# A community-based participatory study investigating the epidemiology and effects of rabies to livestock owners in rural Ethiopia.

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**Abstract**

A participatory study was carried out in the Oromia region of Ethiopia to ascertain the principal epidemiological features of rabies and its impact on livestock owners. Due to the variation in topography (and therefore livestock and human populations within the study area) villages from both high (>1500m) and lowland areas were included. Local development agents who had no knowledge of the study's purpose recruited a total of one hundred and ninety six participants from eleven lowland and ten highland villages. A facilitator trained in animal health and participatory techniques conducted the interviews with groups of up to eleven participants. Methods used included ranking, scoring, proportion piling, seasonality calendars and open discussions to investigate a set of questions pre determined from a pilot study. The relative importance of rabies to other zoonoses, temporal distributions of the disease, the species affected, current methods of control within affected species and consequences of their loss were all explored. Data was compared between high and lowland areas and previously published studies.

The study found that rabies was considered the zoonosis of greatest risk to public health in both areas. It reportedly occurred with higher frequency in highland areas and subsequently affected more livestock in these parts. Two distinct temporal patterns within the areas were described and participants provided reasons of biological plausibility for the occurrence. Livestock were found to contribute as a higher proportion of all species affected than previously shown in published material. This is likely to be due to the low level of reporting of affected animals to the available veterinary services, from where comparative data originated. The death of infected livestock species was found to have numerous social and economic implications and the ramifications of this are made greater by the perception that the highest incidence of clinical disease being in areas of greatest livestock density. The underestimation of the burden of disease by central bodies is likely to influence the economic rationale behind effective rabies control in the future.

Keywords; Participatory epidemiology; Rabies; Livestock; Ethiopia.

## Introduction

Rabies is endemic in Ethiopia (Yimer, 2004) where it has been recognized as an important disease for many centuries (Fekadu, 1982). As well as affecting people and canids, the disease has been identified in a number of other domestic species including cattle, donkeys, horses and sheep (Fekadu, 1982). There has been an increase in disease incidence in the last decade in these species (WHO). Whilst attention has been given to the public health impact of rabies, concerns regarding the economic implications as a result of animal loss have also been raised (Knobel et al, 2005). Under representation of cases in species of economic importance is likely to have a significant impact on the quantification of disease burden and any economic rationale behind disease intervention.

The Ethiopian Nutrition and Health Research Institute (ENHRI) in Addis Ababa is the sole diagnostic testing facility in the country responsible for relaying data to the World Health Organisation (WHO). It is reliant on voluntary submission of suspect cases from veterinarians. Passive surveillance reportedly underestimates the occurrence of human disease in Ethiopia (Fekadu, 1997) and this is likely to be true in affected animal species due to poor submission rates, in particular from rural areas. This is likely to be a result of the limited surveillance capacities of the country. Whilst the increase in privatisation of veterinary services has improved some services the diagnostic and reporting capacities remain limited (Admassu, 2003)

All rural areas are reliant on ruminant and non ruminant species for agriculture-based activities which contribute up to 85% of household revenue (Benin et al., 2003). Highland areas are more temperate, conducive to crop growth and therefore more densely populated by people and their livestock compared to arid lowland areas where pastoralism predominates (Halderman, 2004). However, very little is known about the perceptions and knowledge of rabies amongst livestock owners in either area. This project sought to meet some of these short-comings by exploring livestock owner perceptions of rabies in two topographical areas of Ethiopia.

Participatory appraisal methods were used and involve the participation of the people being studied and the use of their personal perceptions, experience and knowledge as data (Chambers, 1994; Chambers, 1992). The in depth knowledge of rural livestock owners and their ability to effectively identify diseases seen in their livestock has been well documented (Catley et al., 2002, Catley et al., 2001; Mariner et al., 2003). Although no absolute measure of disease incidence could be provided the study explored the perceptions of the importance of the disease relative to other zoonotic diseases identified by participants and the difference in the perceived effects between the two rural areas. This provided potential risk factors associated with the disease that could be considered in future disease control. Data was also collected on current preventative measures and treatments used by livestock owners. Finally the relative proportion of mortality of each livestock species from rabies was compared to official reports to ascertain if there was evidence of under reporting.

