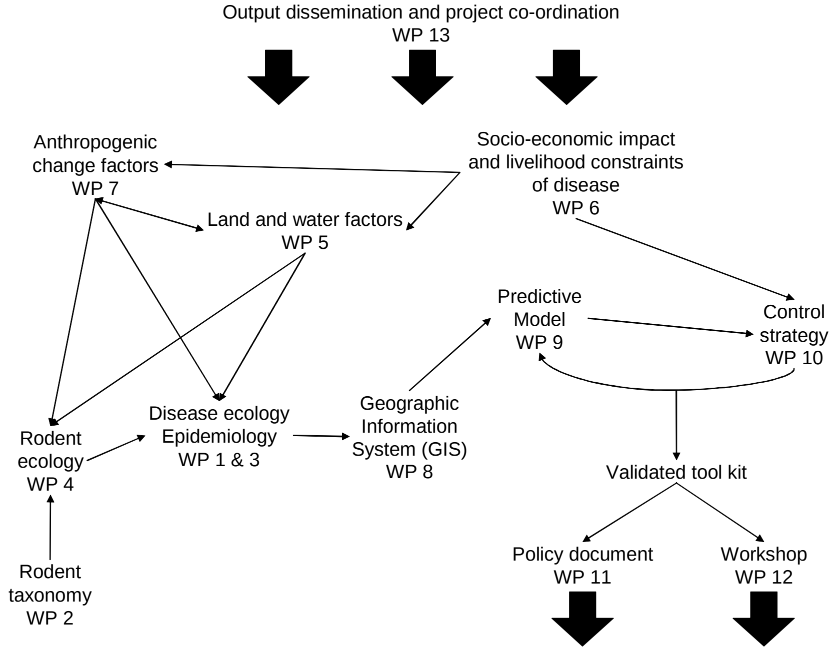
Steven Belmain, Natural Resources Institute, UK

The ratzooman project is one of the first truly international multidisciplinary research projects to focus on the role of rodents in vectoring human disease. The project focuses on public health risks of rodents as disease vectors and the role they play in the spread and transmission of many diseases, but particularly on plague, leptospirosis and toxoplasmosis. These diseases were chosen as 'model' diseases because of the different roles rodents play in their transmission as direct, indirect or intermediate hosts for disease organisms. The objectives of the project were to develop new insights on the risks to public health caused by rodents living in close association with humans in rural and peri-urban areas of south-eastern Africa and apply this information for the development of risk-management strategies. It was hypothesized that changes in rural ecology could make previously rare diseases become more common while increasing connectivity between rural and urban areas could allow these diseases to reach cities and deteriorating hygiene and increasing urban rodent pests could facilitate these diseases spreading and persisting in cities. Climate change, urbanisation, sanitation, rural expansion and increased connectivity could all contribute to increased rodent disease problems particularly in less developed tropical countries where the overall human disease burden is highest. The research project was expected to:

- Increase understanding of zoonosis prevalence in rural and peri-urban areas and the impact of agro-ecological and anthropogenic factors on disease transmission pathways
- Establish the impact of rodent-borne diseases on sustainable livelihoods
- Raise the profile of the effects of rodents on people's health
- Inform and influence policy formulation at government, institution and community levels
- Provide potential risk reduction strategies that can be used to reduce the impact of zoonotic diseases
- Create predictive and simulation modelling tools to measure the threats of zoonotic disease

The research team involved institutions from four European countries (UK, Denmark, Belgium, The Netherlands) and four African countries (Mozambique, Tanzania, South Africa, Zimbabwe), and research activities were divided into workpackages as per the below figure. Details of the technical aspects of each workpackage are available at
http://www.nri.org/ratzooman/docs/technical%20annex.pdf

Figure 1.   Relationship of research actions within the ratzooman research project



Knowledge generated from the project has been successfully disseminated through peer-reviewed science journals as well as the popular media. Further details of project activities and outputs are available through the project website: http://www.nri.org/ratzooman/

Figure 2. Front page of the ratzooman project website

Rats and disease

Herwig Leirs, University of Antwerp, Belgium & Danish Pest Infestation Laboratory, Denmark

Rodents are involved in the transmission of more than 60 infectious diseases to humans. Some of these are caused by viruses (e.g. Lassa fever, hantavirus disease, tick-borne encephalitis, Argentine and Bolivian hemorrhagic fever,….), bacteria (e.g. plague, leptospirosis, lyme disease, relapsing fevers,…), protozoans (e.g. leishmaniasis, toxoplasmosis,….) or helminths (e.g. trichinellosis, echinococcosis, capillariasis,…). That rodents play such a prominent role as reservoirs or vectors has to do with the fact that they are, as mammals, physiologically quite similar to humans, their huge diversity and the fact that some species live in close contact with humans.

There are more than 1700 species of rodents. The Muridae are a family of mostly granivorous or omnivorous species of African, Eurasian or Australasian origin and known reservoirs such as the genera *Mastomys* in Africa, *Apodemus* in Eurasia. This family also contains the commensal house mouse (*Mus* sp.), black and brown rat (*Rattus rattus* and *R. norvegicus*) that have spread literally all over the world. The family Microtidae (in Eurasia, e.g. *Microtus*) and Sigmodontidae (in the Americas, e.g. *Peromyscus*) also contain several known disease reservoirs. These three families have numerous species, but it is worth mentioning that the order of rodents is actually very diverse (including also species that are less "rat-like" such as squirrels, porcupines, guinea pigs, mole rats, etc...). Given the diversity of rodents, it is important that species are correctly identified if their role in the epidemiology of diseases is to be understood. For example, two very similar species of multimammate rats occur together in parts of South Africa and the only way to recognise them is to count the number of chromosomes. Yet, one species *Mastomys coucha* with 36 chromosomes is a good reservoir for plague, while *M. natalensis* with 32 chromosomes is not.

Rodents spread diseases to humans through a number of pathways. Some are direct such as rat bites, or humans eating infected rat meat. Others are more indirect, through spoiling of food with infected rodent excreta, pathogens excreted in the environment and later inhaled or ingested by humans, or penetrating the human skin, or pathogens that are transmitted by ectoparasites. In some cases, rodents do not transmit pathogens to humans themselves, but they are important as intermediate hosts in order to maintain a parasite's life cycle. Other contributions at the workshop will discuss examples of such infections in more detail.

Rodent management can play a role in the control of these diseases at several levels. The risk for humans is related to the frequency with which they have contact with (infected) rodents, and this in turn is also related to the density of these rodents. The density of rodents is also important because infections need a certain minimum threshold density in order to be able to persist in a population.

The global burden of rodent borne diseases is difficult to calculate because they are often under-diagnosed, some have a low incidence but carry high risks if they would start spreading (plague is a prime example here), and many are very focal in time and in space. In addition to the health costs, there is also the economic cost that a country may face when affected by diseases that affect its international trade position.

While there has been optimism for some decades that infectious diseases were becoming less and less important, there currently is a concern that the risk for rodent-borne diseases actually may be increasing. Factors that contribute to this include deteriorating public hygiene conditions (especially in rapidly expanding megacities), humans intruding in new habitats and coming into contact with "new" pathogens, the development of pathogens' resistance to treatment, lowered immunocompetence in people (AIDS) that may allow previously fairly benign infections to become a serious cause of mortality and finally climate changes that may improve conditions for some reservoir species. The Ratzooman project tries to address some of these issues in an African urban and peri-urban context.

Leptospirosis overview

Rudy Hartskeerl, Royal Tropical Institute, The Netherlands

Leptospirosis is caused by *Leptospira*, which are long, thin helically coiled bacteria with one or two hooked ends. There are pathogenic and saprophytic *Leptospira*. Saprophytic *Leptospira* live in the environment while pathogenic *Leptospira* live in the kidneys host animals and are excreted with the urine into the environment where they can survive for months depending on favourable conditions (i.e. humid, warm and slightly alkaline). Most mammalian species can be a natural host with rodents and insectivores representing the most notorious infection reservoirs. Other accidental hosts, including humans, become infected by direct or indirect contact with the carrier animal or the contaminated environment, and in contrast to the natural host usually develop disease. Transmission occurs through wounded or water-weakened skin and through the mucous membranes of mouth, eyes and nose. Leptospirosis is probably the most widespread and most prevalent zoonotic disease but is most endemic in tropical counties where environment is favourable for survival of the pathogens and anthropological and socio-economical conditions contribute to a high risk of infection.

Leptospirosis is a disease with protean manifestations mimicking many other diseases. It is difficult to diagnose both in the clinic and the laboratory. Therefore, the disease is frequently not recognised and consequently severely neglected in humid tropical and sub-tropical areas. This is notably true for Africa. Leptospirosis is (re)-emerging globally and numerous outbreaks have occurred worldwide during the past decade, one of the most recent examples being the outbreak following the flooding in Mumbai in 2005. There are an estimated 300,000 to 500,000 severe cases annually with fatality rates of 5 to 20%. However, this is likely an underestimation. The true spread and increase of leptospirosis remains unknown, as diagnostic tests, testing facilities and surveillance systems are frequently not available.

The epidemiology of leptospirosis is highly complex and dynamic. Currently there are nearly 300 serovars known, each adapted to its own mammalian host. One serovar might have adapted to several hosts while one host might carry more than one serovar. Adaptation is a dynamic process with serovars adapting to new hosts and new serovars appearing, e.g. by introduction of new hosts in an environment. This might particularly be true for the urban/peri-urban interface of ever-growing (mega) cities were commensal mammals mix with (new) wildlife.

Thus control measures should be tailor made on a temporal and spatial basis and thus require research and constant surveillance. It should be stressed that leptospirosis is a disease of humans, mainly as an occupational risk, and animals, including farm animals. Economic losses in the public and veterinary health sectors are considerable, probably exceeding billions per year.

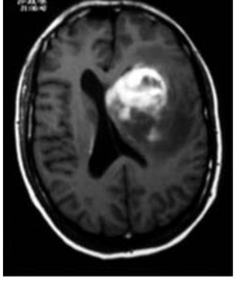
Toxoplasmosis overview

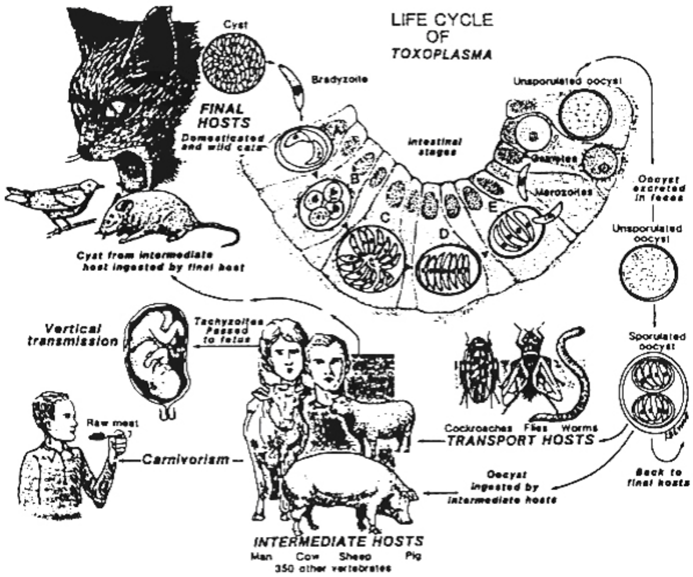
Ricardo Thompson, National Institute of Health, Mozambique

Toxoplasmosis is a protozoan disease caused by the organism *Toxoplasma gondii*. The main host is the domestic cat where the organism is able to sexually reproduce. Cysts are shed in cat faeces which are then consumed by other animals. When other animals eat them, the cysts do not enter a sexually reproductive stage but migrate around the body asexually dividing. These are eventually attacked by the animal's immune system and become encapsulated within the animals tissues, meaning they are alive but dormant. The cycle is completed when another cat eats the animal with encapsulated cysts which then wake up and infect the cat where they can sexually reproduce. Humans and other animals can be exposed to the disease by eating infected animals (e.g. rodents, pigs) or food/water/surfaces that has been contaminated by infected cat faeces or raw infected meat. Research has shown that rodents with toxoplasmosis are more easily predated upon by cats (so that the parasite completes its lifecycle). As with cysts of trichinosis, adequate cooking should readily kill any toxoplasmosis cysts in meat. Risks of contracting toxoplasmosis exist when people handle raw meat, failing to wash hands afterwards, or when surfaces that have been contaminated with raw meat are then used to prepare uncooked food, e.g. fruits and vegetables. Pet cats are a risk factor, particularly when irregularly cleaning cat litter boxes. However, most individuals contract toxoplasmosis through improperly cooked meat or handling raw meat/contaminated surfaces.

Many people contract toxoplasmosis without realising it. The worst case symptoms are usually similar to a very bad case of the flu. Severe cases would be debilitating for a few weeks, but cases of death are unheard of in normal healthy individuals as long as any associated dysentery is treated. Life-long immunity occurs after a single exposure so although no illness will derive from future exposure episodes, the cyst load may marginally increase with each subsequent exposure. If contracted during pregnancy for the first time, the disease will either cause miscarriage or severe congenital deformity. Retinal scarring and blindness are common among individuals that are congenitally infected. Immuno-compromised individuals (e.g. HIV) that were previously exposed to toxoplasmosis can have cerebral re-activation where the dormant cysts in the body come alive again. As the immune system is unable to re-encapsulate the cysts, the person dies as the cysts continue to multiply and migrate around the brain and body. This is considered one of the most common causes of death among AIDS patients with some estimates indicating that more than 80% of AIDS patients show Toxo cysts within the brain.

The disease is unlikely to persist in an area where there are no cats. It is likely that disease incidence is only minimally affected by climate, but it could be affected by the susceptibility of cysts to desiccation and periods of drought. Hygiene standards and eating rats will certainly contribute to the prevalence rate.





