Appraisal of Peste des petits ruminants disease by Turkana pastoral community of Turkana County in Kenya

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Abstract

Peste des petits ruminants (PPR) a disease of the sheep and goats remains a major constrain to small stock production in Turkana Kenya. The disease has not been known for long period in Kenya, though the Turkana pastoral community has acquired some indigenous knowledge from their encounter with the disease. Through focused group discussion employing participatory epidemiology methods the Turkana ranked PPR among the ten most important diseases in their small ruminant flocks. Turkana respondents characterized Peste des petits ruminants differentiating the disease from other small ruminant diseases and providing clear association of clinical and post mortem signs as well as risk factors. The respondents provided estimates of the relative incidence of PPR in sheep that ranged between 19% (9.87, 40) in young adults (>6 but <24 months) to 25% (11.4, 40.8) in adults (> 24 months). The relative mortality ranged between 16% (7.3, 37.1) in young adults and 20% (7.8, 34.9) in adults. Case fatality was highest in young adults at 84.2% (68,100). The estimated relative incidences of PPR in goats ranged between 17.8% (8.5, 32.1) in new born kids (< 2 months of age) and 20.9% (10.4, 36) in adults (> 24 months). Relative mortalities varied from 14.2% (6.1, 28.6) in newborn kids to 17% (5.5, 25.5) in older kids (>2 but <6 months). Case fatality was highest in young adults (>6 but <24 months) at 84.5%

(58.6, 100). Turkana perceive vaccination as an effective PPR control methods but have problem in accessing the service. This study has illuminated further the need to utilize the indigenous knowledge for purposes of understanding diseases in the community and setting up strong participatory surveillance systems that involve the communities as the basic element of disease surveillance intelligence gathering.

Keywords: Peste des petits ruminants, Participatory epidemiology, Indigenous knowledge, Turkana, Kenya

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Introduction

The small ruminants are important livelihood assets for the Turkana pastoral community of Kenya. Sheep and goats are considered as mobile banks and are easily liquidated into cash in short notice to satisfy household requirements, with minimal consultation (Imana, 2008). However a major constraint to production of small ruminants in Turkana and other pastoral areas of Kenya has been the recent outbreaks of Peste des petit ruminants (PPR) disease into Kenya (OIE, 2014). Pastoral communities in Kenya have had rarely encountered Peste des petit ruminants disease prior to the known outbreaks of 2006 and 2007, thus indigenous knowledge on the disease is not as developed as in other small stock diseases (Ohta, 1984). In Turkana community, PPR disease was much associated with descriptive and local naming of rinderpest prior to rinderpest eradication (Ohta, 1984; Kihu *et al*, 2012a). However,

with increased occurrence of the classic cases of PPR disease in the Turkana herds, the Turkana herders in 2006 adapted the name *Lomoo* for the PPR disease (Bett *et al,* 2009). This study is a community appraisal of Peste des petit ruminants (*Lomoo)* disease in Turkana. The validation of this community's knowledge was done using scientific and laboratory analyses of cases and samples collected from appraised PPR cases by the community and was reported in scientific report in press titled "Clinical, pathological and molecular investigation of Peste des petits ruminants virus infection in goats from Turkana County in Kenya".

Material and methods

Study area

The study was carried out in Loima, Oropoi, Kakuma, Lokichogio, Kaleeng and Kibish administrative divisions of Turkana County (Figure 1). The county is located in the extreme north west of Kenya and is characterized by arid and semi-arid lands covered with grass and sparse thorny shrubs (Schilling *et al.,* 2012). The rainfall pattern and its distribution are unreliable and erratic over the years. Turkana County has a human population of approximately 849,277 and an area of 77,000 km^2 with a small stock population of 3,517,151 sheep and 5,994,861 goats (KNBS 2010). Approximately 70% of the population in Turkana are nomadic or semi-nomadic pastoralists (Imana, 2008) deriving their livelihood from extensive livestock production (Figure 1).