## Materials and Methods

### Location and Participant Selection

The study was carried out over six weeks in August and September 2009 in the Oromia region of Ethiopia in an area covering approximately two hundred and fifty kilometers. Ethiopia is divided into nine regions that are, in turn, divided into zones containing a number of small provinces or *woredas*. The study sites in lowland areas, Dugda Bora and Adami Tullu *woredas,* were in the West Shewa zone, whilst the highland sites were within the Tijo *woredas* of the neighboring Arsi zone. Selection of *woredas* and villages (*kebele)* was dependent on vehicular access (to within a few kilometers) and cooperation of the *woredas* agricultural department (all departments approached agreed to cooperate, so this criterion did not result in any exclusions). From each village groups of up to eleven participants were invited to take part in the study. They were selected by village development agents according to two pre-defined criteria; ownership of ruminant and non- ruminant livestock in the household and agriculture being the predominant source of household income. The development agent had no prior knowledge of the subject matter of the study before recruiting participants. Inclusion of women in the groups was encouraged. There was no prior knowledge by the authors of the government veterinary services available in the *kebele* or of any rabies control programs in place. The study was approved by the research ethics committee at the University of Liverpool.

**Participatory Appraisal Methodology**

The discussions were conducted in either of the two principal languages of the region, Afan Oromo or Amharic, using a facilitator fluent in both languages and previously trained in participatory methods. During the study, no individuals were encountered that did not speak fluently at least one of these languages.

The methods used were trialed and adapted through pilot meetings in a number of sites not included in the main study and a resulting schedule of open-ended questions was used to guide discussions. The study design was such that participants could visually display their opinions and this, in turn, encouraged debate within the groups and elicited further information. Efforts were made to ensure all members of the discussion group expressed their opinions and that discussion was open and not dominated by one or a few individuals. Nevertheless, with any group discussion, there remained the potential for a subset of people to dominate or for people to voice what they believe to be an acceptable, rather than their own, opinion. Participants in pilot meetings reported finding the use of local materials (e.g. beans, pebbles) to be ill-suited and took more interest when using modern materials. In the face of low levels of literacy, pictures and other visual cues were used were possible and where necessary groups appointed a literate group member to write on behalf of the remaining participants; materials used included a white board, pens of different colours, card counters and photographs. Where written materials were used (for example, disease names were written on cards for subsequent ranking) the local facilitator ensured discussions relied on verbalization of (rather than reading) the words. The local facilitator also ensured the nominated scribe accurately reflected the views of the group. The first author was responsible for noting key results during discussions and all discussions were recorded. Semi-structured interviews and additional information elicited by debate were translated from local languages to English after the meetings.

**Ascertaining the Importance of Rabies Compared to Other Zoonoses.**

The importance of identified zoonoses was determined by three criteria; the risk of each disease to human health; the incidence of clinical signs of each disease in owned animals and the impact of each disease on animal mortality. This was undertaken in order to explore the communities' knowledge about zoonotic diseases in general, and to enable ranking these diseases without specifically naming rabies as the focus of the study. Initially, participants were asked to name domestic animals that they owned and a photograph of each named species was placed in the middle of the group with a photograph representing a rural person. Participants were asked to list the diseases that passed from animals to people in the *kebele.* These were written (by request of participants) in the appropriate language on card. Descriptions of clinical signs, gross post-mortem changes, modes of transmission and beliefs about underlying pathologies were used, where possible, to determine the Western name of diseases mentioned and to ensure disease names were used consistently between groups. The participants were then asked to rank the named diseases according to their perceived risk to human health. Participants showed their response using card circles of different size – the greater the size, the greater the risk imposed. Participants placed the now labelled circles around a central object (representing the *kebele*), with the relative distance from the object representative of the relative frequency of presence of the disease in domestic animals in the *kebele*. Diseases always present were placed on the marker. The frequency of human disease was not separately investigated. Animal mortality was measured using counters that the participants distributed amongst the diseases according to the proportional loss of animal life when infected by each disease comparative to one another. This created a three-way Venn diagram (Kumar, 2002) representing the three criteria for each named zoonotic disease. At each stage the participants' decisions were explored and supporting reasons sought.

**Relative frequency of rabies in domestic animal species.**

With the same photographs used in exercise 1, participants were asked to identify those species believed to be affected by rabies. These photographs were then ranked by the participants based on the frequency each species was seen clinically affected by rabies – rank 1 always being the animal most often seen with rabies. In six of the appraisals a number of card counters representing all animals clinically affected were then provided. The participants distributed the counters among the species according to the relative number of animals of that species they saw affected.