Plague overview

John Frean, National Institute of Communicable Diseases, Republic of South Africa

Plague is an ancient disease. There are descriptions of diseases which could be plague in the Bible, or in even older sources. There have been 3 pandemics in recent history: the Justinian plague (541-750 AD); the medieval pandemic (Black Death & later, 1347 – 17th C); and the current 3rd pandemic (mid- 19th C to present) when plague spread rapidly around the world from its Hong Kong focus at the end of the 19th C, and established itself, amongst other places, in southern Africa, the Americas, India, and Madagascar.

Principles of plague epidemiology are based on the fact that *Yersinia pestis* is an obligate pathogen and does not exist freely in the environment. It is unable to replicate outside a host (flea or mammal) in natural conditions, and plague is maintained in foci in mammals, mainly rodents, with transmission between individuals via fleas. Human plague occurs when wild rodents encroach on human habitat because of food, weather, deforestation, or other destruction of habitat; commensal rodents are then at risk for infection. Alternatively, humans may encroach on rodent habitat because of agriculture, hunting, or residence. Humans' domestic animals can also intrude into rodent habitat, get infected, and be a source of human infection (Figure).

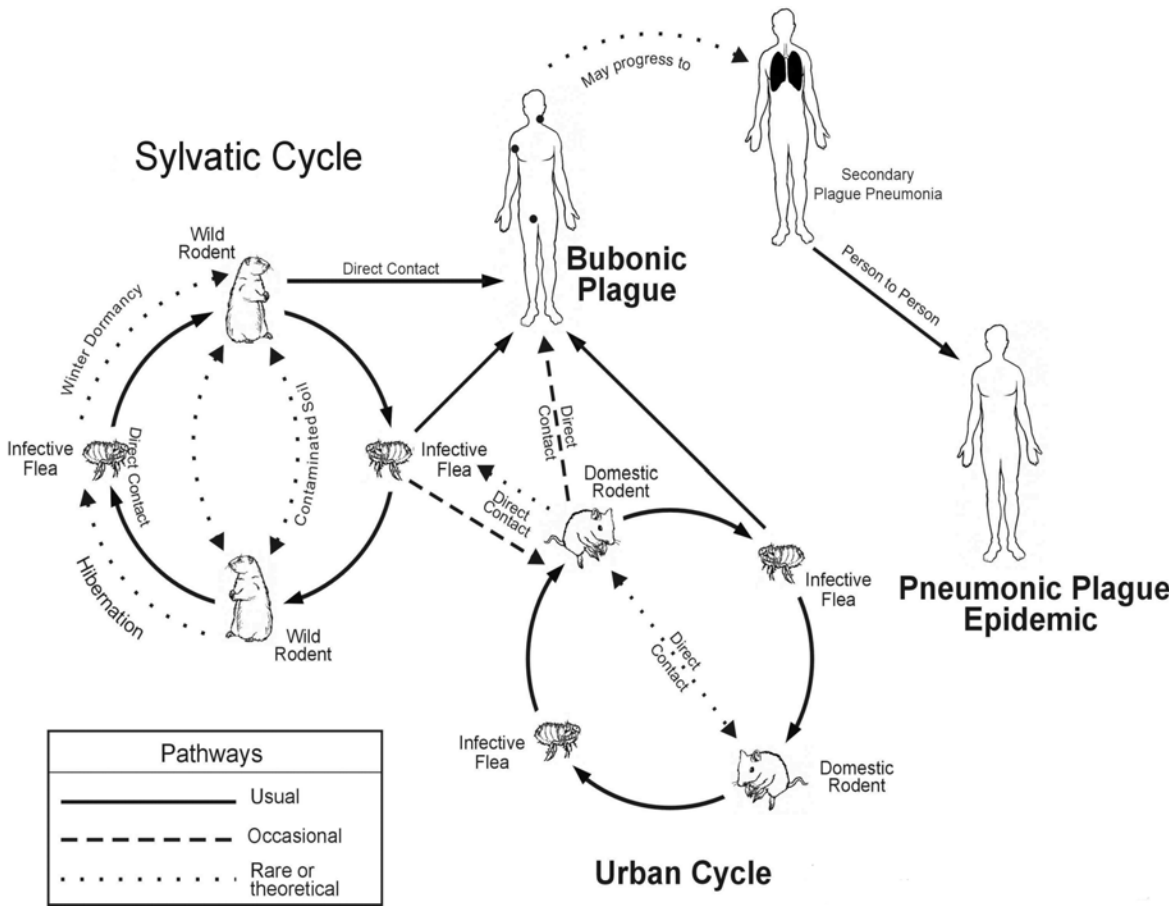


Figure. Transmission cycles of plague

Clinical forms of plague include bubonic, carbuncular, septicaemic, and pneumonic plague; occasionally, pharyngeal plague or plague meningitis can occur. Diagnostic techniques include antigen detection (rapid dipstick method), examination of stained smears, culture, serology, and molecular methods (e.g. PCR). Plague is readily treatable with aminoglycosides, doxycycline, or cotrimoxazole. A few multidrug-resistant isolates have be found in Madagascar, but antibiotic resistance is not a major problem currently.

Public health control of plague involves environmental insecticiding, followed by trapping or poisoning commensal rodents; elimination of rodent harbourages; case tracing and treatment, including isolation of ill patients and antibiotic prophylaxis for contacts.

In Africa, plague is regularly reported from DRC, Madagascar, Malawi, Mozambique, Uganda, and Tanzania. 82% of cases worldwide and 85% of deaths from plague occur in Africa. A feature of plague is its resurgence after long periods of quiescence, as has recently occurred in Algeria after 50 years, and in India, 30 years after its last reported case. Historically, plague was endemic until relatively recently in southern Africa, and the ratzooman project has renewed interest in plague surveillance in South Africa. Modern transport means that aircraft can move pneumonic plague victims between countries in a few hours, which has implications for control. As with SARS and avian influenza, special observation for ill passengers and notification of destination, and surveillance by local health authorities is required. Regarding bioterrorism, plague is regarded as category A agent.

There are some fundamental questions about plague that remain unanswered: is there a 'perfect' reservoir host? Is there an undiscovered long-term environmental niche, eg soil, or soil inhabitant (nematode, protozoon)? What factors trigger resurgence? Are vectors other than fleas (e.g. lice) involved in some human epidemics? Is plague epidemiology more complex than current dogma suggests?

Session II: Understanding rats and disease problems

Lassa Fever spatial and temporal risk linked with rodent ecology and human behaviour in Guinea

Elizabeth Fichet-Calvet, Paris Natural History Museum, France

Lassa fever is a viral hemorrhagic fever, which occurs in West Africa, from Guinea to Nigeria. The morbidity of Lassa fever has been estimated to two million people per annum with a fatality rate of 5‰ (McCormick 1999), but a recent review evaluated the risk to contract the disease for three million with fatalities up to 67,000 per annum in Guinea, Sierra Leone and Nigeria (Richmond and Baglole 2003, figure 1).The pathogen agent is an arenavirus, the Lassa virus, discovered for the first time in humans in 1969 in Nigeria (Buckley et al. 1970) and in the African rodent, *Mastomys natalensis* in 1972 in Sierra Leone (Monath et al. 1974). Humans possibly become infected by inhaling virus-laden dust particles, by eating food contaminated with infected rodent urine, or using rodents for consumption (Stephenson et al. 1984, ter Meulen et al. 1996). This rodent is commensal in Guinea where its lives in houses and gardens, but its distribution varies with season. At the end of the rainy season, rodents disperse out of the houses because many crops are available outside, whereas they live in houses during the dry season, attracted by the crops preserved inside. At the beginning of the rainy season, rodents remain inside because of the lack of food sources (figure 2). These dynamics support the hypothesis of a higher incidence of Lassa fever in humans in the dry season, due to the high number of Mastomys inside (Fichet-Calvet et al. 2004). Nevertheless, infected rodents by Lassa virus are more numerous in the rainy season, suggesting that other factors could enhance the transmission, such as increased environmental stability of the virus and human behaviour. In the dry season, people remaining at home are possibly exposed to the virus for a longer time than during the rainy season. The consumption of rodents is usually practised by children who could be infected by skinning or eating the animals. But hunting rodents takes place in distant cultivated fields, and involves rodent species which are not a reservoir of Lassa virus. This behaviour is, therefore, considered as minor in relative comparison to the large quantity of virus deposited by rodents living in houses which humans are breathing throughout the year.

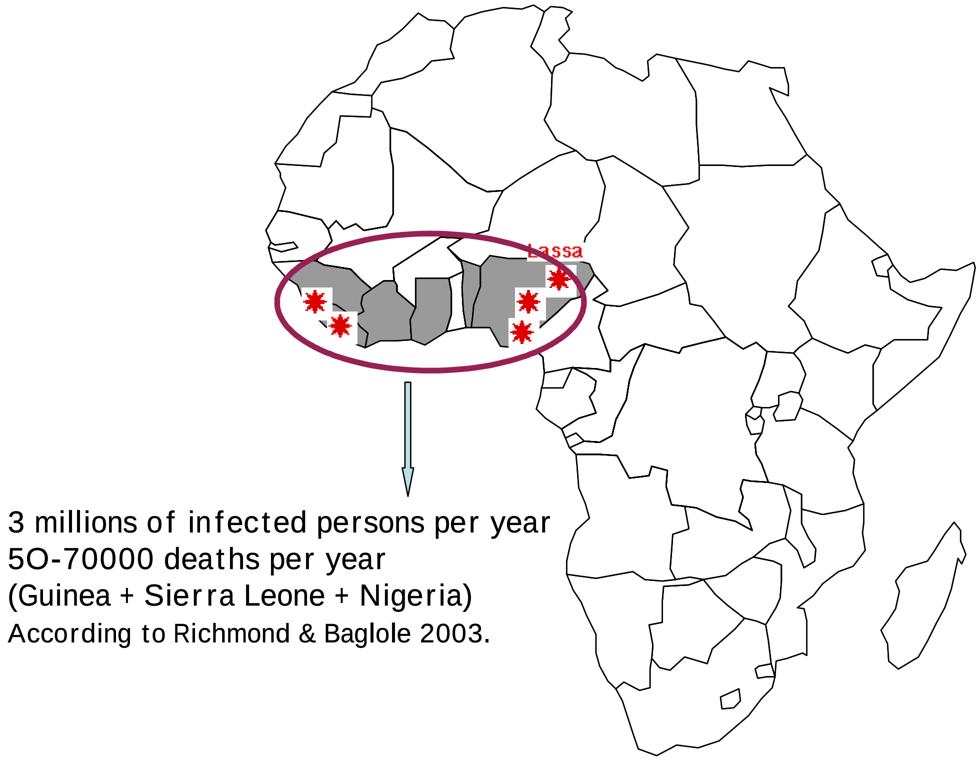


Figure 1: Distribution of Lassa fever in Africa. Red stars correspond to outbreaks location in Nigeria, Sierra Leone and Liberia.

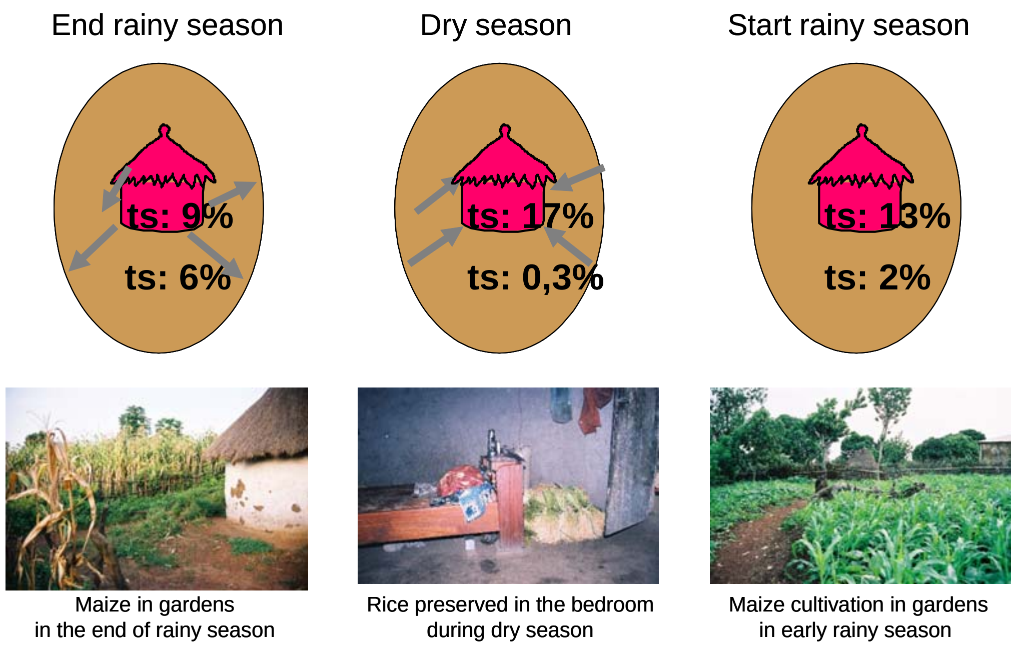
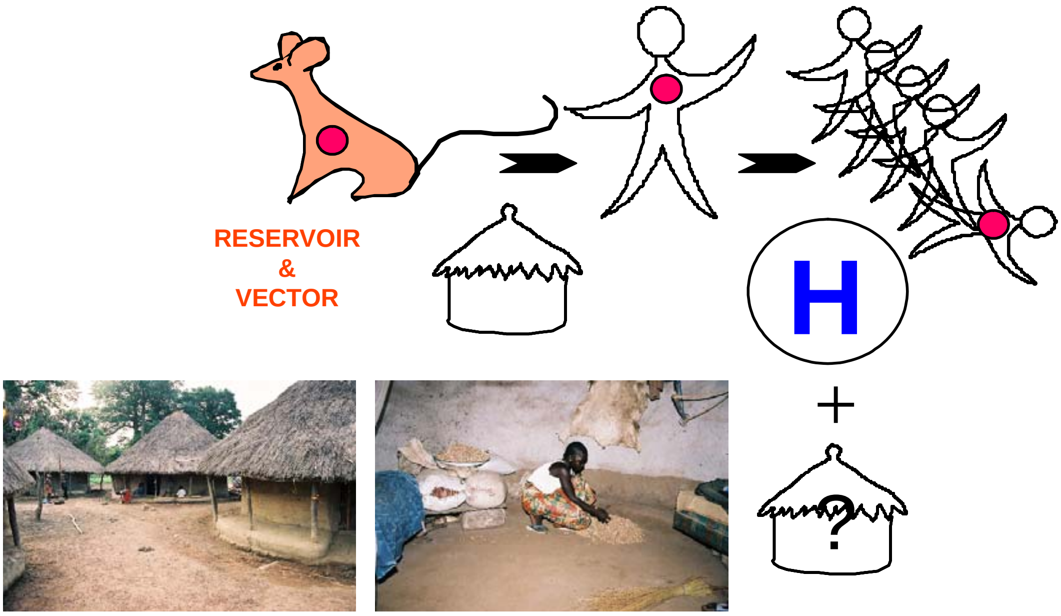


Figure 2: Seasonal dynamics of *M. natalensis* in two villages located in Upper Guinea.Ts = trapping success.