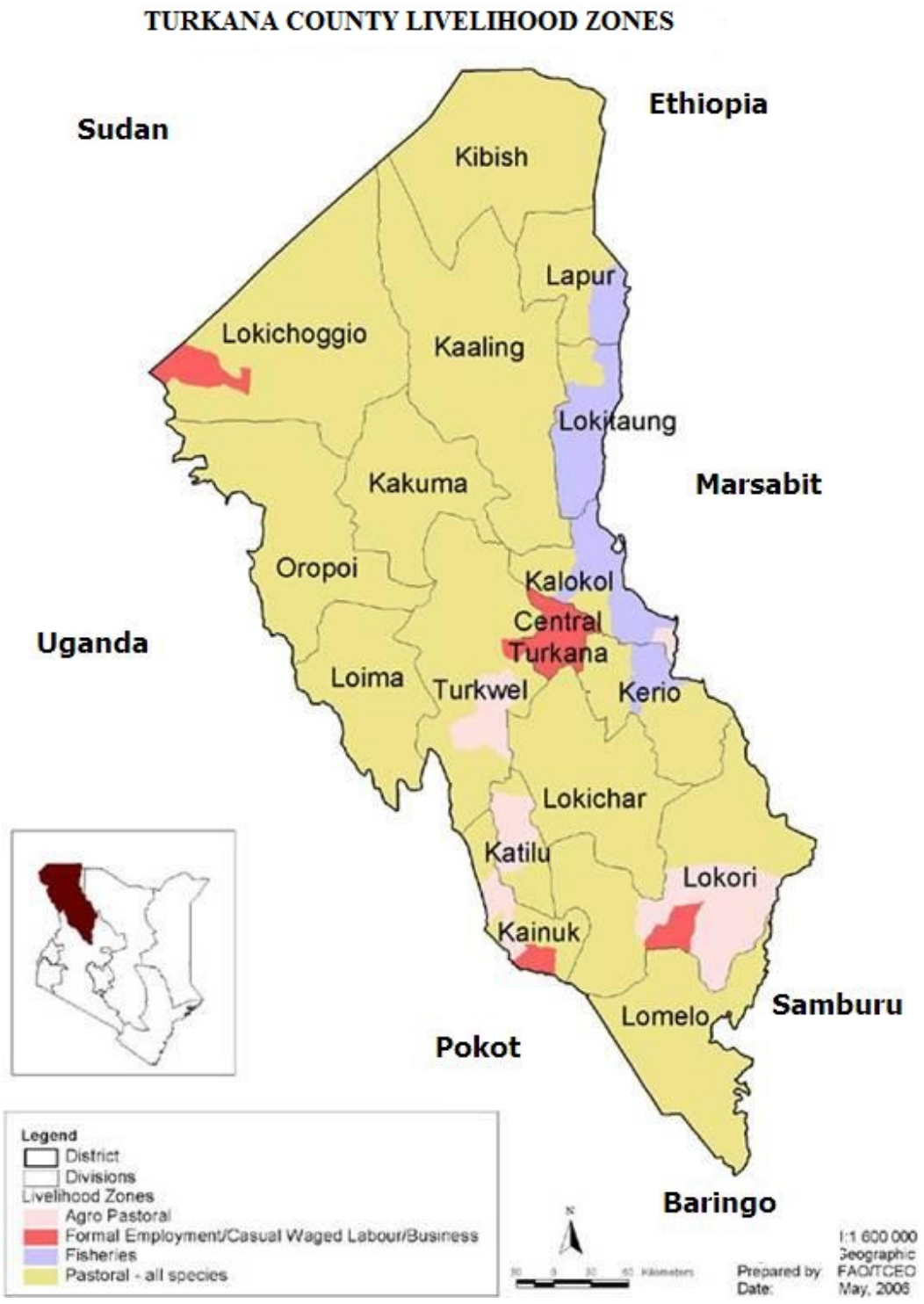
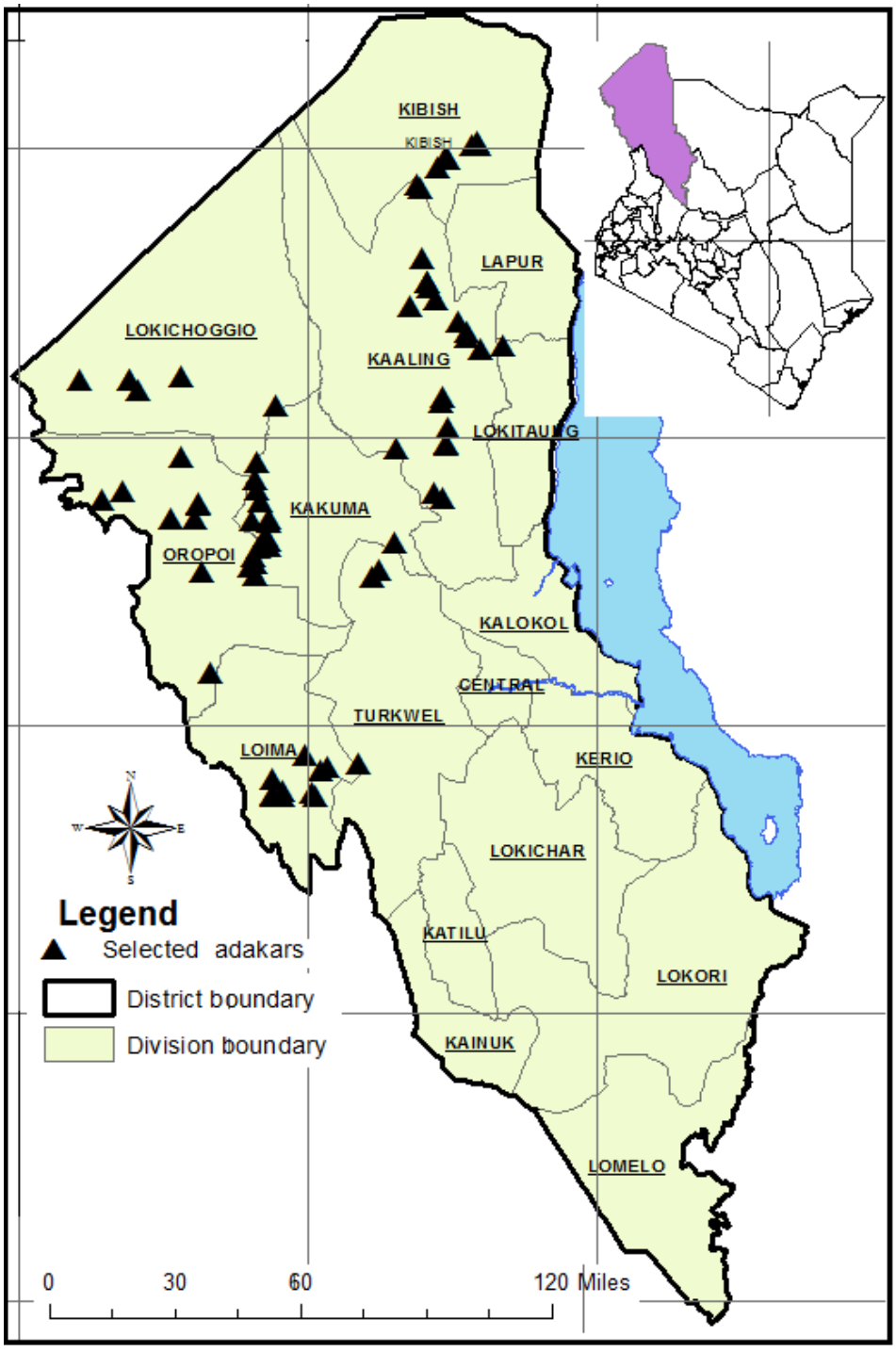