Reasoning to support the ranking and proportion piling were obtained through discussion and this yielded information regarding the risk factors for each species being bitten by infected animals.

**The seasonality of rabies.**

Each group constructed their own seasonality calendar. A line, representing the year was drawn and local names for seasons and months were placed on the line to divide the year. All groups divided the calendar into the 13 months of the Ethiopian calendar and then sub-divided these based on agricultural activities. As a common marker all groups were then asked to identify the month of highest rainfall (which was later compared to official sources of rainfall data to verify the division of time). Groups were then asked to identify the months in which rabies was seen in any animal within the *kebele*. In groups where rabies was not an annual event this information was often hard to elicit. Semi-structured questions regarding significant features of the years when rabies was seen were then used, and group discussion was encouraged. All groups identified domestic dogs as the primary source of disease in a kebele. Therefore, they were asked to identify predisposing factors for the incidence in dogs in the months shown and these ideas were further explored. Factors included times of year when: the most jackals were seen, hyena bites occurred, dog movement was greatest, and sources of food and water for domestic dogs were least available. Often these topics arose later in the discussion and the seasonality calendar was revisited and modified appropriately.

**Preventative measures and treatments used by participants.**

Participants then created an annotated diagram showing the pathway of transmission of rabies between species. This was used as a focus point for group discussion about current methods of preventing rabies occurrence and spread within the village. Open-ended questions were used to begin discussions and semi-structured techniques were then used to pursue ideas regarding prevention/treatment and criteria that influenced the decisions taken.

Open discussions involved all participants in the groups. An emphasis was placed on the freedom of everyone to speak and the translator used his discretion to draw ideas from specific members, in particular women or those less forthcoming. Preferred treatment and control methods were often determined by religious practice of participants that differed within groups. Discussion of religious issues was highly sensitive and care was taken when discussing these options.

**Data collection and analysis**

All appraisals were recorded by dictaphone and the discussions relating to specific questions were transcribed. Analytical computer software (NVIVO 8, QSR International Ltd, Cambridge MA) was used as an aid to thematically code the discussions and measure the frequency of occurrence of emergent themes.

**Use of rank data**

The importance of rabies compared to other zoonoses was investigated by using the rank data collected on 2 criteria: the impact on human health; and the relative frequency of the diseases in domestic animals. Within each group and for each of these criteria the ranks were converted to scores using the following formula, where a group had not identified a disease the value 0 was appointed.:

$Sc_{ijk} = N_{ij} - r_{ijk} + 1$

$Sc_{ijk}$ = Score for the $j^{th}$ disease in the $i^{th}$ group (for criterion $k$: human health or incidence of clinical disease)

$N_j$ = The number of diseases identified by group $j$

$r_{ijk}$ = The rank given to disease $i$ by the group $j$ for criterion $k$

This was carried out to allow for a more efficient interpretation of the results – the disease with the lowest rank now received the highest score. The scores of relative incidence of clinical disease, risk to human and health and the score for relative mortality attributable to each disease were then standardised respectively using the following formula;

$STSc_{ijk} = Sc_{ijk} / N_{ij} \times 10$

$STSc_{ijk}$ = Standardised score for the $j^{th}$ disease in the $i^{th}$ group

$Sc_{ijk}$ = Score for the $j^{th}$ disease in the $i^{th}$ group

$N_{ij}$ = The number of diseases identified by group *i.*

Due to the non-parametric nature the median value scores of each criteria were then used to assess the importance of rabies relative to other diseases in each criteria respectively. Using STATA ll, Friedmans test was used to test the hypothesis that there was evidence of a difference between the scores of each disease. A Wilcoxon rank sum test was then used to test the hypothesis that there was a difference between the scores of each disease and rabies when individually comparing paired scores. The tests were repeated for each criteria respectively.

Official rainfall data for towns within the study areas was obtained for 1998 to 2008 from the National Meteorological Centre, Addis Ababa and was compared to rainfall patterns reported in the groups. Unofficial data from the Ministry of Agriculture regarding cases of rabies diagnosed on clinical signs alone, reported by veterinary services in the East Shewa and Arsi zones, were also collected and compared with data of confirmed cases from EHNRI.

## Results

A total of ten highland and eleven lowland villages were used in our appraisal with participant group numbers ranging from eight to eleven. Despite a specific request for their inclusion in the discussion groups, women were under represented (often reported by other participants to be due to their high domestic workload).  In total there were 196 participants of which 14 were female.