Lassa fever: cycle of transmission

- arenavirus
- primary transmission: rodent - Human
- secondary transmission: Human - Human



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Rodents, salmonella and the risk to the food industry

Alan Buckle, University of Reading, UK

The World Health Organization recognises 31 common food-borne human pathogens[1] and rodents have been implicated in the transmission of many of them. The mode of transmission is often mechanical, however, and other public health pests such as flies and cockroaches may also be involved in any particular disease outbreak. Diseases like salmonellosis, have long been associated with rodent infestation, but recent studies in the UK have revealed a bewildering array of pathogenic organisms isolated from Norway rats captured in both rural and urban environments; many the causative organisms of food-borne disease (e.g. listeriosis, cholera, diarrhoea (*E. coli*) and dysentery)[2,3]. Other important food-borne diseases in which rodents are implicated are the enteric diseases caused by *Campylobacter*, cryptosporidiosis and a wide range of diarrhoeal diseases. The main route of transmission among humans of all these diseases is the consumption of food which has been in contact either with infected faeces, via pests (including rodents) or human hands, or with contaminated water and soil.

Rodent infestation is present throughout the 'food chain', from the storage of raw materials through to manufacture and retail sale, and is associated with all modes of transportation between these stages. Attention to cleanliness is the main method by which the transmission of food-borne disease is prevented. This includes the prohibition of any contact between rodent infestations and human food during storage, preparation, distribution and sale. Increasingly, quality is driving consumer decisions concerning the foods they consume and an expectation that a foodstuff will not contain harmful levels of any food-borne pathogen is among the most fundamental of all quality requirements. Highly effective rodent pest management is therefore integral to every aspect of food handling. In the developed world, audit schemes aimed at improving quality determine procedures and stipulate effective pest control right along the food chain[4]. Such considerations may be far removed from the reality of daily life in many sub-Saharan countries however, where the provision of sufficient food to prevent malnutrition may be an overriding concern. Nevertheless, we must constantly strive to improve knowledge, competence, and practice in the management of rodent pests in food handling at both commercial and domestic levels in order to reduce the currently heavy burden placed by food-borne diseases on overstretched health and welfare infrastructures. The Ratzooman project has played an important role in raising the profile of rodent-borne diseases in southern Africa and has provided an important stimulus to improved practices of rodent pest management.

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Intestinal parasites of rats from Durban and implications for human health

Chris Appleton & CE Archer, University of KwaZulu-Natal, Republic of South Africa

Urban rats (*Rattus* spp.) generally harbour an endoparasite fauna composed largely of cosmopolitan protozoon and nematode species with a smaller number of trematodes and acanthocephalans. About half of these have been reported as zoonotic infections in people. Three protozoans, two cestodes and eight nematodes were recovered from *Rattus norvegicus* and *Mus musculus* from two localities in Durban, South Africa (no nematodes were found in *M. musculus*). Of these, four are likely to be of public health importance in South Africa, the protozoon, *Balantidium coli*, and the tapeworms, *Hymenolepis diminuta* and *Vampirolepis nana*, are routinely found infecting children in Durban and elsewhere in South Africa though they are not common. *B. coli* occurs at prevalences <2% and *H. diminuta* and *V. nana* at <5% and <10% respectively. *Balantidium coli* has not previously been reported from urban rats.

Nothing is known of the transmission biology of either *H. diminuta* or *V*. *nana* in South Africa. This study has shown that *R. norvegicus* and *M. musculus* are both natural hosts for *H. diminuta* and probably serve as reservoir hosts for its transmission to children. *Rattus norvegicus* is likely to be the more important host with 12/27 (44.4%) infected compared with 1/11 (9.1%) for *M. musculus*. *Vampirolepis nana* was not confirmed from either host but provisional identifications suggest a moderate prevalence in *R. norvegicus*. Evidence was found that *H. diminuta* eggshells rupture in the host's intestine to release embryos that resemble the eggs of *V*. *nana.* Despite having polar thickenings instead of the polar filaments usually given as diagnostic for *V. nana*, these could be misidentified as *V. nana* (see Figure).

Figure

Intact *H. diminuta* egg

ruptured egg releases embryo

embryo without egg shell resembles *V. nana* egg

Eggs of *Ascaris lumbricoides* were recovered from both rodent species and in different stages (unembryonated, embryonated, corticated and decorticated). In these situations *A. lumbricoides* is a 'pseudoparasite' meaning that these rodents are coprophagous and ingest its eggs which then survive passage through the rodent's alimentary tract. They will presumably then be distributed, sometimes in large numbers, by the rodents via defaecation. Rodents may therefore play an unrecognized role in the transmission of ascariasis in urban areas of South Africa.

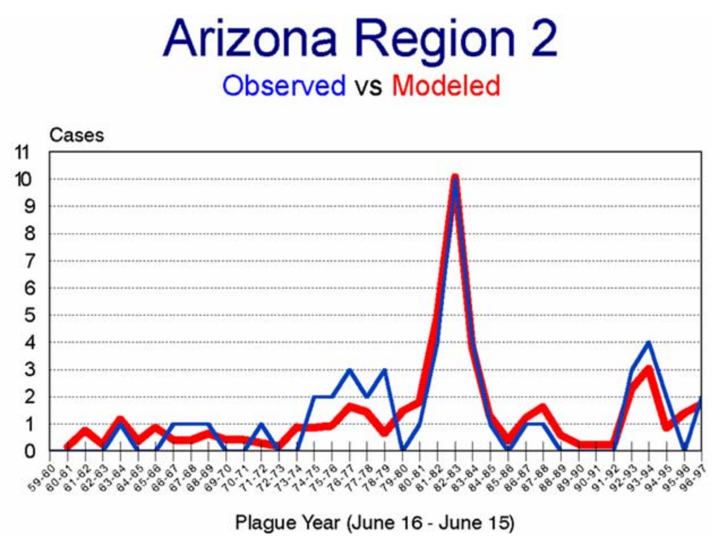
Acknowledgements: We are indebted to Dr P. Taylor (Durban Natural History Museum) for supplying the material and Prof. J. Boomker (University of Pretoria) for identifying the helminths.

GIS and climate modelling for zoonotic disease risk

Russell Enscore, Centres for Disease Control, USA

Model parameters derived from satellite remote sensing and climate recording stations can be integrated into Geographic Information Systems to construct map-based risk models for vector borne diseases. In North America this has been done for several diseases, notably for Plague, Lyme Disease and Sin Nombre Hantavirus. ESRI Arc GIS software packages have been used to merge parameters and present outputs as risk maps. Temporal risk models have also been created, using climate parameters, for human plague risk.

Enscore, et al., (2002) used regression analysis (Poisson) to model annual human plague risk using precipitation and temperature climate variables. Early Spring precipitation was found to produced increased human plague cases lagged 1 and 2 years. Concurrent high temperatures were found to reduce plague risk. The resulting equation has been extremely accurate in predicting plague incidence since then.



Ongoing studies, publications currently in progress, on the geographical distribution of plague in the American southwest have identified land-cover, elevation, and slope parameters as being critical to modelling risk distribution. Several examples of work in progress were discussed and shown.

Eisen, et al., (2006) used forest land-covers to model nymphal tick (*Ixodes pacificus*) distribution and Lyme Disease risk in California. Model parameters included NDVI values as well as climate variables (solar radiation). Nymphal tick distributions were shown to closely correlate with Lyme Disease distribution (risk).

Glass, et al. (2002) used remotely sensed landscape and climate parameters to model the geographical and temporal distribution of Hantavirus (Sin Nombre caused Hantavirus Pulmonary Syndrome). Annual incidence was closely modelled for a region in the south-western USA.

In areas where ground-based monitoring of disease reservoirs and vectors is not practical or economically possible, satellite remote sensing products and climate parameters may be used to model disease risk both geographically and temporally. By identifying high risk locations or time periods, public health agencies may better focus limited resources and more efficiently reduce disease incidence. Modelling also provides a “back-door” avenue to ecological researchers to identify environmental parameters that affect zoonotic disease incidence and prevalence.

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The agriculture-health divide: leptospirosis and typhus in Southeast Asia

Grant Singleton, International Rice Research Institute, The Philippines & Paul Newton, University of Oxford, UK

Rats are becoming the most serious pest of rice in Asia, causing annual pre-harvest losses of about 5 – 10%. In addition, reports of 10% loss of grain post-harvest are not unusual. Rats are also transmitters of important human diseases, such as the plague, arena and hanta viruses, rat typhus, lungworm, leptospirosis and toxoplasmosis. The epidemiology of most of these diseases in Asia is poorly understood.

Too little attention has been paid to the whole agro-ecosystem when developing programmes to manage zoonoses. This paper presented data from a leptospirosis epidemic in rural northeast Thailand, human clinical studies of leptospirosis and typhus in Lao PDR, and a field study of leptospirosis in wild caught rats in the Mekong Delta region of Vietnam.

In Thailand, a leptospirosis epidemic was first recorded in 4 provinces in 1996 and had spread to 16 provinces in 2001. At the height of the epidemic, >14,200 cases were reported with 362 deaths (Tangkanakul et al. 2005). People who were at high risk of infection were males those who spent a lot of time working in flooded rice fields.

In the Philippines, >1,000 people are hospitalized annually with leptospirosis. Fatality is high rate ranging from 11% to 20%. This appears to be in part because people go to hospital only if severe symptoms develop because they cannot afford to pay for long stays in a hospital. Therefore, it is the urban and rural poor who are at greatest risk because of higher rates of exposure to infectious bacteria and little available income for early medical intervention.

In Lao PDR, serological investigation of 427 adults with unexplained fever during 2001-03 indicated acute infection of leptospirosis in 10%, acute murine typhus in 10% and acute scrub typhus in 15%. Field studies of rodent populations in urban, peri-urban and rural areas are planned to determine the likely role of particular rodent species as reservoirs for these diseases.

In Vietnam, rodents were screened from "rat meat" factories in two southern provinces. In Soc Trang, approximately 20% were seropositive (n=63), whereas in Bac Lieu no rats were seropositive (n=65). People who process the rats for human consumption take few precautions against contracting rodent zoonoses. A public education program is urgently needed.

In his opening address to this workshop, Belmain concluded that the apparent increase in rodent pest populations, together with the decrease or lack of progress in human living conditions, provided a strong foundation for rodent disease problems in humans to increase. Asia, with more than 750 million people below the poverty line, contains 70% of the world's poor. Yet the research effort on rodent zoonoses in Asia is lamentable, particularly in the poorer countries such as Bangladesh, Cambodia, Lao PDR, Mynamar and the Philippines. Therefore it is imperative that we develop future strategies for managing rodent-borne diseases in humans. This requires more studies to determine the main rodent reservoir species, to understand the ecology of these species and to improve our understanding of rodent-human interactions in rice-based agricultural ecosystems. Armed with such knowledge we can better target farmer's practices for rat management, and the factors that predispose them to various zoonoses. In turn this would generate improvements to human livelihoods through greatly improved health and higher crop production. The latter would arise because of a greater surety of healthy labourers at key times in crop production.

Reference

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Session III: Ratzooman and human disease in southern Africa

Understanding human behaviour and the transmission of rodent-borne diseases

Monica Janowski, Natural Resources Institute, UK

Dr. Janowski outlined the work which has been done under the RATZOOMAN project to look at behaviours, practices, beliefs and perceptions which relate to the likelihood that people may pick up rat-borne diseases, and at the individual and household characteristics which are associated with this likelihood. She explained the choice of sites which were used in South Africa, Mozambique, Zimbabwe and Tanzania for anthropological and questionnaire surveys, and gave details of the collaborators in each country who were involved in the data collection. Four anthropological reports and one socio-economic report have been produced.

Dr. Janowski briefly gave details of the findings of this research. Rats were found to be very common and to be present in houses in all sites, although this varied to some extent according to socio-economic status. There was found to be no awareness among local people that rats carry disease *in themselves*, except in the two sites (Morrumbala in Mozambique and Lushoto in Tanzania) where plague has occurred recently. However, there *was* found to be a widespread belief that rats are a possible vehicle to carry disease through witchcraft/magic. In Lushoto there have been campaigns to educate people about the transmission of plague; despite this, it was found that most people turn to traditional healers for initial treatment, only going to government clinics in most cases if traditional treatment fails. Most traditional healers interviewed were found to believe that they are capable of treating plague.

In Lushoto, where plague has been officially known to be present since 1980, certain practices among women and children appear to be associated with a higher incidence of plague (and health campaigns have focused on changing some of these), but the significance of these is hypothetical since the epidemiology of plague is still not clearly understood. There is also higher incidence in certain communities in Lushoto, which appear to be closer to forested areas, but again the significance of this remains hypothetical.