Figure 1: Map of Turkana district with administrative divisions adapted from FAO (2006).

Figure 2: Map of Turkana sampling sites (Kihu et al., 2012b).



Sampling unit and selection of study sites

The sampling unit was a village herd (*Adakar)*. An *Adakar* entails a cluster of often-related Turkana households that pursue similar socio-economic activities such as search for pasture, water and security,

under a trusted leader (Bett *et al.*, 2009). In a preliminary visit to the are,a key informants from local administration and leadership provided information on *Adakars* that had high densities of small stock which became target for sampling. The study sites were selected purposively and were well distributed across the six administrative divisions (Figure 2).

Data collection

Key informants interviews

The study team introduced the purpose of the research to the local chiefs and elders and requested consent to work with the local community before any interview was conducted. To ensure the community did not bias their answers in favor of researcher's disease of choice (Peste des petits ruminants), the introductory-brief to key informants and villagers was made in such way as not to highlight PPR disease but dwelt on generalities of small stock diseases.

Key informants interviews were conducted with local administrative and opinion leaders, staff from Ministry of livestock development and local non-governmental development actors who provided background information on sheep and goat diseases prevalent in the area, the control activities that were ongoing on and security situation. This information was necessary for preparation of checklists to be used in focus group discussions as well as choosing safe areas to carry out the study since Turkana County experiences erratic insecurity incidences. The developed checklists to be used in focus group discussion were field tested and adjusted so as to collect intended data prior to the initiation of the study.

Focus group discussion

Focused group discussions were carried out with a group of 5 to 15 respondents. The discussions were led by a member of study team who was assisted by a local Turkana translator who helped translate between English and Turkana language. The focus group discussions employed various participatory

epidemiology tools to elicit participation and triangulate various responses from the respondents. The key participatory epidemiology (PE) tools used were semi structured interview, simple ranking, matrix scoring and proportional piling, as described by Jost *et al*. (2010) and Catley *et al.*, (2012). A total of 60 focused group discussions were held in all the six administrative divisions

Semi Structured Interviews

Semi-structured interview (SSI) was the main tool used throughout the focused group discussions for collection and probing of general data on small stock diseases, epidemiological clinical and post mortem characteristic(s) of each disease and risk factors associated with the diseases. The SSI was guided by checklist of open-ended questions that provided for structured discussion with the respondents as described by Jost *et al*. (2007) and Ameri *et al*. (2009). The SSI generated a list of small stock diseases including some general characteristics of the diseases of sheep and goats from the Turkana herders.

Simple Ranking

Simple ranking method was used to arrange sheep and goat diseases listed by respondents in order of importance, based on mortality and morbidity of the diseases as described by Ameri *et al.*, (2009). The respondents were asked to give a list of diseases acquired by each of the small ruminant species over a 1-year period prior to the time of the interview. The respondents discussed among themselves and arranged the listed diseases according to the criteria. The respondents often used the local disease names to identify diseases. The names of the diseases and descriptions given by the pastoralists were later triangulated using matrix scoring and information from local veterinary office. Two ranked lists of disease and their characterization were generated, one for sheep diseases and another for goat diseases. The simple ranking method was repeated in 20 village herds (*Adakars).*

Matrix scoring

To better understand the local characterization of the sheep and goat diseases and allocate meaning to local small stock disease names, a disease matrix scoring was used as described by Catley, (2005). The method allowed the herders to show their local perception on association between mentioned diseases and clinical, postmortem signs, risk factors. The process entailed drawing a matrix row after another one.The top six ranked diseases of sheep and goats were used on x-axis (rows) of disease matrix scoring. Clinical, post mortem signs and risk factors generated for each disease during the semi-structured interviews by respondents were used in the y-axis of the disease matrix.