Participants identified a total of seven zoonotic ‘diseases’.. The western classifications of the disease entities ‘liver disease’ and ‘lung disease’ are thought to be pulmonary tuberculosis and tuberculous lymphadenopathy from the description of clinical signs in people, belief that the disease is transmitted from milk from infected livestock and observations at the time of the study. Rabies and anthrax were the only zoonoses identified by all participating villages. Internal parasites were identified as disease in highland appraisals only.

Both high and lowland areas rated rabies as the zoonosis of greatest risk to public health. Numerous factors influenced participant perception of public health risk, including the severity of clinical signs seen, the risk of death posed by the disease, vaccine availability and participant personal experience of seeing the disease in people. Although the relative incidence of clinical disease was greatest for anthrax in all of the study population figure 1 shows that there was a disparity between high and lowland sites: in highland areas rabies was the disease to have a greatest incidence in clinical disease. In lowland areas anthrax had the highest score in this criteria followed by rabies. As only highland PRA’s perceived internal parasites to be present the incidence of clinical disease was greater than in lowland areas.

The temporal pattern of rabies disease varied between the highland and lowland areas (Figure 2). The identification of the month of highest rainfall was consistent with official rainfall data verifying that participants could accurately associate events with months. In highland areas, the incidence of clinical signs of rabies was reported by all ten of the groups to be an annually occurring disease and identified the months in which they saw rabies with ease. In lowland areas, nine of eleven groups identified rabies as a disease that *did not* occur annually and that there was an ‘irregular’ occurrence associated with years when there was an extended dry season. This was universally defined as a year when no *short* rain season occurred. Two groups in lowland areas could not complete the exercise of identifying months when rabies was seen but both mentioned that the incidence of clinical signs of rabies was associated with absence of the short rain season. The additional criteria were added to the seasonality calendar throughout the appraisal in order to illustrate factors identified as affecting rabies occurrence (Figure 2). In highland areas there was a greater difference in the incidence of clinical signs of rabies between months resulting in seasonal peaks of the disease; at the end of the dry season and the start of the harvest season. In lowland areas the disparity was not as great and disease was reported to occur throughout all of the dry season. In both topographical areas months where rabies was seen in animals was correlated with times when more groups thought more jackals were seen but inversely associated with groups identifying when hyena attacks occurred in livestock.

All participating groups claimed to have seen dogs, cattle and human beings affected by rabies, and all but 2 groups (1 from highland and 1 from lowland areas) had seen rabies in donkeys. Participants were able to provide a detailed description of clinical signs in all species. Dogs were identified as the primary source of infection in domestic animals, the species most affected and the predominant vector in transmitting disease to other species. Cattle were regarded as the species with the second highest proportion of animals affected in all groups. Reasons reported for this were that dogs were kept at night with cattle in an enclosure or '*mora'*, and that the close proximity of the animals meant they were more likely to be bitten. The management of all working equids was believed to be a protective factor as they were kept within the home or an adjoining building at night. Six groups accounted for the proportion of animals per species they perceived to lose as a result of rabies as a proportion of the total number of animals of all species they lost to the disease. Comparison of these figures (Table 2) with passive surveillance from EHNRI (Yimer, 2002) and unpublished records based on diagnosis by clinical signs alone in veterinary clinics in East Shewa and Arsi zones (Ministry of Agriculture, private source) suggest that non-canine species are under-represented in these latter sources. There was no difference in the order of disease incidence by species between high or lowland areas.

The primary control method used by participants was to kill dogs that demonstrated clinical signs of rabies to prevent transmission to other animals. Additional preventive methods used included: traditional medicine given by drenching (cattle) or in drinking water or in milk (dogs) following a period of withholding water; splashing or drenching animals with holy water (this method was mentioned by highland areas only), and burning the carcass of the dog initially seen with rabies and gathering animals around to inhale the smoke.  Two groups in highland areas mentioned using a 'vaccine' from traditional sources that was put in milk and fed to dogs. No participating group mentioned any form of veterinary intervention that was, or had previously, been used and no participants knew of any available vaccines.

The restraint (by tying up) of animals known to have been bitten by others showing clinical signs was mentioned by nine groups. Traditional medicine or holy water were then given to the restrained animals. Once clinical signs were seen all animals were killed by a variety of methods. Beating was the only method of euthanasia mentioned for dogs (n=18 groups). Similarly, slaughter (and distribution of the meat between villagers for consumption) was the only method mentioned for affected cattle (n=18). Methods of euthanasia reported for equids included beating (n=9), shooting (n=2) and tying somewhere in order for the animal to killed by hyenas (n=7). No reference was made by any of the groups present to seek veterinary attention although a third of sites had veterinary facilities within the *kebele*.