In Morrumbala, as in nearby parts of Tanzania, Zimbabwe and Zambia, rats are hunted and eaten. Eating rats is a risk factor for both plague and toxoplasmosis. However, rats are an important source of protein and liked as a food; they are often sold in local markets, providing a source of income; and their hunting is an important part of initiation into manhood. The hunting and eating of rats in plague-prone areas should be seen as an important challenge.

Water-related behaviour, both in relation to drinking water and in relation to physical contact with water through washing and children's play, was found to be such that the likelihood of transmission of diseases from rats to humans like leptospirosis is very likely. Cats, which can carry toxoplasmosis although they can also control rats, were found to be widely present; many of these were found to be feral or semi-feral.

In relation to the future, Dr. Janowski suggested that two points were particularly important: that local beliefs and practices need to be understood before interventions are designed; and that public awareness of rat-borne diseases should be increased.

Finally, Dr. Janowski gave details of a radio series, Rats!, which was made by the BBC World Service in collaboration with the RATZOOMAN project, and which has been broadcast twice since it was made in March 2005. Links to these programmes can be found through the ratzooman website.

The ratzooman GIS

Ricardo Thompson, National Institute of Health, Mozambique

Dr Thompson outlined the organisation of the geographic information system developed for the ratzooman project. This is comprised of two linked entities, a database developed using Microsoft Access and an image mapping interface developed with specialist ArcView software. The database contains all project collected data including data on rodents captured, socio-economic surveys, weather data, serological results for the different diseases and tests performed on rodent, human and other animals tested in all the different localities used as survey sites in the countries of Tanzania, Mozambique, South Africa and Zimbabwe. The data is georeferenced to the point of collection and this allows the data to be plotted on satellite images and queried for correlations among different factors, for example to see if there are links between disease prevalence and rodent species or whether disease cases are clustered around geographical features such as rivers or linked to socio-economic parameters such as education level. The analysis of links between data sets will require research beyond the life of the ratzooman project to understand the complex interactions that may be occurring.

The GIS was also used to investigate land use change in the target countries over time by remotely sensing and categorising land use types and comparing historical satellite images to compare changes in urbanisation, deforestation or agricultural intensification.

Figure showing how data are structured with the ratzooman information system

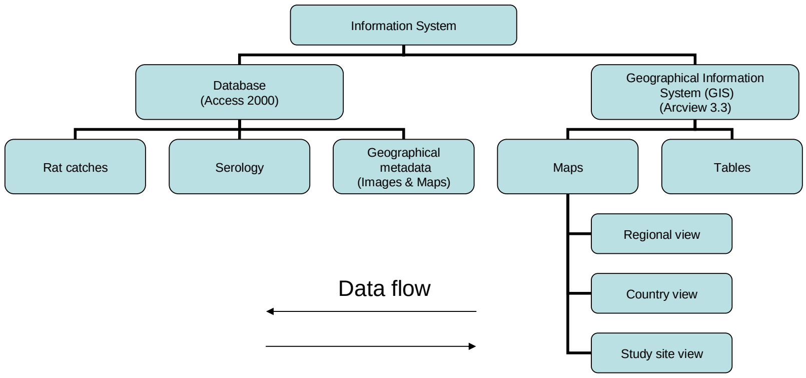


Figure showing relationships among the data sets collected in the ratzooman database

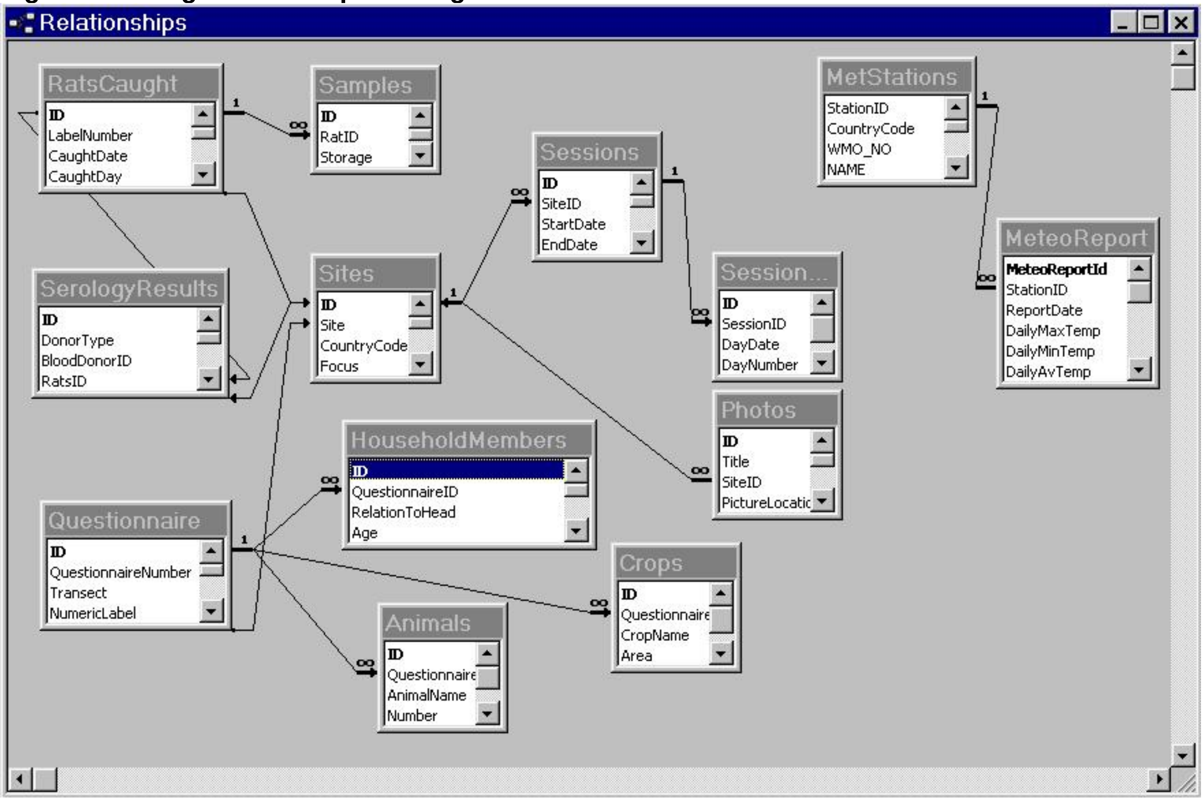


Figure showing the proportion of rodent species caught at the different survey locations

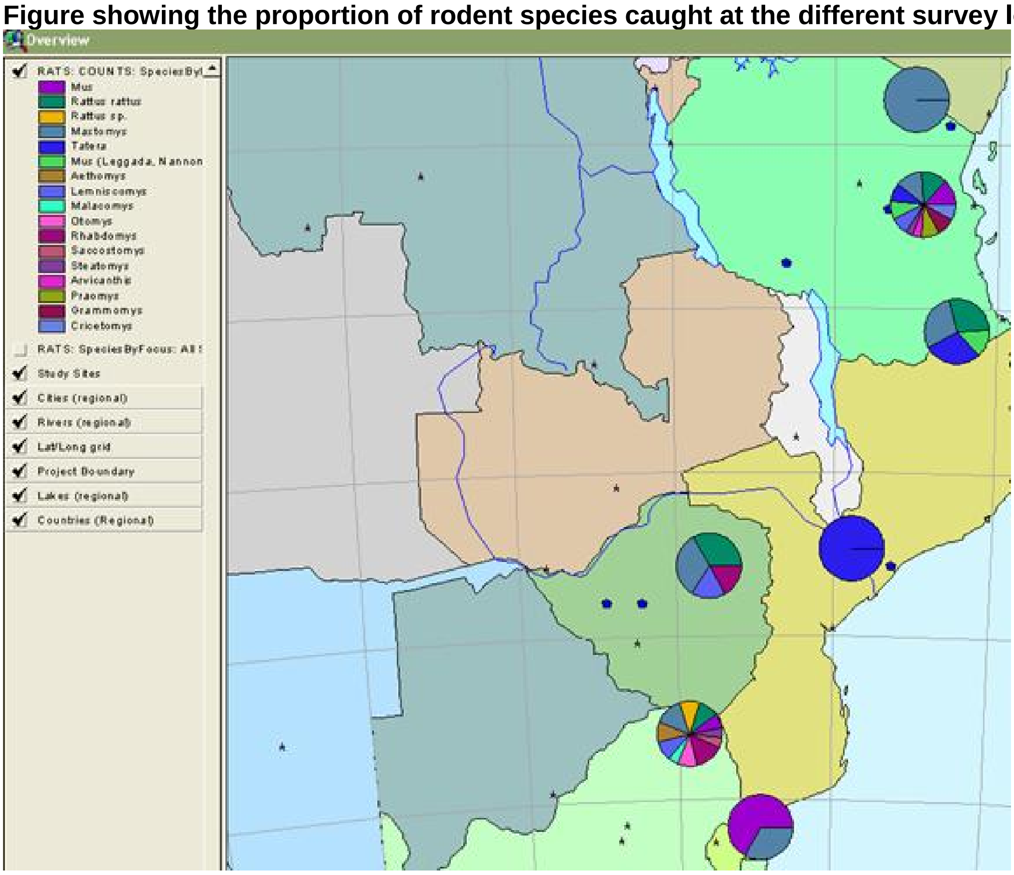
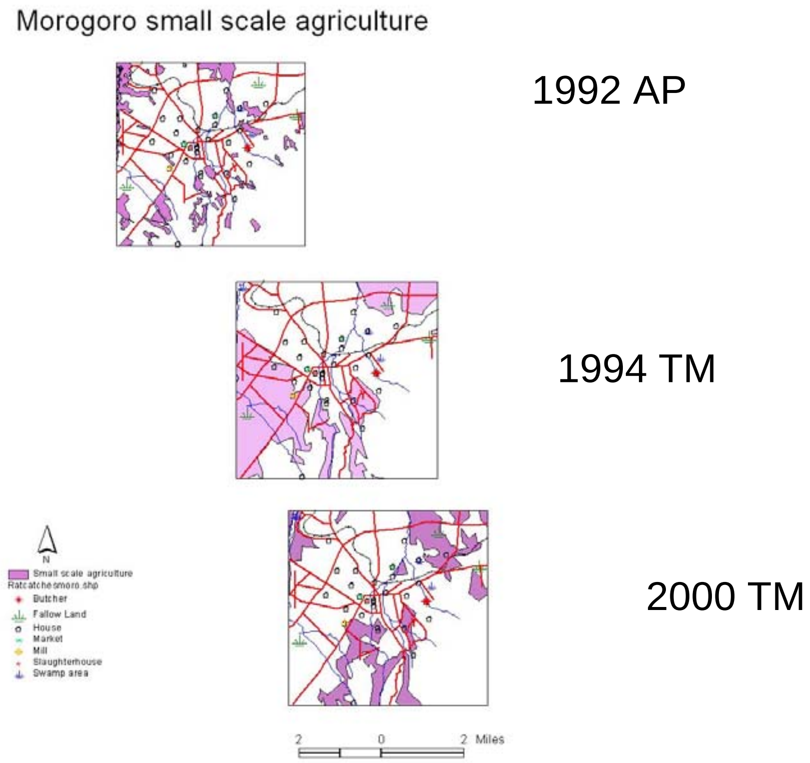


Figure showing how agricultural land has changed in Morogoro, Tanzania.



Surveying for rodent disease in a squatter camp, Cato Crest, Durban

Peter Taylor, Durban Natural Science Museum, Republic of South Africa

"RatZooMan" (Rodent Zoonosis Management: www.nri.org/ratzooman/) is an international project concerning zoonoses in four African countries; this study reports data from one site, Durban, a major harbour on the east coast of South Africa.

Blood and tissue samples of approximately 250 rodents of four species (*Rattus norvegicus*, *Rattus tanezumi*, *Mus domesticus*, *Mastomys natalensis*), from the greater Durban region were tested for antibodies or DNA for plague, leptospirosis and toxoplasmosis. Samples came predominantly from the harbour and commercial districts of Durban and the Cato Crest informal shack settlement. To determine environmental and socioeconomic disease risk factors in Cato Crest, rodent trapping was accompanied by parallel studies of soil PH and socioeconomic factors.

No rodents were positive for plague, but five Norway rats, *R. norvegicus* (2.5% of sample tested) were positive for toxoplasmosis, and 19 (10.3% of sample tested) were positive for leptospirosis. Infections were concentrated in two major foci: a localised area of Cato Crest (leptospirosis and toxoplasmosis prevalence was 39% and 8% respectively) and the CBD of Durban (38% and 12.5% respectively). The leptospirosis hotspot in Cato Crest was a "tuck shop" (food outlet) in a valley where the soil was constantly damp, and litter abounded, thus ensuring ideal conditions for the proliferation of rats and the spread of leptospirosis.