Matrix scoring for disease clinical characterization

Nine clinical signs were used in the sheep disease matrix of which five clinical signs (diarrhoea, depression, ocular discharge, nasal discharge and death) formed the clinical case definition of PPR while each of the other four clinical signs was a common disease sign to any of the other diseases in the matrix. The process was repeated for goat diseases where six top ranked diseases of goats were used in the x-axis of disease matrix. Ten clinical and post mortem signs were used in y-axis of goat disease matrix. Of the ten clinical signs used in goat disease matrix seven were a case definition of PPR (depression, diarrhea, emaciation, coughing, nasal discharge, ocular discharge and death) while three other clinical signs were common to three other diseases in the matrix. Thirty counters were placed on each clinical sign and the respondents were asked to divide the counters to each of the disease in y-axis based on how much that clinical sign is related to that disease. The more a clinical or post mortem sign was prominent in a disease, it was allocated more counters while the less prominent it was with a disease it was allocated less counters. The counters to each disease for each clinical sign were then counted and recorded in a matrix. The method was repeated in 12 *Adakars.*

Matrix scoring for disease risk factor characteristics

Two risk factor matrices one for sheep diseases and another for goat diseases were developed by the respondents. In a similar pattern six top ranked diseases of sheep or goat were placed in x-axis and the

risk factors on the y-axis of disease risk factor matrices. Thirty counters were placed on each risk factor and the respondents were asked to divide the counters to each of the disease in y-axis based on how much that risk factor is related with that disease. The counters for each risk factor were counted and recorded as a matrix. The method was repeated in 10 *Adakars*

Proportional piling

The Turkana perception of herd structure and proportional herd composition as well as PPR impact on sheep and goat herds as demonstrated by relative morbidity and mortalities was generated using proportional piling method as described by Ameri *et al.,* (2009) and Catley, (2005).

Proportional piling for age structure

Respondents provided names of four age groups in goats and sheep. Age categories in sheep were, new born lambs (*imethek*) up to age of 2 months, lambs in the age group between 3 and 5 months (*nanyang*), sheep in middle age group (*amethek nakale*) 6 months to 24 months; and adult sheep (*amethek naapolon*) with age above 24 months. Age categories in goats were new born kids up to 2 months age (*Ikale*); kids in the age between 3 and 5 months (*namenaoei*); goats in middle age group (*akale*) with age between 6 months to 24 months, and adults (*Akine*) with ages more than 24 months. Hundred counters representing a herd of sheep in an *Adakar* were laid on ground. The respondents were asked to divide the counters into the four age groups piles of sheep to determine proportional pile size to depict proportion of that age group in sheep herds. The process was repeated for the goats. The proportional piling for age structure was carried out for both sheep and goats in 27 *Adakars*

Proportional piling for morbidity and mortality

The relative incidence and mortality of PPR (*Lomoo*), was determined relative to other five sheep and goat diseases and a category of “other diseases” that were considered important by the Turkana community. These other five diseases of sheep were sheep pox (*Etune*), anaplasmosis (*Lonyang*), bottle jaw (*Loborbolio*), anthrax (*Lookot*) and foot and mouth (*Lojaa*). Similarly for the goats, five diseases

evaluated alongside PPR (*Lomoo*) were caprine pleuro-pneumonia (*Loukoi),* thin goat syndrome (*Loutogonyen*), diarrhea (*Naosin*), bottle jaw (*Loborbolio*) and babesiosis (*emany*). Using a pile of 100 counters to depict an age group in a herd, the respondents were asked to divide the counters into two piles to show the pattern of sick sheep and healthy sheep during the last one year (2010). The pile of counters representing sick sheep was then sub-divided by the respondents to show the pattern of sheep having each of the diseases listed above plus the "other diseases" category. Each pile of counters representing a disease category was then further sub-divided to show the pattern of sheep dying and surviving for each disease category. When all the six diseases and other disease category were scored, the counters were counted and recorded. This process was repeated for each age group in each species (sheep and goats) and all piles generated were counted and recorded. The exercise was carried out for both sheep and goats in 44 *Adakars.*

Sustainability matrix for PPR local control methods

Turkana community analysis of local PPR control methods was carried out using a sustainability matrix. The several local PPR control methods practiced by Turkana community were debated by the respondents and later listed as follows: tradition hot stone (*Amoru*); local medicinal plants *Egis (Cissus guadrangularis), Emus (Euhorbia Uhligiana), Eichuchuka (Aloe Turkanensi);* Human antibiotic capsules, traditional quarantine/herd isolation and conventional PPR vaccination. Similar livestock disease control methods have been reported in other studies (Ohta, 1984; ITDG and IIRR, 1996; Msafiri, 1996; Bosch 2006). The respondents in the focus group discussion were then provided with disease control sustainability criteria that was initially generated and agreed upon in a key informants' interview. The disease control sustainability criteria composed of the following factors: accessibility of the control measure, its effectiveness in disease control, affordability, ability to use with ease, local knowledge of control method, commitment to provide labour in participation and commitment to finance the control measure. The respondents were given hundred counters and asked to score the sustainability criteria based on their importance. The criterion deemed to be most important got more

counters and thus carried more weight while criterion with less importance got few counters. After weighting the criteria for sustainability of local disease control methods, a matrix was drawn on the ground where the x-axis was represented by PPR control methods while the y-axis had sustainability criteria. Each criterion had counters that represented its weight. The respondents were asked to score the local PPR control methods using counters in each weighted criterion based on its prominence on the control methods. This was repeated for the whole criteria. The scores for each PPR control method were then totaled thus providing a measure of sustainability. The higher the score the more sustainable the disease control method was perceived by local community.