## Discussion

This study provides a detailed account of beliefs and understanding of issues relating to rabies in two rural areas of Ethiopia. The participatory methods used are flexible and so provided an opportunity to explore recurring themes in more detail. Whilst group numbers were high there was a low representation of women. The study was also limited to villages with reasonable vehicular access, and hence the results may not reflect the views of more remote areas, or other regions of Ethiopia. Results showed high levels of agreement between groups in each area, but with differences evident in answers between highland and lowland participants in many of the topics. However, rabies and anthrax were the only zoonoses mentioned by *all* participating groups. Although this study could not provide conclusive diagnoses to confirm participant suspicions, previous studies have found that livestock owner recognition of rabies cases has a greater than 74% probability of confirmation by diagnostic testing (Lembo et al., 2008). As the study was a representation of the perceptions of livestock owners the conditions of "liver disease", "lung disease" and "warts" remained for comparative purposes although it could not be confirmed that their aetiology was zoonotic.

Although all participants regarded rabies as the disease of greatest risk to public health and village dogs as the primary source of infection to other species, there were key spatial differences in the perception of the temporal incidence of clinical signs of rabies.

Constant endemic infection within the domestic dog population *alone* is considered dependent on the domestic dog density within an area. Populations of >5 dogs per $km^2$ may be sufficient to maintain an endemic status with sporadic occurrence of rabies in areas with <1dog $km^{-2}$ (Cleaveland and Dye, 1995). Whilst there is little information on the canine population within Ethiopia the highest human population is found within highland areas (Bewket, 2007;

Comenetz et al., 2002) and domestic canine populations are likely to follow this pattern. We speculate that this may contribute to maintenance of an annual infection in the highland areas.

Risk factors for intra-area occurrence of disease are suggested from the seasonality calendars. Both highland and lowland groups indicated an overlap between times when incidence of clinical signs of rabies was highest with times when jackals were most likely to be seen and rainfall levels were low. Rabies antibodies have been found in both jackal species (*canis mesomelas and canis aureus)* in Ethiopia (Sillero-Zubiri et al., 1996) and it is acknowledged that inter-species transmission occurs (Lembo et al., 2008). Once disease has been established within a jackal population it is maintained separately and inter-species transmission may re-occur, especially during times of increased contact.

An increased incidence of rabies with low rainfall has been found in other studies (Bingham and Foggin, 1993, Courtin et al., 2000). These times are associated with an increase in the number of roaming canid species in an attempt to find permanent water sources and an increased chance of interspecies contact and therefore infection (Courtin et al., 2000). In highland areas a secondary peak in the number of groups perceiving rabies incidence to rise is in October immediately prior to harvesting when household food levels are particularly low and so people within the *kebele* provide no waste food to domestic dogs. This suggests that risk factors for an increase in the clinical incidence of rabies in all species in the village includes the increased roaming distance of domesticated canids that results in contact with wild canids. The causal factor of these behaviours, are intra household water and food shortages. Dehydration and malnutrition are known to have deleterious effects on immune-competence (Chandra, 1997). These findings suggest that improved care of *kebele* dogs, including provision of water and food during times when there are low resources may lower the risk of interspecies transmission by reducing the need for domestic dogs to roam.

The seasonal occurrence of rabies contrasts with those found in other study's where rabies outbreaks were expected between July and September (Fekadu, 1982). However, this difference might be accounted for by the former research area being centered on urban areas and the potential difference in epidemiology of the disease.

There was uniformity in all groups regarding the relative mortality in each species and this study provides risk factors for species that could be reduced by altered animal husbandry. Comparing findings to other data sources shows lower estimates of the impact of rabies on mortality in cattle and equids in comparison to other species. The most recent reports do not show a breakdown of species submitted that are not canid or feline (Deressa et al., 1997). Data from the Ministry of Agriculture, based on diagnosis from veterinarians on clinical signs alone, shows greater correlation of percentage species mortality with the present research than reports from EHNRI which relies on submission of cases from examining veterinarians and is used by central bodies such as WHO.