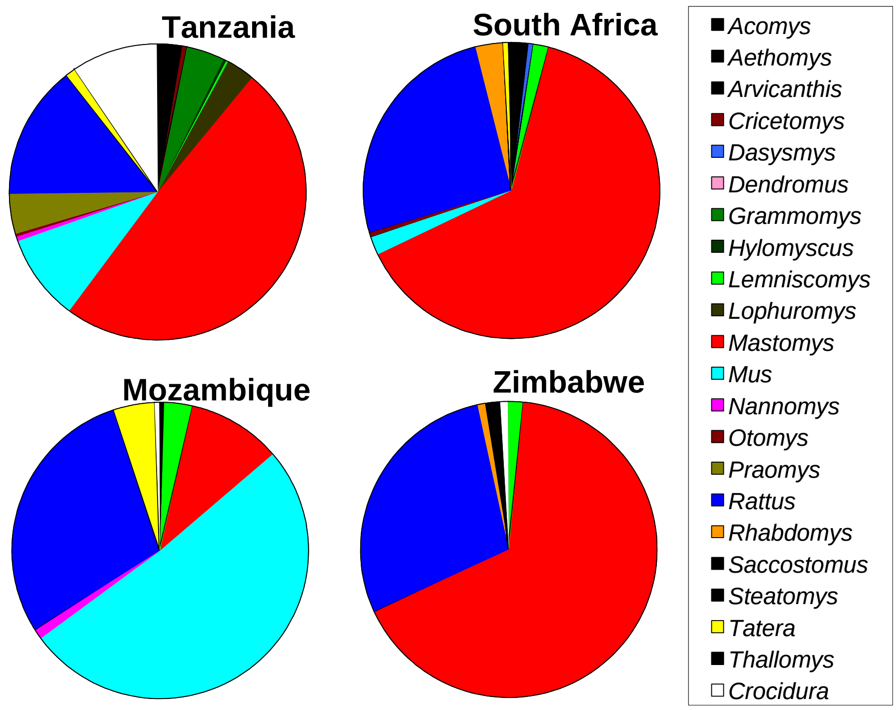
The results guided precise and effective action by vector control staff (e.g. multi-feed rodenticide baiting) to prevent serious disease outbreaks. Recent serology tests of humans living in Cato Crest (n = 219) showed 0% exposure to plague, 23% to leptospirosis and 35% to toxoplasmosis. Compared to shack-dwellers, residents of brick houses showed slightly lower exposure to both diseases (12% for leptospirosis and 23% for toxoplasmosis).

Rodent ecology across rural, peri-urban and urban habitats

Herwig Leirs, University of Antwerp, Belgium & Danish Pest Infestation Laboratory, Denmark

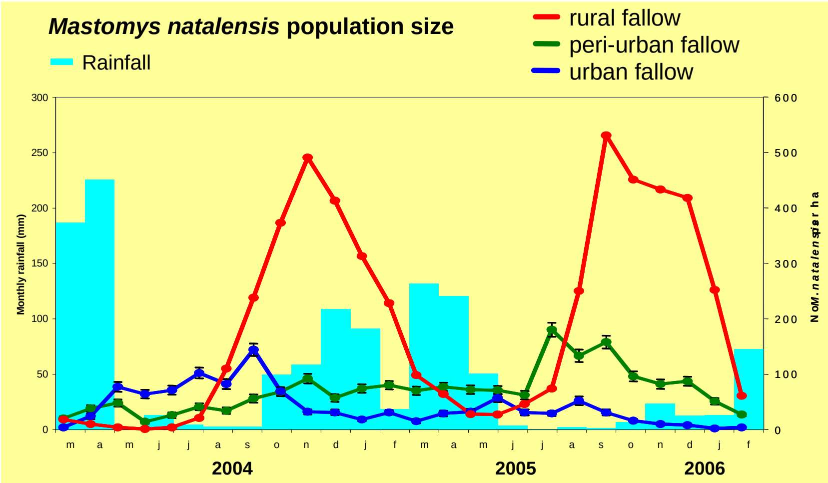
One of the basic activities in the Ratzooman project was to describe which rodent species occur in and around developing cities in south-eastern Africa, and how their abundance changes with spatially (habitat) and temporally (season). For this work, a number of study foci were selected throughout the region (see the map to the right). In these sites, rodents were collected at various intervals following protocols that included a variety of trapping techniques, a number of different habitats where traps were placed and standard processing of the collected rodents, taking blood and tissue samples for detection of infection status, recording information about the reproductive condition of the animals and preservation of tissues and specimens for later taxonomic studies. All the information was stored in standardised data files in order to facilitate later data analysis.

In total, the project had collected at the time of the workshop almost 6000 specimens from the four involved countries (Tanzania:4326 specimens, at least 19 species; South Africa: 832 specimens, at least 12 species; Mozambique: 450 specimens, at least 10 species; Zimbabwe: 125 capture data, at least 7 species) and work still proceeding. The species composition differed considerably between the different countries (see figure below) but this was also due to the fact that the sampled habitats were not identical in the different study sites. Also within a country there was a considerable difference in species composition depending on the locality and the scale of observation. Clearly, and as expected, there were even differences within a locality, depending on the habitat in which traps were placed. For example, in Morogoro, Tanzania, *Mastomys natalensis* was the most common species in crop fields, fallow land or swampy areas in and around the urban area, while in houses and other buildings, this species was still present, but its dominant position was taken over by black rats, house mice and shrews.

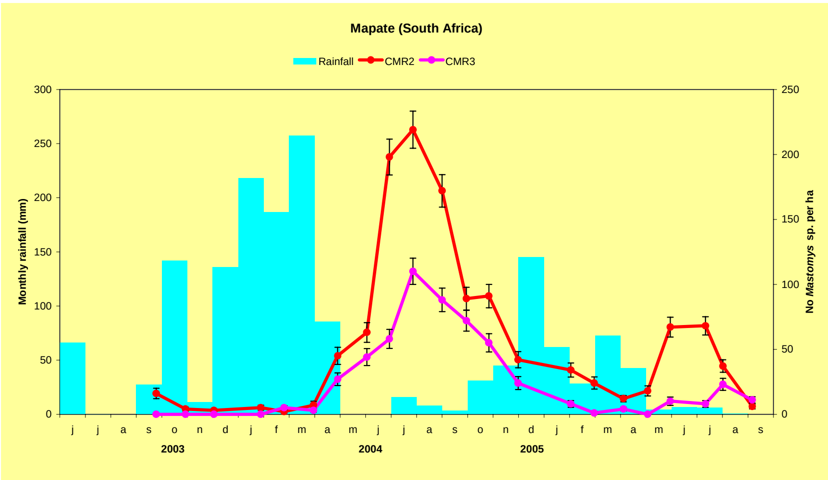


Urban rodent populations can come in contact with rodents and their pathogens from rural areas at the city periphery, but also at sites where rural rodents, or their pathogens, may be introduced in the city, such like markets, grain stores and mills or slaughterhouses and butchers. We estimated the distance that rodents move around such sites by placing baits marked with Rhodamin B. Five days later, rodents were trapped at different distances from the site. Around 200m from the site, there were no more marked rodents, which suggests a minimum distance for perimeter rodent control around such sites.

The population dynamics of the most common species was investigated in a capture-recapture study at replicated crop/fallow fields at a focal urban site in each country. The ecology of *Mastomys natalensis* in rural fallow land is relatively well known, so we also used data from such an area in Morogoro, Tanzania, for comparison. As shown in the figure at right, *M. natalensis* has a strict breeding season and considerable seasonal fluctuations in abundance. In the urban areas, breeding is equally seasonal, but the resulting population dynamics show a much flatter and less regular abundance curve.



In NE South Africa, the same species also shows clear seasonal fluctuations in numbers, but there is some degree of reproduction throughout the year. Moreover, where the abundance peak is reached the early wet season in Tanzania, it comes already in the middle of the dry season in South Africa. Similar differences in breeding seasons among localities and habitats within localities could also be seen from the reproductive information in the removal trapping data.



In conclusion, despite many similarities, urban areas in southeastern Africa present differences in rodent fauna composition, but also in the ecology of a same species. Such differences must be taken into account when studying the ecology of diseases transmitted by these rodents, or when designing rodent management strategies for the control of these diseases.

Rodents and human disease in Mozambique

Rassul Nala, National Institute of Health, Mozambique

Plague first occurred in Mozambique in the year 1898, but this was not documented for another 60 years when it was noted that Mutarara District in Tete Province and Morrumbala District in Zambezia Province were prone to seasonal outbreaks of plague. These are rural areas on opposing sides of the Zambezi River. Serological surveys have not been common, and one preliminary study was carried out in the year 2000 showing that 2% of blood samples taken in Morrumbala were positive for plague.

Figure Number of confirmed cases and deaths from plague in Mozambique

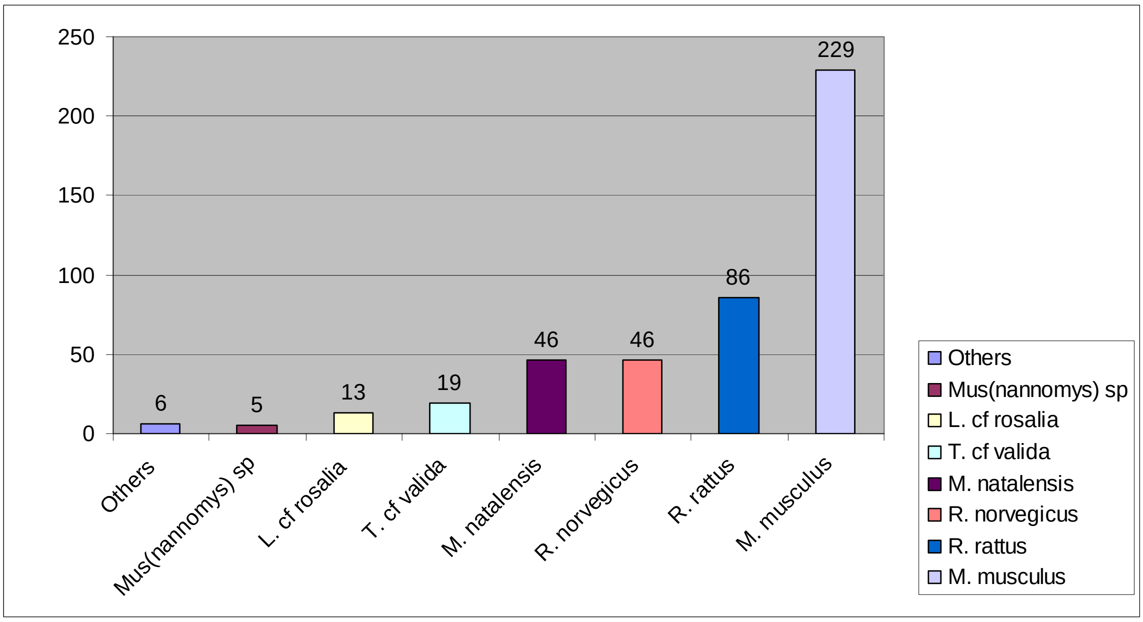
Year	Cases	Deaths
1976	15	6
1977	97	14
1978	12	0
1989	6	0
1992	121	0
1993	47	0
1994	259	3
1997	825	18
1998	282	0

Leptospirosis was surveyed in one small study during 1994 among febrile patients in a community hospital in Maputo that showed a prevalence of 10% among those reporting clinical symptoms of fever. A 2003 survey for toxoplasmosis among HIV patients showed that 72% had been previously exposed to toxoplasmosis and were, therefore, at risk of cerebro-reactivation.

Prior to the ratzooman project, the ecology of rodent vectors and zoonosis have not been studied in Mozambique and remain poorly understood. Management has been related to outbreak management of plague in focal areas. It should be noted that people eat rodents in the plague endemic areas of Mozambique, and this is certainly increasing the individual risk of contracting plague, but it is still not understood how important this is in causing plague outbreaks.

Three sites were chosen for the collection of data, Morrumbala, Mutarara and a peri-urban/rural area of Maputo. Pooled results for the rodents species caught are indicated in the below graph.

Figure showing rodent species caught in Mozambique during the ratzooman project



The analysis of tissue and blood samples taken from rodents indicated that leptospirosis and toxoplasmosis are common diseases in rodents.

RODENT SAMPLES (N=97)

Plague –	0%
Leptospirosis –	20.6%
Toxoplasmosis –	21.3%

PCR results for Leptospira (n=197)

Positive	3.6%
Doubtful	3.6%

In the analysis of human sera for the presence of the three diseases, it can be seen that all three diseases were present in clinically healthy people as indicated in the below table.

Diseases	**Morrumbala**		**Mutarara**	
	Cases	**%**	**Cases**	**%**
Plague	4	1.1	9	2.3
Leptospirosis	288	77.2	255	64.2
Toxoplasmosis	191	51.2	154	38.8

Febrile individuals that gave blood during the ratzooman survey also showed significant positive results to the three diseases. The age group of blood donors did not appear to influence disease prevalence.

FEBRILE POSITIVE CASES (N= 54)
Plague: 3.7% (2)
Leptospirosis: 22.2% (12)
Toxoplasmosis: 14.8% (8)

Despite the low numbers plague remains endemic in the foci of Morrumbala and Mutarara. Human behaviour related to disease transmission needs to be better understood, including in relation to rat eating. This also occurs in neighbouring countries where plague is endemic (Malawi, Zimbabwe and Tanzania). Leptospirosis and toxoplasmosis are infections that remain grossly undetected in Mozambique and may explain a significant portion of clinical cases reporting Fevers of Unknown Origin. The ratzooman project has highlighted the importance of rodent-borne diseases in Mozambique and the need for further research to define appropriate preventive and control measures.

Rodents and human disease in Zimbabwe

Godfrey Chikwenhere, Plant Protection Research Institute, Zimbabwe

There are more than 30 different species of rodent documented in Zimbabwe, and the major pest species are considered to be *Rattus rattus*, *Mastomys natalensis*, *Tatera* app. *Mus musculus* and *Cricetomys gambianus*. Zimbabwe is also prone to outbreaks in rodent populations in rural agricultural areas, and a number of these have occurred and been documented, with about one large outbreak each decade during the 1900’s.

The earliest recorded case of plague was in 1972 and the last outbreak was in 1994 when there were 37 confirmed cases and 11 deaths. There is no active surveillance programme for plague in Zimbabwe, and cases have tended to be confined to rural areas in Matabeleland North Province. Leptospirosis is poorly documented but has been confirmed to occur among cattle farmers in the Harare area through surveys carried out in the mid-1980’s. Surveys of toxoplasmosis are unknown in Zimbabwe.

The ratzooman project carried out research in three different localities in Zimbabwe which involved collecting rodent samples from different habitats in rural and peri-urban settlements, including informal settlements. In addition, dog sera was collected and human sera was obtained from blood banks in each locality. The results of the serological analysis are presented in the below table.