Data management and statistical analysis

Both qualitative and semi-quantitative data were collected in the study. The qualitative data were presented without being subjected to formal statistical analyses. The quantitative data was entered and cleaned in Microsoft Excel (Microsoft Corp., Redmond, WA). It was then exported to SPSS (2008) statistical software version 17.0 (IBM Corp., Armonk, NY) for analysis using non-parametric statistical tests. Analyses were undertaken using descriptive statistical procedures and data summarized using medians to determine central tendency while dispersion was expressed by 10^{th} and 90^{th} percentiles estimation. Analysis of disease ranks entailed conversion of the ranks into scores and summarized using Freidmans test. To determine the significance of association between clinical signs and diseases; risk factors and diseases the Friedman's test was used (Jost *et al*., 2010)

Results

Perception of Turkana herders on ranking and characterization of PPR

The respondents described and ranked the disease of sheep and goats in their Turkana language. The frequency of sheep and goat diseases reported varied slightly between village herds (*Adakars)* though a

trend emerged where PPR *(Lomoo*) featured prominently among the six top ranked diseases in all areas. Table 1 shows the six most highly ranked diseases of sheep from the first to the sixth out of 17 diseases reported. The diseases were: Anthrax, Anaplasmosis, Sheep pox, Acute helminthiasis (possibly hemonchosis), Foot and Mouth disease (FMD), and PPR. Peste des petits ruminants was ranked at position six among sheep diseases. The respondents'association of the sheep diseases with the ranks was statistically significant at $p<0.001$.

Table 1: Top six ranked diseases of sheep

Disease rank	**Disease in English**	***Disease equivalent in Turkana language***
1	Anthrax	*Lookot*
2	Anaplasmosis	*Lonyang*
3	Sheep pox	*Etune*
4	Bottle Jaw due to blood sucking Worm; Heamonchosis	*Loborbolio*
5	Foot and Mouth Disease	*Lojaa*
6	*Peste des petits ruminants*	*Lomoo,*

N=10, Freidman test statistic $\chi 2$ (16)=102.825; $p<0.001$

The top ranked six diseases of goats, out of 27 disease reported, were Contagious caprine pleuro pneumonia (CCPP), PPR, babesiosis, Heavy intestinal worm infestation (chronic helminiathiasis), Thin sickly goat syndrome, Acute helminthiasis (possibly heamonchosis) in that order (Table 2). Peste

des petits ruminants was ranked at position two after CCPP among goat diseases. The respondents' association of the goat diseases and with ranks was statistically significant ($p<0.001$).

Table 2: Top six ranked diseases of goats

Disease rank	Disease in English	*Disease equivalent in Turkana language*
1	Contagious caprine pleuro pneumonia	*Loukoi,*
2	*Peste des petits ruminants*	*Lomoo*
3	Pasteurellosis	*Emany*
4	Heavy worms load, constipation and soiling of anal area	*Naosin*
5	Thin sickly goat syndrome	*Loutogonyen,*
6	Bottle Jaw due to blood sucking Worm; Hemonchosis	*Loborboloi*

N=11, Freidman test statistic $\chi 2$ (26)=150.572; $p<0.001$

Local characterization of PPR by the Turkana herders showed that they were knowledgeable at recognizing symptoms and risk factors associated with the PPR disease in both sheep and goats. The respondents consistently associated through matrix scoring, the symptoms of clinical case definition of PPR as being indicative of PPR. Further, the respondents correctly associated appropriate disease signs with other diseases scored alongside PPR in the matrix scoring. Table 3 shows that the respondents scored highly for diarrhea, depression, ocular discharge, nasal discharge and death to associate these symptoms with PPR in sheep. The respondents' association of the symptoms with PPR was statistically significant ($p<0.001$).

Table 3: Sheep diseases characterization by clinical and postmortem signs using matrix scoring

Clinical signs	Median scores (10th and 90th percentiles in parenthesis)					
	Loborbolio	*Lojaa*	*Loyang*	*Lookot*	*Loomo*	*Etune*
Diarrhoea***	0 (0, 15.6)	0 (0,11.2)	0 (0,0)	0 (0,7)	16 (0,30)	0 (0.8)
Depresion***	1 (0, 6.6)	7 (.4, 11.2)	2 (0,7.8)	0 (0,21.2)	12 (4.4,22)	0 (7.6)
Pox lesions***	0 (0,0)	0 (0,0)	0 (0,0)	0 (0,0)	0 (0,0)	30 (30,30)
Bottle jaw ***	30 (19.6, 30.0)	0 (0,5.6)	0 (0,0)	0 (0,0)	0 (0,4.8)	0 (0.0)
Alopecia *	0 (0,0)	0 (0,0)	0 (0,0)	0 (0,0)	0 (0,7.2)	0 (0,30)
Yellow meat***	0 (0,0)	0 (0,0)	30 (6,30)	0 (0,0)	0 (0,0)	0 (0,0)
death***	3 (0,14.4)	2 (0, 3.8)	3 (.2, 9)	6 (1.2,13.2)	10 (2.2,19.4)	3 (.2,6.8)
ocular discharge***	0 (0,8.8)	14 (0,24.8)	0 (0, 4)	0 (0,3.2)	13 (5.2,30)	0 (0,6.8)
Nasal discharge***	0 (0, 13.8)	7 (0,23.6)	0 (0,7)	0 (0,4.8)	16 (5.4,30)	0 (0,4.0)