The most likely reason for the difference between data with regard cattle is the lack of livestock in urban areas coupled with the low number of suspected clinical rabies cases submitted for diagnosis from rural areas due to logistical and economic reasons. For working donkeys there is an additional factor of low social worth that is likely to influence an owner's decision to seek veterinary attention. However, the apparent lack of veterinary advice and intervention sought by livestock owners in the event of an animal being clinically affected is likely to be largely responsible for the discrepancy of figures between the data. Although all villages had access to government veterinary services and at least six were within the same village of the PRA – no participants listed them as a consulting service for infected animals or source of prevention or treatment of the disease. A limitation of this study was that it did not collect information on the structure of animal health services within the study areas. Other sources demonstrate the significant role of community based animal health workers in disease control in rural Ethiopia (Admassu et al,. 2005) but that surveillance is limited by the restrictions in its capacity (Admassu, 2003) often as a result of the private gains that drive CBAHW priorities (anon). However other studies have shown that with simple and effective reporting systems CBAHW's substantially contribute to the surveillance mechanism (Allport, et al., 2005)

Whilst this study provides evidence of the perceptions of the relative occurrence of clinical disease a more systematic mechanism is required within these areas to ascertain absolute figures. This is necessary for the service to achieve a more accurate account of disease loss so that appropriate prioritization can be given from subsequent estimates of the economic impact that were beyond the scope of this study. More information to livestock owners about the options of disease prevention and control could then be justified.

Currently, the most effective method of disease control in villages is believed to be the killing of affected animals. Traditional medicines and the use of faith dependent interventions is still common practice. Reasons for the perception of the risk of rabies included that a vaccine was available to protect animals, and therefore humans from anthrax, where as no such vaccination was believed to be available to protect against rabies. Vaccination of dogs was never mentioned as an option for the prevention or control of the disease. In open discussions after the appraisal, numerous villages asked whether a vaccine for dogs might become available in the future highlighting the low level of awareness of this method of control.

Until 2008, canine rabies vaccine distribution within Ethiopia only occurred in response to specific demand by domestic dog owners and subsequent importation by private veterinary practices. Availability was limited to those who were aware of the vaccine and who could afford to pay such costs. The National Veterinary Institute of Ethiopia (NVI) is currently importing rabies vaccines for the first time, to distribute to the government-run veterinary clinics that predominate in rural areas (*pers comm.* Dr. Martha Yami, General Manager NVI). Administration of vaccines is still subject to payment by animal owners. It is estimated that 82% of Ethiopia's population live off less than US$1 per day (Halderman, 2004) suggesting that financial constraints are likely to inhibit vaccine accessibility to livestock owners. Other methods of vaccine distribution and use have been attempted by outside groups. However, implementation of central point canine vaccination programs within Ethiopia has been found to be difficult to achieve (Cleaveland et al., 2003).This has been attributed to the negative attitude Ethiopian dog 'owners' are thought to have towards their dogs. For example in one study 65% of Ethiopian householders denied ownership of dogs that were present within the area of their homesteads, (Ortolani et al., 2009) and therefore any responsibility for their health. Whilst all participating groups within this study acknowledged the presence of domestic dogs within their village, they did not actively seek to provide water for them and only waste food was made available which was not possible when food supplies were low. Whilst vaccinations are available it is suggested that their accessibility will be low amongst livestock owners due to economic constraints. Promoting responsible attitudes towards stewardship of dogs and the importance of maintaining their needs and health may contribute to protection against transmission in times when risk factors are prevalent.

Incentives for improved care could be provided from a more thorough economic evaluation of rabies as a result of livestock loss. Evidence from this study suggests the greatest incidence of the disease in areas of highest cattle density and a proportionately high level of disease in these species. The monetary loss is likely to be important both at owner and national level through loss of subsistence income (Benin et al., 2003). Furthermore, in this study animal mortality was the only economic loss considered. Different results are likely to be found for other causes of loss, such as reduced production and subsequent secondary effects including loss of crops. The rural population is also highly reliant on the working equid population of which Ethiopia has one of the highest, estimated at 7.9 million (Ayele, 2007). They provide transportation of goods to and from the homestead and as a direct source of income if they are hired out (Fernando et al,. 2004). Working equid loss has a considerable gender specific impact on society. Many roles of women, such as fetching of water and firewood require the use of donkeys which substantially reduce the physical burden (Fernando and Starkey, 2004). The high proportion of equine rabies cases found in this study is supported by a report from Botswana where rabies was the most common disease encountered in equids (Segwagwe et al., 1999).