Study area	Animal	Disease presence in blood sera		
		Plague	Leptospirosis	Toxoplasmosis
Mbare	Rodent n=96	0	31	1
	Dog n=18	0	15	0
	Human n=55	0	16	5
Hatcliffe	Rodent n=96	0	35	0
	Dog n=15	0	13	0
	Human n=55	0	11	3
Nkayi	Rodent n=56	0	22	0
	Dog n=17	0	16	0
	Human n=49	0	13	2

The results indicate that leptospirosis and toxoplasmosis are likely to be widespread diseases in Zimbabwe. Further surveys would be required to establish accurate prevalence rates as sample sizes within the ratzooman study were relatively small.

Rodent and human disease in Tanzania

Robert Machang'u, Sokoine University of Agriculture, Tanzania

Rodents are, next to humans, the most populous animals on the globe. The economic importance of rodents are reflected especially in the dangers the pose to public health. The commensal nature of rats, mice and shrews have made them "excellent" vectors of zoonotic diseases, passively or actively. Within the Ratzooman Project (2003-2006) studies were carried out in different parts of urban/periurban Tanzania, to determine the role of rodents and shrews in the transmission of three important zoonoses, namely plague, leptospirosis and toxoplasmosis. In addition, attempts were made to isolate and characterize leptospiral agents from rodents and humans.

Plague

Plague has been described sporadically in different parts of Tanzania, but in the last two decades an endemic foci in the north eastern Tanzania's district of Lushoto has been reported with a striking seasonality. In the course of the Ratzooman Project a total of 908 rodent species belonging 19 described species were captured from Lushoto and tissues and blood samples of these animals were sent to Institute Pasteur, Paris, for the screening of the plague agent Yersinia pestis. Flea ectoparasites from these rats were also collected for screening, to complement the epidemiology of plague in the affected area.

Leptospirosis

Little information is available on the prevalence of leptospirosis in Tanzania. For the studies on leptospirosis sera of humans (n=400) and obtained from referral hospitals across Tanzania and rodent and shrew sera (n=500) from Morogoro (East Coast) and Masasi (Southern) were screened for antibodies to Leptospira spp. An overall seropositivity of 17.5% was recorded with the human sera. Percentages varied with the prevalent leptospira serogroups, from 0.5% (Ballum) to 10.43% (Icterohaemorrhagiae). In rodents and shrews a seropositivity of 10% with serogroups Icterohaemorrhagiae and Canicola showing the prevalences of 5% and 2.8%, respectively. The rodents studied belonged to at least 15 described species. Isolation and characterization of the Leptospira isolates from the rodent kidney tissues have given rise to 35 isolates, of which 16 were from shrews (n=346, i.e. 4.62% isolation). The remaining 11 isolates were from Mastomys natalensis (n=1582 i.e. 8% positive) and Cricetomys gambianus (n=237 i.e. 1.6% positive) respectively. No isolates were obtained from human urine and blood cultures until the time of this report: a total of 112 cultures were still under study. Preliminary characterization of the isolates has revealed the following leptospira serogroups (serovars and numbers in brackets): Ballum (Kenya, 11), Icterohaemorrhagiae (Sokoine, 5), Australis (Lora, 4) and Canicola (Schueffneri, 1). Serovar Sokoine is a newly described serovar. The remaining 16 isolates are yet to be characterized.

Toxoplasmosis
There is even much less known on Toxoplasmosis in Tanzania. Studies of Toxoplasmosis, within the Ratzooman Project, were limited to serology of humans and rats obtained from the Southern district of Masasi, where rat meat is commonly relished. Human and rodent samples (n=120 and 110 respectively) were screened for antibodies to Toxoplasma spp. A seropositivity of 19.2% was recorded with humans, however, for the case of rodents the results were inconclusive due to incompatibility of the serological test kit.

The results of this study stresses the importance of rodents in the transmission of a re-emerging disease (plague) and of two neglected diseases (leptospirosis and toxoplasmosis) in the urban/periurban environment. This was the theme of the Ratzooman Project and hence the studies were time limited. These findings therefore, justify further research and also on other zoonoses of public health importance in Tanzania, such as typhus, tularaemia and diverse haemorrhagic fevers.

Rodents and human disease in South Africa

Lorraine Arntzen, National Institute of Communicable Diseases, Republic of South Africa

The RATZOOMAN project looked at three zoonotic diseases, eg: plague, toxoplasmosis and leptospirosis in humans, rodents and small mammals. Three different geographical sites where used. These were Mapate in the Limpopo province, Durban in KwaZulu Natal and Port Elizabeth in Eastern Cape. The last recorded human plague outbreak was in Port Elizabeth in 1982. Active plague surveillance stopped a number of years ago in South Africa and the RATZOOMAN project helped to revive the plague surveillance program. No positive plague samples were found from any of the sites tested.

Plague serology results: Positive / total tested	**Human:**	**Rodent:**	**Dogs:**
Durban	0/217	0/223	
Mapate		0/202	0/34
Port Elizabeth		0/1200	

Toxoplasma gondii is a widespread parasite which chronically infects ± 25% of the worlds population and is an important opportunistic pathogen in patients infected with HIV. Recent reports revealed that up to 60% of AIDS patients are diagnosed with clinically active toxoplasmosis (Maiga *et al* 2001). No data were found that demonstrated a link between animals and humans in South Africa. From the RATZOOMAN reports it was stated that cats were present in Mapate mostly as strays, but in Durban they are mostly kept as communal pets by the community. People interact with these cats in both these sites.

Toxoplasmosis serology results: Positive / total tested	**Human:**	**Rodent:**	**Dogs:**
Durban	76/217	9/223	
Mapate		37/202	18/34
Port Elizabeth		182/1200	

No previous data could be found on the incidence of *Leptospirosis* in rodents linked to human infection in South Africa. The main source of infection is contaminated water, food or soil. Leptospires can survive for long periods of time in soil and water if the conditions are right. In Durban, clean water is piped free to communal taps. A few of the more formal houses have piped water in the house. Rivers and streams are not generally used for drinking water, but these water sources are used for washing of clothes. Rivers and pools of water are used by children for playing in. Formal piped sewerage does not exits in Cato Crest in Durban. Sewerage and run off water from taps causes informal drainage streams and damp soil to develop in these areas. These conditions are ideal for the survival of *Leptospirosis.*

Leptospirosis serology results: Positive / total tested	**Human:**	**Rodent:**	**Dogs:**
Durban	43/217	22/223	
Mapate		37/202	33/34
Port Elizabeth		272/1200	

Plague is not a problem at present, but ongoing surveillance is needed and the RATZOOMAN project helped to revive this program in South Africa. With Toxoplasmosis, there was a high prevalence in the human sera tested in the Cato Crest area of Durban with a surprisingly lower prevalence in the rodents from the same area. Unfortunately we were unable to test human sera from all three study sites and do a comparative study. Dog sera tested from the Mapate area had a very high prevalence. Leptospirosis screening showed a high prevalence in the human sera tested, but much lower prevalence with the MAT serology tests. The prevalence in rodents from the three areas varied between 9% to 22.7%, again the prevalence in dogs was very high. The test that was used is evaluated for human use and was backed up with the MAT test and PCR where possible. This study has highlighted a problem with both Toxoplasmosis and Leptospirosis. Further in-depth studies are needed.

Session IV: How can we reduce the rodent disease burden?

Rodent control strategies in a changing city: making rodent disease surveillance succeed with communities and government

Guy Redman, Durban Natural Science Museum & Mel Hayter, Republic of South Africa

Making rodent disease surveillance succeed with communities and government

The publication of the Natural Sciences Museum's Ratzooman research findings on the extent of the health problem caused by rats, particularly in Cato Crest, raised some serious challenges for the Cato Manor ABM (Area Based Management) and the eThekwini Municipality. Some of the identified causes for the prevalence and increase in the number of rats in the area were the amount of litter, rubbish dumps and broken/leaking pipes in the area. Following the official publication of the ratzooman project results, the Cato Manor ABM set in motion a series of meetings involving key stakeholders. These meetings also involved a site visit by the stakeholder team to assess the extent of the problem. It was, therefore, decided at these meetings that a clean-up campaign should be held on the 3rd June 2006. The clean-up campaign was supported by an intense awareness and education drive two weeks prior to the clean-up.

The project has taken a multi-agency partnership approach to dealing with the clean-up of Cato Manor. Various municipal departments are playing a role in the planning and implementation of this campaign. The following departments are currently contributing to this partnership: Durban Solid Waste (DSW), Storm Water Maintenance, Environmental Health Services, Vector Control, Natural Sciences Museum and Water Services. Further to this, the Cato Manor ABM has forged a partnership with a local radio station, iGagasi 99.5, which will be assisting in mobilizing the community to participate in the beautification of the community. The radio station will be hosting a live talk show feature on Cato Crest on Monday 16th May between 18h00 to 19h00 to be attended by the Director of the Durban Natural Science Museum, Guy Redman, and the Mayor of eThekwini, Cllr. Obed Mlaba. The station will also be hosting a live broadcast from Cato Crest on the day of the clean-up campaign on Saturday 3rd June 2006. This programme will be rolled out throughout Cato Manor, but our initial focus is Cato Crest where the Ratzooman study was undertaken initially.

Rodent control strategies in a changing city

The presentation covered the aspects of a modern city such as Durban being subjected to an influx of a rural population attracted to the city for the chance of a new life offering, housing, schooling, work and medical benefits. The emerging informal settlements, street trading and resultant litter were shown to have a major influence on the city's rodent population and how vector control strategies must work under these circumstances. Durban has the added danger of having an International Sea Port with the ever present danger of the importation of a rodent-vectored disease. The rodent strategies adopted by the Vector Control section were described showing how field operations work to meet these new challenges. Rodent control in Durban has been helped through the awareness generated by the ratzooman project and through the involvement of the Vector Control section in the project activities. Although the project has showed there are no plague positive results in the city, the confirmation that rodents were capable of spreading other diseases through the positive leptospirosis and toxoplasmosis results indicated the necessity of increasing the city's efforts to manage its rodent pest problems. The ratzooman project has help ensure the Vector Control section continued budgetary support from the local council.

Predicting disease through mathematical models

John Holt, Natural Resources Institute, UK & Stephen Davis, University of Antwerp, Belgium

A model of Leptospirosis infection in an African rodent

We developed a mathematical model of leptospirosis infection in the rodent, *Mastomys natalensis*, the species thought to be the principal source of human infection in parts of Tanzania. The purpose of the model was to challenge conventional thinking and assumptions about the epidemiology of leptospirosis epidemiology in wildlife hosts. Because leptospirosis risk to humans is related to levels of infection in rodents, the model can be used to interpret human disease patterns. Different parameters in the model are affected by different disease management interventions, e.g. rodent mortality is affected by trapping, and the model can be used to investigate the potential impact of management alternatives. Two specific questions were considered: What is the seasonal cycle in Leptospirosis risk to humans? How can we manage rodents to reduce Leptospirosis in humans?

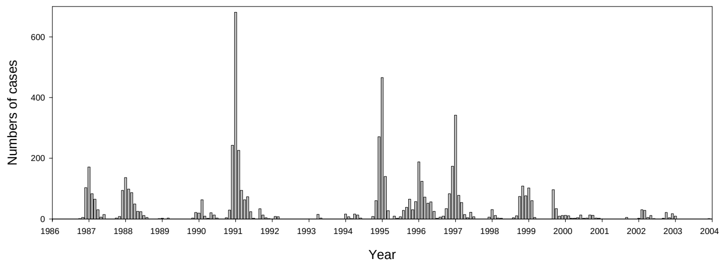
Our model comprises a system of linked differential equations and is complicated by the existence of three leptospirosis transmission routes, sexual, mother to offspring and indirect from leptospires shed into the environment by infected hosts. Seasonal rainfall patterns cause an annual cycle in both rodent and leptospire abundances. Predicting the outcome of the interactions of the epidemiological and seasonal processes, our model, representing the climatic conditions in central Tanzania, suggests a strong seasonality in the force of infection on humans with a peak in the abundance of infectious mice between January and April in agricultural environments. In urban areas the dynamics are predicted to be more stable and the period of high numbers of infectious animals runs from February to July.

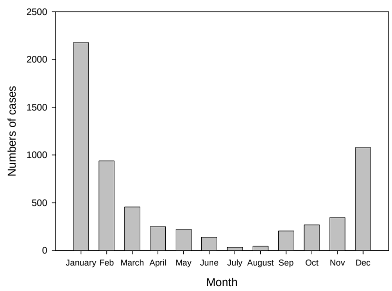
By looking at the sensitivity of model predictions to parameter changes, two potential approaches to rodent control were compared: trapping/baiting and reducing habitat suitability. The most sensitive model parameter was the survival of adults and sub-adults, s_1. This parameter had a large impact on the three key variables: leptospire abundance, rodent number and leptospire prevalence in the rodents. An alternative to rodent control is to reduce the suitability of the habitat to rodents by reducing their access to potential nesting sites and food supplies. The parameter c controls the density dependent maturation of sub-adults thereby limiting rodent population size. Changes to the parameter c can be regarded as representing a change in rodent habitat suitability such that the same area can support fewer rodents. An increase in c did reduce variables associated with leptospirosis risk but the sensitivity was somewhat less than that for s_1; in particular the effect on prevalence was much less. Our results indicate that removal of animals by trapping rather than reducing the suitability of the environment for rodents will have the greater impact on reducing human cases of leptospirosis.