*P<0.05;**P<0.01; ***P<0.001. No asterix means P>0.05

Table 4: Goat diseases characterization by clinical and postmortem signs using matrix scoring

Clinical/PM signs	Median scores (10th and 90th percentiles in parenthesis)					
	Loborbolio	*Emany*	*Loukoi*	*Loutogonyen*	*Naosin*	*Lomoo*
Emaciation ***	2.5 (0,6)	0 (0,5.4)	0.5 (0,4.7)	4 (0.6,9.1)	7.5 (3.3,12.4)	12 (7.9,19.1)
Bottlejaw***	27 (3.9,30)	0 (0,0)	0 (0,0)	0 (0,8.8)	0 (0,18.2)	0 (0,13.7)
Alopecia	0 (0,21)	0 (0,0)	0 (0,0)	0 (0,0)	0 (0,21)	0 (0,21)
Coughing***	0 (0,0)	0 (0,8.4)	24 (18.3,30)	0 (0,2.1)	0 (0,0)	4.5 (0,10.4)
Enlarged liver***	0 (0,6.3)	30 (13.1,30)	0 (0,16)	0 (0,8.4)	0 (0,0)	0 (0.0)
Death***	1 (0,3)	2.5 (.3,8.8)	7.5 (3.6,13.5)	3(1,6)	3 (.3,6)	12 (5.6,16)
Diarrhoea***	1 (0,10.9)	0 (0,1.4)	0 (0,0)	4 (0,9.7)	14.5 (5, 23.1)	10 (0,19.7)
Ocular Discharge***	0 (0,4.8)	0 (0,0)	0 (0,0)	10.5 (.9,23.1)	0 (0,6.4)	14.5 (1.8,24)
Nasal discharge***	2 (0,10.7)	0 (0,0)	0 (0,6.1)	6.5 (0,11.8)	1.5 (0,17.5)	16.5 (5,27.3)
Depression***	0 (0,7.1)	0 (0,8.1)	1 (0,8)	1 (0,7.4)	4 (0,9.4)	17.5 (11.6,30

*P<0.05;**P<0.01; ***P<0.001. No asterix means P>0.05; PM=post mortem

The respondents' characterization of the diseases of goats scoring clinical and post mortem signs. The respondents again scored highly for emaciation, depression, nasal discharge, ocular discharge, and diarrhea as symptoms strongly associated with PPR in goats. A further clinical sign associated with PPR in goats was cough, though it was not highly scored (Table 4). Just like for the sheep diseases, the respondents correctly and strongly associated appropriate disease signs with other diseases scored alongside PPR in goats in the matrix scoring. The respondents' association of the clinical signs with PPR was statistically significant ($p<0.001$).

Characterization of sheep and goat diseases by risk factors.

Risk factors identified and scored by respondents for PPR in sheep were: long rain season (*Akiporo*), dry season (*Akamu*), all age groups except new born lambs, migration, herd mixing and raids (Table 5). The respondent scored highly for migration, dry season (*Akamu*), raids, herd mixing and all age groups except the newborn lambs. Wet season (*Akiporo*) was scored marginally. The respondents associated seasonal risk factors with PPR in sheep; long rain season (*Akiporo*), dry season (*Akamu*) showed a statistical significance ($p<0.01$). The association of herd migration as a risk factor for PPR in sheep was statistically significant ($p<0.001$). Other risk factors that had statistical significance ($p<0.01$) for association as risk factors of PPR in sheep were raids and herd mixing. The respondents association of adult age group, middle age group and older kids age group as risk factors for PPR in sheep did not have any statistical significance. However association of newborn kids with the diseases as a risk factor was statistically significant ($p<0.001$).

Table 5: Sheep disease characterization by risk factors and seasonality using matrix scoring