The social implication of livestock loss is not individual to rabies. However the endemic status of rabies, its multi-mammalian host capacity and its inevitably fatal outcome in affected livestock, in addition to the ongoing risk to human life, result in serious social and economic implications that provide a strong argument for further financial input to its control.

**Conclusion**

Participants from this study were able to provide a large amount of concise information on the impact and epidemiology of rabies in their villages. There answers were justified by factors of biological plausibility that could be supported by other studies, providing validity to the method used. In the context of other zoonoses rabies is a disease of serious concern to livestock owners. There is evidence of under reporting by owners to veterinary facilities and of those cases diagnosed on clinical signs alone, not being forwarded to central data collection services. The subsequent bias in case recording is likely to have resulted in an underestimation of the disease and will hinder evidence for decision making in cost effective rabies control. An effective, integrated approach is needed from both veterinary and medical professionals to improve case reporting, provide information to rural communities about available control measures and improve disease surveillance. This study identified differences in the epidemiology of the disease between topographical areas and more research is needed to identify the cause of this and potential effects it may have on future control programmes. Whilst the main outcome of this study is to increase information on the epidemiology and impact of disease within the area, this paper also identified preventative measures that could be implemented by livestock owners immediately in their animal management practices. Education within these areas could provide an immediate reduction in disease occurrence while more sustainable plans are made.

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**Table 1 Diseases identified by participants, median standardised score and respective P-value of diseases in each criteria**

| Condition | Number PRA's identifying disease | Median Score (Standardised) | Inter quartile range | Z - score* (P value) |
|---|---|---|---|---|
| Perceived risk to human health ** <0.001 | | | | |
| Rabies | 20 | 10.0 | 9.37 – 10.0 | na |
| Anthrax | 20 | 6.67 | 6.67 -7.37 | 0.010 |
| Internal parasites | 7 | 0.00 | 0 – 3.33 | <0.001 |
| "liver disease" | 6 | 0.00 | 0.0- 2.5 | <0.001 |
| ''lung disease' | 5 | 0.00 | 0.0 – 0.83 | <0.001 |
| Warts | 6 | 0.0 | 0.-2.5 | <0.001 |
| Brucellosis | 1 | 0.00 | 0 -0.0 | <0.001 |
| Incidence of clinical disease <0.0001 | | | | |
| Anthrax | 20 | 7.08 | 3.33- 10.0 | 0.958 |
| Rabies | 20 | 6.67 | 5.0 – 6.67 | na |
| Internal parasites | 7 | 0.00 | 0 – 10.00* | 0.005 |
| "liver disease" | 6 | 0.00 | 0.0- 2.7 | <0.001 |
| ''lung disease' | 5 | 0.00 | 0.0 – 0.83 | 0.002 |
| Warts | 6 | 0.0 | 0.-2.5 | <0.001 |
| Brucellosis | 1 | 0.00 | 0 -0.0 | <0.001 |
| Relative mortality <0.0001 | | | | |
| Anthrax | 20 | 7.73 | 3.0 – 6.67 | 0.42 |

| | | | | |
|---|---|---|---|---|
| Rabies | 20 | 3.33 | 3.0 – 4.53 | na |
| Internal parasites | 7 | 0.00 | 0.0–0.0 | <0.001 |
| “liver disease” | 6 | 0.00 | 0.0- 0.00 | <0.001 |
| ‘’lung disease’ | 5 | 0.00 | 0.0 – 0.16 | <0.001 |
| Warts | 6 | 0.0 | 0.0-0.0 | <0.001 |
| Brucellosis | 1 | 0.00 | 0 -0.0 | <0.001 |

* Wilcoxon rank-sum test

** Friedmans chi-squared P-value

**Table 2 Comparison of the relative proportion of mortality in each species according to source**

| Source | Canine | Bovine | Equine | Human | Feline | Ovine | Caprine | Dromel |
|---|---|---|---|---|---|---|---|---|
| PRA | 46% | 23% | 14.8% | 9% | 5% | na | na | na |
| MoA | 69% | 17% | 7% | 2% | 0.2% | 1.7% | 0.13% | 0.4% |
| EHNRI | 90% | 3% | 0.1% | <0.01% | 6% | 0.04% | 0.1% | na |

PRA - Data from present study.

MoA – Unpublished material provided by the Ministry of Agriculture; reported diagnosis made on clinical signs alone from veterinary clinics across the East Shewa and Arsi zones.