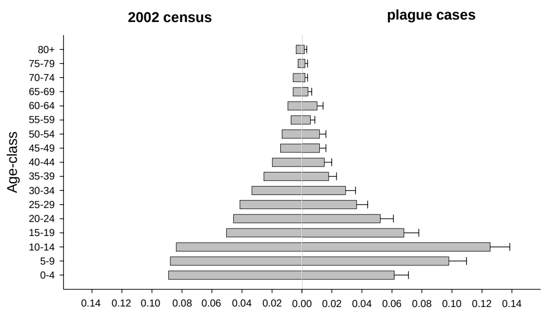
Demographic and spatio-temporal variation in human plague in the Western Usambara Mountains, Tanzania

Human plague in the Western Usambara mountains in Tanzania has been a public health problem since the first outbreak in 1980. The wildlife reservoir is unknown and eradication measures that have proved effective elsewhere in Tanzania appear to fail in this region. We use census data from 2002 and hospital records kept since 1986 to describe the temporal, spatial and demographic variation in human plague. A seasonal peak in cases occurs from December to February with the numbers of cases during this peak varying between 0 and 1150. Variation in incidence, calculated for each village as the mean number of cases per thousand inhabitants per year, indicates that human plague is concentrated around a group of three neighbouring, relatively isolated, high-altitude villages; Nywelo, Madala and Gologolo. However, there was no evidence that these villages were acting as a source of infection for the remainder of the focus. The likelihood of becoming infected with plague is highest between the ages of 5 and 19 and lowest for adult men. This was most clear in the ward encompassing the three high-incidence villages where the risk of plague among children aged 10-14 was 2.2 times higher than for adults aged 30-34, and among adults aged 30-34, risk was 2.4 times higher for women than men.

There are four types of variability in the data; spatial, seasonal, interannual and demographic.







The practicalities of rodent control in managing disease

Adrian Meyer, Natural Resources Institute, UK

Adrian Meyer identified five practical issues that need to be addressed if effective control of rodent populations is to be achieved when managing disease.

Firstly, the dynamics of the disease itself must be understood. This will enable effective targeting of both the vectors, the transmission routes and the environments within which the disease is an issue.

Secondly, a thorough knowledge of the ecology and behaviour of the rodent species involved is essential. Otherwise, it will not be possible to target the control strategy sufficiently effectively to obtain the levels of mortality that will be required to reduce the incidence of the disease. In addition, effective environmental management will depend upon an understanding of the way in which the rodent species involved exploits the environment in which it lives.

Effective rodent control will always depend upon obtaining the cooperation of the people who live in the areas where control is being undertaken. Good communication with these populations and an understanding of their perceptions of the issues, is essential if control strategies are to be applied effectively within the environments in which they live.

There are a range of control techniques available to reduce rodent populations, these include the use of toxicants, trapping and environmental management. It is essential that they are combined in an effective integrated rodent management programme and that the results of the programme are adequately monitored. The appointment of managers experienced in the use of the control techniques is essential if effective rodent control is to be achieved.

Very often the most difficult part of any control operation is to obtain sufficient funding over a long enough period of time. In seeking such funding it is imperative to stress not only the issues related to the transmission of disease, but also to attempt to quantify the full cost benefits of any rodent control operation. Rodents not only transmit disease, but also impact the human environment in many other ways. These include damage and contamination to growing and stored food, and structural and system damage. By identifying the full cost benefits of any rodent control programme, the required finances are more likely to be made available.

Policy recommendations for reducing rodent diseases

Jens Lodal, Danish Pest Infestation Laboratory, Denmark

Strategies for managing rodent diseases form the basis for policy recommendations. In this context we are dealing with three different zoonoses. Rodents are involved in all three diseases but for each of the three diseases some important characteristics have to be taken into consideration. These characteristics were briefly outlined.

Data for development of strategies have been collected in other parts of the RATZOOMAN Project. Data on rodent species trapped and data from serological surveys regarding the three diseases together with the reports from social anthropological studies have been most complete for the urban settlement Cato Crest and the two rural areas Mapate and Lushoto and very late in the project period also for the rural area Morrumbala in Mozambique. A report on the socio-economic factors covering all study sites has been available during the latest months of the project.

Strategies have to be based on rodent biology and behaviour and biology of the diseases. The end goal should be reduction of infection rates of plague, leptospirosis and toxoplasmosis. As rodents are involved in transmission of the three diseases, integrated pest management is to be incorporated into the strategies along with other elements such as handling and storage of food and water, hygiene and sanitation. Strategies should be sustainable and very simple and also include other animals than rodents when they are of any importance for a specific disease.

Policy recommendations are defined at three different levels of activities:
1) Individual level: reduce contact with rodents, break transmission routes for diseases;
2) Community level, e.g. village or settlement: education and information, organizing water supply and waste removal, rodent control;
3) Governmental level, i.e. local, regional, provincial or other relevant authority: monitoring, warning, education, training, information and funding.

Examples were given to illustrate details of activities at each level which depend on the diseases occurring.

Chemical control of rodents is not considered a sustainable method but it may turn out to be a valuable element when possible, especially in urban settlements. Control carried out by professional control operators is considered the best solution based on the experience expressed by inhabitants of the project areas. Mechanical control with traps can be carried out by the households themselves. Biological control of rodents may to some degree be possible with cats and dogs.

A very special situation exists in areas such as Morrumbala in Mozambique where rodents are considered good to eat and in fact they are an important source of protein. Plague occurs in the region, and, therefore, it is very risky to handle rodents because when a rodent dies, its fleas will try to jump to the nearest warm-blooded host. Furthermore, handling and cooking of rodent meat are other potential risk factors. In order to avoid close contact between humans and rodents in this region, other sufficient protein sources than rodents have to be provided and made available to the human population.

It was pointed out that monitoring and warning systems are important tools in integrated pest and disease management strategies.

Putting policies into practice

Martha Mpisaunga, Syngenta, Zimbabwe

Dr Mpisaunga summarised the current situation regarding rodent management as fragmented with little interaction between private companies and local authorities involved in implementing rodent management campaigns. Rodent pest control is further fragmented between the health sector (Environmental Health) and agriculture/livestock (Extension Agents) which target communities and individuals in very different ways with responsibility for rodent pest control depending upon whether rodent impacts are perceived to be affecting human health or agricultural production, whereas in fact rodents are simultaneously causing many cross-sectoral problems.

The training given to public and private sectors workers as well as to those within health or agriculture varies considerably in content and quality, and often the appropriate tools for carrying out rodent management in a particular context are not available.

Current government policies on rodent pest management are not well-developed in most African countries, and there is little joined-up thinking that attempts to holistically address the problems which rodent pests cause for people. Rodent control often relies on individual action by homeowners who are not well informed, despite it being well-recognised that rodents pests usually need to be managed on a larger scale than the individual home or farm. Government policies are affected by the fact that rodent pests can be a political problem in squalid urban settlements where the presence of rats are seen as a sign of failure. Governments may not wish to encourage debate and new information about rodent diseases simply because it raises further fodder for political opponents about ongoing rodent pest problems. For these reasons, rodent diseases do not receive much political attention, and this needs to be changed through positive communication and awareness raising initiatives.

Awareness about rodent-vectored diseases is low among many rodent pest control service providers and the general public, and improved rodent management can not succeed without strong education programmes to change this situation. Awareness can be better in situations where there are chronic disease problems such as the focal plague areas in Madagascar and Tanzania. Advanced national strategies do exist in Madagascar and Tanzania for surveillance and outbreak response on plague because it is considered a long term problem there. However, other African countries threatened by plague have not developed appropriate infrastructures for surveillance and communication management, and this could lead to panic and inappropriate responses in the event that plague re-emerges in long-dormant areas.

Policies can be changed through well-informed and balanced journalism, and not sensationalism that focuses on the negative. This creates a situation where government can see reasons for intervening. However, sensationalism dominates health policy decision making, and this sometimes may be useful to get politicians involved in changing policies. Policies must ultimately be based on more data on neglected diseases, fevers of unknown origin and causes of human mortality. We must have a better idea of the impact of rodent diseases on people's livelihoods. Communicating information about rodent diseases will increase awareness among decision makers and the general public.

Why do policies change? Many factors can drive change including public demand, international pressure, increased awareness, changing standards and expectations, and ultimately depend on the financial and intellectual capacity to change policies. Rodent disease problems are, of course, competing for attention against other issues which are often perceived to be of greater importance. It is, therefore, our duty as scientists and communicators to put rodent diseases in the appropriate perspective to encourage changes in policies.

Outbreak Groups

Disciplinary group reports

1. How should we improve surveillance and monitoring of diseases and diagnostic capacities within African countries?

This discussion group was formed of workshop participants who had experience of carrying out research and the technical delivery of research programmes. The group indicated that the main way to improve surveillance and monitoring was to raise awareness about the existence of particular diseases and their association with rodents. Different groups of people need to be targeted, particularly health workers such as doctors and nurses. Training should be given to health workers during their formal training as part of their curriculum. This necessarily implies that governments need to revise their national curriculum to include rodent-borne diseases as part of health staff training and degree programmes. Awareness training should also target schools, ensuring that teacher training is revised so that school children learn about particular diseases.

Dialogue with communities potentially affected by rodent-borne disease must increase, encouraging their participation in disease surveillance programmes. It was stressed that the right timing is important when engaging with communities so that it fits in with their time constraints and to ensure that surveillance is not adversely used in political fora.

Standardisation and centralisation of data for surveillance must be established to make it comparable and simple to carry out. Research on easy diagnostic tests (i.e. dipsticks) must continue, as well as improving the provision of medical treatment so that sick people come forward for treatment, knowing that there is a cure for their ailment.

Staff should consider using questionnaires to high risk groups (those exposed to rodents, pregnant, HIV) as a means of rapid surveillance, and government should establish rodent monitoring programmes for the early detection of disease. Predicting disease problems through modelling needs more time and data collection, and ultimately research programmes such as ratzooman must be extended to in order to deliver cost-beneficial prediction systems.

2. How can we influence national and international research priorities and funding opportunities to improve knowledge about rodent transmitted diseases?

This discussion group was formed of workshop participants who had experience of managing research programmes and senior scientific staff involved in developing research. The group indicated that greater effort must be spent on carrying out impact assessments, collecting data on deaths and morbidity, effects of rodent-borne diseases on people's livelihoods, their impact on national economies and social impacts. These can be ballpark estimates which are refined over time and could be developed through three to four case studies. These case studies should capture a multidisciplinary approach, including several government sectors (e.g. health, agriculture, local government). Action research is important in this process as it translates basic research into practical application. There should be an emphasis on regional collaboration in this process of measuring the impact of rodent-borne diseases.

Funding for research was broken down into two streams: bilateral funding which is focussed on national priorities, and multilateral funding where the priorities are set by donors. At the national level, it is important to engage with policy makers and politicians in order to raise their awareness of the issues and thereby influence funding priorities. Awareness raising through the development of international communiqués (e.g. from ratzooman) can be useful for policy particularly when countries have no impact data. This sort of work needs a "Champion" spokesperson who has a high profile and the development of flagship cases where evidence can be collected and used as reference.

3. How do we get Departments of Agriculture, Health and Environment working together to develop national rodent management strategies?

This discussion group was formed of workshop participants who were involved in rodent pest management, from both the public and private sector. Discussion focussed on the relative importance of different government sectors to determine the mandate of different departments over coordination, financing, research, legislation and surveillance. Agriculture and forestry departments should be looking at the impact of rodents within pre and post harvest agriculture, livestock (including feed, produce and contamination), rodent damage to structures, and implication of rodents to causing animal and human disease. The health department should focus on policy, awareness and implementation of structures to improve rodent disease diagnosis, treatment and management. Human health and environmental management should be their main remit. Environment departments have less involvement in rodent disease issues, and are mainly responsible for issues of biodiversity. Within this, there is perhaps some call for monitoring sylvatic rodents for zoonosis particularly in cases where land use change (deforestation, agricultural expansion) may be changing rodent biodiversity and disrupting small mammal interactions.

The group proposed that the best way of integrating cross sectoral issues related to rodent diseases is through the establishment of national permanent rodent management committees. These groups should be backed up by legal frameworks to ensure financial support and a long-term sustainable structure for operation. The committee should be chaired by the health department and include members from the departments of agriculture, forestry, health and environment including people responsible for pesticide registration, livestock specialists, vets, medical doctors, crop protection, rodent specialists as well as industry representatives, farmer organisations and non-governmental organisations with relevant expertise. This committee should have a coordination role over research priorities, prediction/forecasting issues, training, cross border issues, and policy formulation.

4. How can we improve clinical treatment, prevention and interventions against rodent-borne diseases?

This discussion group was comprised of workshop participants who were Vets and MDs. The group indicated that improving education and awareness at the community level and among health personnel were the crucial first steps to improve clinical management of rodent-borne diseases. Clinical staff should be receiving refresher courses for specific diseases and areas, and that structures and budgets were needed within the health sector to ensure this happens. Rodent diseases need to be integrated into the existing clinical guidelines for similar diseases (based on symptoms). Some diseases such as leptospirosis still face knowledge gaps with regards to their clinical presentation and this suggests that syndromic management guidelines should be drawn up for particular clinical presentations.

Rapid tests should be adopted for rodent disease diagnosis where available, giving appropriate training on the tests. These diagnostics need to be backed up by national or regional reference labs for confirmation using more complicated diagnostic tests. Networking and standardisation of tests through local evaluation must be carried out at an international level (e.g. SADC) and central lab facilities can be strengthened through such networking.

Treatments and drugs available for particular diseases need to be selected on their cost-effectiveness and potential resistance developments, making sure they are available at the right clinical level. There should be a focus on prevention of rodent diseases within local communities, using partners who are active in the area (churches, NGOs, extension services) and ensuring that communities understand and assist in health impact assessment projects as a way of increasing our knowledge on the impact of rodent-borne diseases. These impact assessments in local situations must consider the disease transmission and socioeconomic status and could be set up through sentinel sites (as what occurred in ratzooman) for action at the SADC and other levels.

5. How do we raise awareness about the risk of rodents transmitting diseases with the general public, service providers and the international community?

This discussion group was comprised of workshop participants who were involved in communication as journalists, information technology, knowledge dissemination and generating public awareness. It was stressed that communication to the general public should recognise the role of community leaders (e.g. traditional leaders, councillors). Before carrying out communication events, a profile of the community and its structures should be obtained, noting how things works in the particular context (urban, rural). An appreciation of other problems in the community, and the real problems facing the community can help tailor messages appropriately and make them relevant. It is also helpful to establish a network of volunteers who can give an insider's view of the community before, during and after a communication event. 'Buy-in' of community leaders before an event can lead to a 'win-win' situation to ensure that the communication is positive, trying not to blame leaders for problems.