Risk Factors	Median scores (10th and 90th percentiles in parenthesis)					
	Loborbolio	*Lookot*	*Lomoo*	*Etune*	*Lonyang*	*Lojaa*
Wet Season *(Akiporo)***	3.5 (0,14.1)	11.5 (.8,28.7)	0.5 (0,12.7)	2 (0,8.6)	4 (0,9)	3 (0,14.1)
Start of dry season *(Ait)*	1 (0,14.6)	1.5 (0,28.3)	0 (0,12)	2 (0,14.2)	5 (0,17.9)	0.5 (0,27.7)
Dry season *(Akamu)***	9.5 (0,14)	0 (0,9)	8 (0.4,20.6)	6 (.2,9)	1 (0,6.8)	0.5 (0,8)
Start of wet season *(Akicheres)*	0 (0,11.4)	4.5 (0,15.7)	0 (0,28.4)	6.5 (0,11.6)	2 (0,9.8)	3 (0,15.6)
Adult *(Namanjong Amethek)*	6.5 (2.1,13.8)	4.5 (.1, 12.6)	5.5 (0,15.7)	5.5 (2.1,7.8)	4 (.2,7.9)	2.5 (.1,8.5)
Young adults (*Nakale)*	4 (1.1,12.6)	4 (.2,7)	5.5 (0,14.4)	7.5 (3.1,12)	3.5 (.1,9.6)	3 (.1,8.8)
Older lambs *(Nanyang)*	2 (0,6.8)	3.5 (0.13.6)	3.5 (0,8.7)	5 (0,11.8)	4 (0,14.3)	2 (0,18.6)
New born lambs (*Imethek*)***	0 (0,3.9)	0 (0,10.4)	0 (0,20)	11 (.9,28.8)	1.5 (0,11.5)	0 (0,17.9)
Fleas	0 (0,30)	0 (0,3.6)	0 (0,27.8)	0 (0,27.8)	0 (0,16.7)	0 (0,3.6)
Migration***	1 (0,7.8)	3.5 (0,12.6)	10 (2.1,14.8)	6 (2.1,17.1)	2 (0,4)	4.5 (3.1,14.9)
Herd mixing**	2 (0,4.9)	3.5 (0,8.6)	6.5 (0,15.4)	9.5 (3.2,16.7)	1 (0,5)	3 (0,11.4)
Raids**	2 (.1,5.9)	2.5 (0,5.9)	7 (.3,15.5)	6.5 (3.1,16.7)	1 (0,7.9)	7 (.3,16.6)
Ticks	0 (0,5.9	0 (0,21.3)	0 (0,2.79)	0 (0,5)	0 (0,22)	0 (0,27.3)
Toxic plants***	0 (0,2.7)	17.5 (0,30)	0 (0,4)	0 (0,10.5)	2 (0,13.7)	0 (0,3.8)
Mountain Pasture & water	5 (.1,18.5)	3.5 (0,12.9)	0 (0,8)	4.5 (0,7.9)	4.5 (0,7.9)	5.5 (1.2, 12.4)

*P<0.05;**P<0.01; ***P<0.001. No asterix means P>0.05

Table 6 shows that the respondents considered seasonality (all seasons), all age groups, livestock movements which entails herd migration, herd mixing and raids as well as environmental factors, such as toxic plants and mountainous pastures, as risk factors of PPR in goats. Dry season was the most highly scored risk factor followed by raids, young adults age group, herd mixing, start of dry season, mountainous pasture, adult age group, young adults age group, older kids age group, migration, long rainy season, short rainy season and toxic plants, in that order. Except for short rainy season all the other seasons were shown to have significant association (*Akiporo* and *Akamu* $p<0.001$ while *Ait* $p<0.01$) with the goat diseases. The association of goat age groups with diseases was statistically significant ($p<0.001$ for adults, young adults and older kids while $p<0.01$ for new born kids). The association of herd mixing, migration and raids with goat diseases was statistically significant at $p<0.001$. The respondents association of environmental factors with diseases was statistically significant with Toxic plants having a significance of $p<0.05$ while mountainous pasture and water had a significance of $p<0.001$.

Turkana perception of PPR incidence and mortality in sheep and goats

The estimated incidences, mortality and case fatality of PPR in sheep and goat age groups are illustrated in Tables 7 and 8.

In sheep, the relative incidence of PPR (Table 7) varied from 19% (9.87, 40) in young adults (*Nakale*) to 25% (11.4, 40.8) in adults (*Amethek Naapolon*). The relative mortality ranged between 16% (7.3, 37.1) in young adults (*Nakale*) and 20% (7.8,34.9) in adults (*Amethek Naapolon*). Case fatality was highest in young adults (*Nakale*) at 84.2% (68,100).

Table 6: Goat diseases characterization by risk factors and seasonality using matrix scoring

Risk factor	Median scores (10th and 90th percentiles in parenthesis)					
	Loborbolio	*Naosin*	*Loutogonyen*	*Loukoi*	*Emany*	*Lomoo*
Wet season *(Akiporo)***	1 (0,7.7)	4 (.1,14.4)	1 (0,2)	12 (.7,15.8)	4.5 (.2,11.7)	6 (0,12.7)
Start of dry season (*Ait*)**	1.5 (0,7.8)	9 (3.2,13.9)	3 (0,9.7)	4 (2.1,14.4)	1.5 (0,8.6)	7 (0,15.7)
Dry season (*Akamu*)***	4 (0,6.9)	5.5 (3,12.5)	4 (1.1,10.7)	4 (0,10.8)	0 (0,2.8)	9.5 (6,15.9)
Start of wet season (*Akicheres*)	3 (0,17.8)	3 (.1,12.5)	2 (0,6)	11 (0,20)	3 (0,9.7)	5.5 (0,10.8)
Adult (*Akine Naapolok*)***	3.5 (.1,6.9)	4.5 (2.1,7)	3 (2.1,4.9)	8.5 (7,11.9)	3.5 (1,9.5)	6.5 (.5,8.9)
Young adult (*Naakalei*)***	2 (0,6.7)	4 (2,9.7)	4.5 (1.1,7.8)	8 (5,15.8)	2.5 (0,7.5)	7.5 (5,10.9)
Older kids (*Nanyang*)***	1.5 (0,4)	2.5 (0,6.9)	3.5 (0,5)	6 (0,15.6)	0 (0,2)	6.5 (0,15.7)
New born kids (*Ikale*)**	0 (0,3.7)	6 (0,14.8)	4.5 (0,18)	9.5 (0,20.4)	0 (0,6.6)	6.5 (0,28)
Fleas	0 (0,6.6)	0 (0,3.6)	1.5 (0,30)	0 (0,3.6)	0 (0,4.5)	0 (0,22.1)
Migration***	1 (0,2.9)	4 (2,13.6)	3.5 (2,14.9)	10 (.7, 17.8)	3.5 (0,7.7)	6 (.4,9)
Mixing***	0 (0,3)	3 (0,5)	3 (0,5.9)	16 (9.1,20.7)	.5 (0,5.9)	7 (5,11.7)
Raid***	0 (0,5.7)	3 (0,4.9)	2.5 (0,5.9)	13 (9,29)	0 (0,5.9)	7.5 (.5,12.7)
Ticks	0 (0,3.6)	0 (0,0)	0 (0,29)	0 (0,27)	0 (0,0)	0 (0,27.6)
Toxic plants*	0 (0,2.9)	8.5 (0,19.7)	1.5 (0,4.9)	0 (0,14.7)	8 (0,17.4)	4 (0,14.3)
Mountain pasture and water***	1 (0,7.7)	0 (0,9.6)	0 (0,2)	13 (6.2,28.8)	3 (0,12.7)	7 (0,12.9)