EHNRI - The percentage mortality per species, submitted to the EHNRI for diagnosis by IFAT following suspicion on clinical signs alone. (Yimer, 2002).

Figure 1 The relative importance of zoonotic diseases affecting villages in highland (dark) and lowland (light) areas. The size of each circle represents the perceived risk of disease to human health. The inset box highlights the bottom left of the main plot and shows results for low scoring diseases.

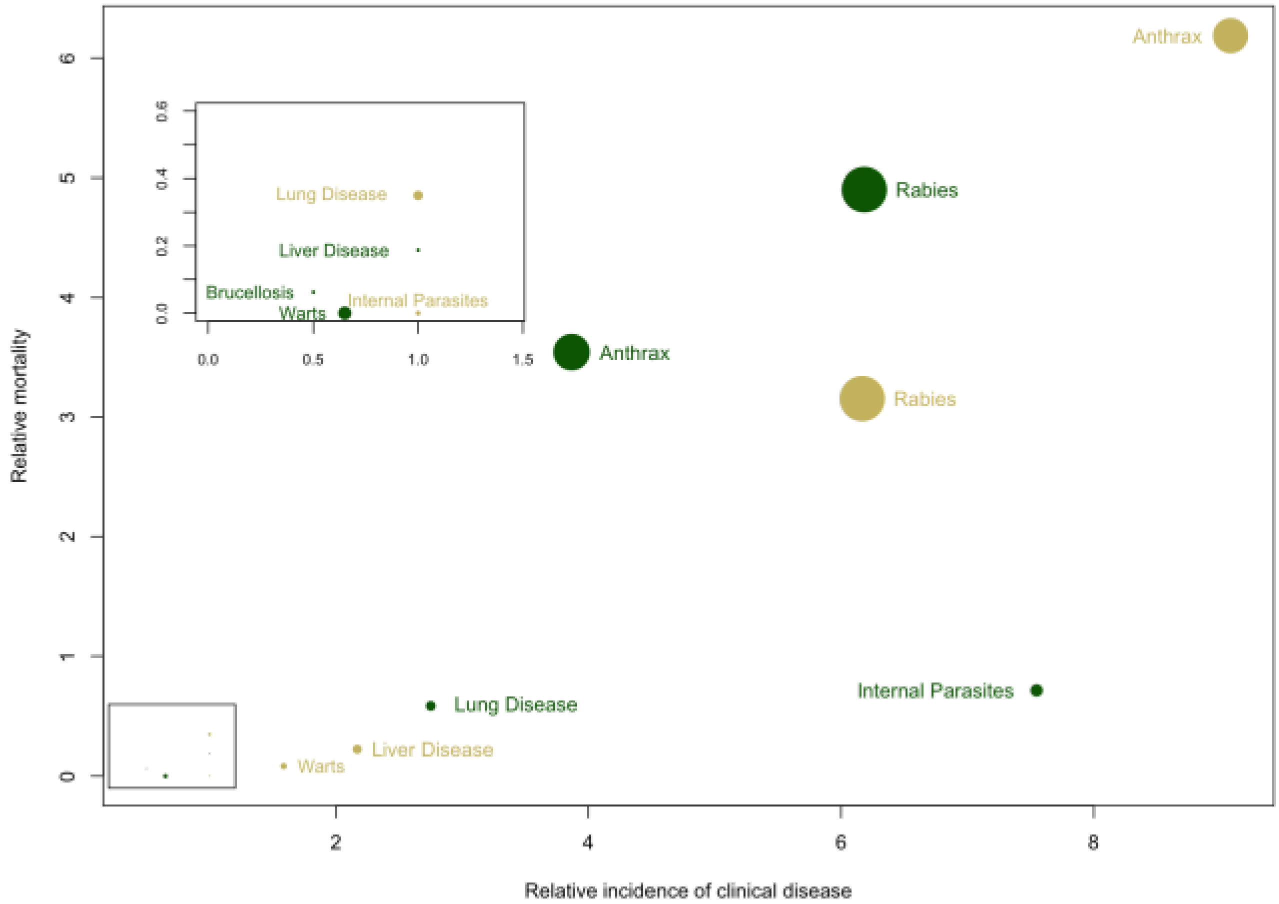

Figure 2 A summary of seasonality calendars developed by groups in highland and lowland areas. Criteria thought to be associated with the incidence of clinical signs rabies and the corresponding number of groups to identify these criteria is shown in circles of representative size.

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