Communication tools vary from general media (radio, TV, newspapers) and the performing arts. It is important to identify the appropriate communication tools for the particular issue and community and best effects may involve several different tools.

Awareness must be sustained through forming structures or using existing structures to help 'mainstream' rat disease issues. Children can be used as an agent of change, and targeting them through education and schools can be an effective way to get to adult awareness (as was used in Cato Crest within the ratzooman project). Sustainable communication must be built on trust between communities and communicators, ensuring that project results are first shared with communities before it is given to the mass media. Awareness campaigns should also be linked to resource support and feedback (e.g. cleanup campaigns, rodent management interventions) and this can help the awareness lead to real changes in human behaviour.

Mass media attention should look to success stories, showing results as opposed to problems, linking the programme to broader developmental issues. It is important to observe protocol and ensure 'buy-in' of politicians as well as government at all levels so that the communication campaign is positive without sensationalising the issue. Mass media is interested in attractive and innovative methods (educational theatre) and will latch on to ideas that are interesting and entertaining. It can also help to get a celebrity involved as an ambassador or crowd puller as this can make the story more attractive, being careful to ensure that the issue is not hijacked by people who have other agendas.

Multidisciplinary group reports

Group A

The group indicated that raising awareness must be one of the key actions taken in reference to improving surveillance and monitoring. This should target political institutions through the use of mass media and local communities through theatre, radio and newspapers. It was recognised that international organisations such as the WHO need to back the call for research on rodent vectored diseases and that donors such as the European Commission must continue support for research on neglected communicable diseases.

Communication between government departments must be increased to deal with the cross-sectoral nature of rodent-borne diseases, and this will need a high-profile champion and positive propaganda to encourage inter-departmental working. The coordination of such work needs sustainable funding and research projects using multidisciplinary teams. Potential bottlenecks are to secure future funding, and demonstrating to donors how rodents impact on human health and more generally to people's livelihoods.

Group B

This group suggested there should be a continuation of the ratzooman project with the following strategic objectives:

- Raising awareness – find champions at all levels who can push the agenda forward
- Obtain advertising/publicity through sponsorship from the private sector
- Provide incentives (non-monetary) if we ask people to participate or conduct social facilitation

Surveillance and monitoring must rely on cost-effectiveness and, therefore, requires the development of cheap and rapid diagnostic testing kits and facilities. It was argued that pharmaceutical companies should be encouraged to participate in this process with active interventions from government to ensure that diagnostics for rodent diseases can be strengthened. Education of health workers must be improved through formal revision of curricula and improved post-qualification training. Government awareness and cross-departmental communication must be increased to deal with rodent-vectored diseases (and other zoonoses) effectively. Research must be extended beyond the three diseases investigated within the ratzooman project.

Group C

This group indicated that the priorities for the future should be to:

- Strengthen primary health care
- Understand the importance of timing when collecting data from case studies.
- Showing clear benefits of surveys to improving interventions
- Increasing data for diseases such as leptospirosis and toxoplasmosis in order to correctly survey
- Understand the differences between urban and rural areas, changes to waste management and lifestyle changes
- Understand the social and cultural context at community and authority levels
- Use all channels of media using positive sensationalism to increase awareness and action
- Develop a realistic campaign using a flagship disease such as plague where it is easier to mobilise awareness and using this as a platform to discuss other diseases such as leptospirosis

Group D

This group indicated that workshop participants must try to inform their own national governments and ensure that both agriculture and health departments are made aware of the work going on with regard to rodent pest problems and disease transmission.

Efforts from the scientific community should focus on fund raising for research and equipment so that data and demonstration of impact can be improved. Data must continue to be generated to give policy makers a clear path towards resolution of rodent-vectored diseases.

Training of existing health personnel must be reformulated to include neglected diseases. This could be partially done through existing channels such as 'road shows' and further education. But structures may need to be changed to ensure that health staff are updated appropriately on the risks of rodent diseases.

Impact studies, particularly looking at the financial impact of rodent diseases and loss to a country's people and development must be carried out at both local, national and regional levels.

Group E

In reference to surveillance and monitoring this group emphasised the important of rapid tests, courses/training for health workers, doctor questionnaires, changes to school science and health curricula, lab training for generating standardised data for participating countries

For influencing research priorities the group indicated that awareness for policy makers and politicians must be increased and funding to national and international organisations will need to be supported by showing the potential socio-economic impact of rodent-vectored diseases. There should be the development of flagship sites were practical surveillance and intervention happens. Regional multi-country organisations, such as the SADC, can help develop cross-sectoral communication among government departments. In this respect, the group strongly supports the idea of creating national rodent management committees at the national level.

Community education should be the cornerstone of improving the treatment and prevention of rodent-vectored diseases. Knowledge on the diseases need to be integrated into clinic frameworks that advise communities on preventative measures using evidence collected through impact and surveillance studies. Awareness through the media should use existing communication structures highlighting success stories (such as Cato Crest within the ratzooman project) and using ambassadors and high-profile people to help get the message through to communities and politicians.

Conclusions

The objectives of the ratzooman workshop were to:

- Raise awareness among key stakeholders about the role of rodents in disease transmission
- Increase scientific communication and networking
- Develop an approach for future action on rodent-vectored diseases
- Outline important issues that need to be addressed to increase knowledge about rodent-borne diseases and improve the way in which rodent diseases are managed

The workshop showed that people drawn from different disciplines and backgrounds can work together and often show remarkably similar thought processes and decisions when faced with common problems and questions. Although brief in time and scope, the outbreak group discussions which took place at the workshop formed an important first step to improving the way in which rodent pest problems are dealt with by the authorities, researchers, communicators and interventionists alike. Many issues and constraints were identified through these group discussions, indicating that the way forward is not simple and will require concerted efforts by several different stakeholder groups in order to change the way rodent pest problems are managed. As suggested by the workshop participants, one of the first steps must be to create multidisciplinary committees at national and regional levels. This will allow for a multifaceted discussion and prioritisation of issues that need to be addressed for building capacity, knowledge, awareness and tools to effectively manage rodent-vectored diseases and rodent management in general. Champions and high-profile leaders are needed to facilitate awareness-raising initiatives and to ensure that rodent-borne disease research and interventions are sustainable.

The outcomes of the workshop show us that the problems associated with rodents are potentially great, particularly with acute zoonoses such as plague that have caused much human suffering and economic disaster in the past as well as with more chronic and widespread disease problems such as leptospirosis. In a world of limited resources, research, funding, communication and intervention appears inevitably to focus on the big killer diseases (malaria, HIV-AIDS, TB). Plague and other rodent zoonoses may not match these in the number of current cases, but they have the potential to exceed in pathogenicity, spreading quickly under the right conditions, but are generally neglected and underestimated in their impact. It is easy to forget diseases such as plague in the 21^{st} century, relegating them to the sidelines. Rodent diseases remain poorly understood, and we cannot afford to ignore them. We should not need to wait for a new epidemic.

Acknowledgements

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The Seminar Support Programme of the Technical Centre for Agricultural and Rural Cooperation (CTA), ACP Cotonou Agreement, P.O. Box 380, 6700 AJ Wageningen, The Netherlands http://www.cta.int/

Coopers Environmental Science, P.O. Box 14374, Bredell 1623, South Africa
http://www.cooperses.co.za/

Rentokil Initial, PO Box 2006, Clareinch, 7740, South Africa http://www.rentokil.co.za/

Scientific Pest Control, P.O. Box 41687, Rossburgh 4072, South Africa http://www.spcs.co.za/

Scientific Supa-Kill, P.O. Box 8020, Edleen 1625, South Africa http://www.supa-kill.com/

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Appendices

List of participants

RATZOOMAN WORKSHOP, MALELANE, SOUTH AFRICA, 3-6 MAY 2006

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Workshop agenda

Rats and Human Health in Africa: A Workshop on Rodent-borne Diseases and the RatZooMan Research Project

4-5 May 2006, The Pestana Kruger Lodge, Malelane,
Mpumalanga Province, Republic of South Africa

3rd May Arrival of Delegates

19:30 *Opening dinner*

4th May

07:00 *Breakfast*

08:00 Welcome and Introductions
Dr Steven Belmain, Ratzooman Technical Coordinator, Natural Resources Institute, UK

08:10 Welcome by Guest of Honour
Dr Lucille Blumberg, Deputy Director and Head of Epidemiology and Outbreak Unit, National Institute for Communicable Diseases, RSA

08:25 Overview and objectives of workshop
Dr Steven Belmain, Ratzooman Technical Coordinator, Natural Resources Institute, UK

Introductory Session
Lorraine Arntzen, Session Chair

08:35 The Ratzooman project
Dr Steven Belmain, Ratzooman Technical Coordinator, Natural Resources Institute, UK

08:55 Rats and disease
Prof Dr Herwig Leirs, University of Antwerp, Belgium and Danish Pest Infestation Laboratory, Denmark

09:15 Leptospirosis
Dr Rudy Hartskeerl, Head of WHO Leptospirosis Reference Unit, KIT Biomedical Research, Royal Tropical Institute, The Netherlands

09:30 Toxoplasmosis
Dr Ricardo Thompson, Research Director, National Institute of Health, Ministry of Health, Mozambique

09:45 Plague
Dr John Frean, National Institute for Communicable Diseases, National Health Laboratory Service, RSA

10:00 Discussion

Understanding rats and disease problems
Frikkie Kirsten, Session Chair

10:10 Lassa Fever: spatial and temporal risk linked with rodent ecology and human behaviour in Guinea, West Africa
Dr Elizabeth Fichet-Calvet, Paris Natural History Museum, France

10:30 Rodents, salmonella and food borne pathogens
Dr Alan Buckle, University of Reading, UK

10:50 *Coffee*

11:20 Intestinal parasites of rats from Durban, South Africa, and implications for human health
Prof Chris Appleton, School of Biological & Conservation Sciences, University of KwaZulu-Natal, Durban, South Africa

11:40 GIS and climate modelling for zoonotic disease risk in North America
Dr Russell Enscore, Centers for Disease Control and Prevention (CDC), National Center for Infectious Diseases, Division of Vector Borne Infectious Diseases, USA

12:00 The agriculture/health divide - leptospirosis, typhus, and angiostrongyliasis in Southeast Asia
Dr Grant Singleton, International Rice Research Institute, The Philippines

12:20 Discussion

12:30 *Lunch*

Ratzooman and human disease in southern Africa
Rudy Hartskeerl, Session Chair

13:20 Understanding human behaviour and the transmission of rodent-borne diseases
Dr Monica Janowski, Social Anthropologist, Natural Resources Institute, UK

13:40 The ratzooman GIS
Dr Ricardo Thompson, Research Director, National Institute of Health, Ministry of Health, Mozambique

14:00 Surveying for rodent disease in a squatter camp, Cato Crest, Durban
Dr Peter Taylor, Curator of Mammals, Durban Natural Science Museum, RSA

14:20 Rodent ecology across rural, peri-urban and urban habitats
Prof Dr Herwig Leirs, University of Antwerp, Belgium and Danish Pest Infestation Laboratory, Denmark

14:40 Rodents and human disease in Mozambique
Dr Rassul Nala, National Institute of Health, Ministry of Health, Mozambique

14:55 Rodents and human disease in Zimbabwe
Dr Godfrey Chikwenhere, Principal Scientist, Plant Protection Research Institute, Harare, Zimbabwe

15:10 Rodents and human disease in Tanzania
Prof Dr Robert Machang'u, Director of Pest Management Centre, Sokoine University of Agriculture, Tanzania

15:25 Rodents and human disease in South Africa
Mrs Lorraine Arntzen, Special Bacterial Pathogens Reference Unit, National Institute for Communicable Diseases, National Health Laboratory Service, RSA

15:40 Discussion

15:50 *Tea*

16:00 *Game drives or further discussion*

18:00 *Bar open*

19:30 *Dinner*
Entertainment provided by Aubrey Silinyana

5th May

07:00 *Breakfast*

How can we reduce the rodent disease burden?
Martha Mpisaunga, Session Chair

08:00 Rodent control strategies in a changing city: Making rodent disease surveillance succeed with communities and government
Guy Redman, Director, Durban Natural Science Museum, RSA and Mel Hayter, Deputy Manager, Communicable Disease Unit, eThekwini Municipality, RSA

08:20 Predicting disease through mathematical models
Dr John Holt, Natural Resources Institute, UK and Dr Stephen Davis, University of Antwerp, Belgium

08:40 The practicalities of rodent control in managing disease
Adrian Meyer, The Acheta Partnership, UK

09:00 Policy recommendations for reducing rodent diseases
Jens Lodal, Danish Pest Infestation Laboratory, Denmark

09:20 Putting policies into practice
Dr Steven Belmain, Ratzooman Technical Coordinator, Natural Resources Institute, UK and Martha Mpisaunga, Syngenta, Zimbabwe

09:40 Discussion

10:00 Formulation of key constraints
Malcolm Iles, Economist, Natural Resources Institute, UK

10:10 Involving stakeholders in setting the agenda
Malcolm Iles, Economist, Natural Resources Institute, UK

11:10 *Coffee*

11:40 Prioritising key constraints related to rodent disease management
Malcolm Iles, Economist, Natural Resources Institute, UK

13:00 *Lunch*

14:00 Discussion

14:45 Development of common statement
Dr Steven Belmain, Ratzooman Technical Coordinator, Natural Resources Institute, UK

15:15 Where do we go from here?
Dr Steven Belmain, Ratzooman Technical Coordinator, Natural Resources Institute, UK

15:30 Closing
Dr Steven Belmain, Ratzooman Technical Coordinator, Natural Resources Institute, UK

15:45 *Tea*

16:00 *Game drives or further discussion*

18:00 *Bar open*

19:30 *Dinner*
Entertainment provided by Swazi dancers

6th May

07:00 *Breakfast*
Delegate departure