*P<0.05;**P<0.01; ***P<0.001. No asterix means P>0.05

Table 7: Relative incidence, mortality and case fatality due to PPR in sheep of Turkana

	Median scores (10th and 90th percentiles in parenthesis)			
	New born Lambs (*Imethek*)	Older lambs (*Nanyang*)	Young Adult (*Nakale*)	Adult (*Amethek Naapolon*)
Estimated Incidence of PPR	20 (7, 38)	20 (10, 40.4)	19 (9.87, 40)	25 (11.4, 40.8)
Mortality of PPR	17 (5.4, 31)	17 (6.5, 34.9)	16 (7.3, 37.1)	20 (7.8, 34.9)
Case fatality due to PPR	80.8 (59.2,98.8)	80 (60,100)	84.2 (68,100)	83.3 (62,96)

The estimated relative incidences of PPR in goats (Table 8) ranged between 17.8% (8.5, 32.1) in new born kids (*Ikale*) and 20.9% (10.4,36) in adults (*Akine*). Relative mortalities varied from 14.2% (6.1, 28.6) in newborn kids (< 2 months of age *Ikale*) to 17% (5.5, 25.5) in older kids (>2 but <6 months *namenaoei*). Case fatality was highest in young adults (>6 but <24 months *Akale*) at 84.5% (58.6, 100).

Table 8: Relative incidence, mortality and case fatality due to PPR in goats of Turkana

	Median % scores (10th and 90th percentiles in parenthesis)			
	New born kids (*Ikale*)	Older kids (*Namenaoei*)	Young adult (A*kale*)	Adults (*Akine*)
Estimated Incidence of PPR	17.8 (8.5, 32.1)	20.5 (8.4, 31)	20 (9.5, 30)	20.9 (10.4, 36)
Mortality of PPR	14.2 (6.1, 28.6)	17 (5.5, 25.5)	16.3 (6.5, 26.5)	16.66 (7.5, 35)
Case fatality due to PPR	83 (62.9,100)	79.1 (57.2,98.4)	84.5 (58.6,100)	82.8 (57.3,100)

Sustainability matrix of PPR local control methods

The focused group discussions established that the Turkana community in their own way and based on their local knowledge have attempted to put measures of controlling PPR in their herds. The Table 9 below lists six approaches of PPR control practiced by the Turkana community each scored against the sustainability criteria. Human antibiotic capsules had a high score of 15.92, Aloe is the second highly scored control method with a score of 15.74, traditional massage hot stone (*Amoru*) is third with 13, *Cissus guadrangularis (Egis)* has a score of 12.79, PPR vaccination has a score of 12, *Euhorbia Uhligiana (Emus)* a score of 11.91 and local quarantine/self restriction or community sanctions 9.83 points (Table 9).

Table 9: Sustainability matrix of PPR control methods as perceived by Turkana community

	Runaway/self or community sanctions	*Cissus guadrangularis (Egis)*	*Euhorbia Uhligiana (Emus)*	Hot stone	Antibiotic Capsules	Aloe *(Aloe Turkanensi)*	Vaccine
Access	2 (.99, 5.52)	2.88 (1, 5.2)	2.88 (.8, 6.2)	3 (.96, 5.95)	2 (0, 5)	3 (1,5.2)	1 (0, 2,91)
effectiveness	2 (0, 4.8)	2 (0, 3.2)	1.02 (0, 3)	2 (0, 6.7)	2 (0, 9.2)	2.04 (.77, 5.2)	3 (1, 6)
Affordability	1 (0,2.93)	2 (0.3.22)	2 (0, 3.1)	2 (0,5.03)	2 (0, 4.4)	2 (0, 3.2)	1 (0, 3)
Easy to use	1.83 (.99, 5.36)	2 (.98, 5.2)	3 (.74, 5)	3 (.95, 5.4)	2 (0, 5.4)	3.7 (1.02, 6)	1 (0, 2)
Local knowlegde	2 (.99, 4.2)	2 (.8, 4.02)	2 (.73, 3.45)	2 (.99, 5)	2 (0, 6.2)	3 (1, 5)	1 (0, 3.2)
Labour commitment	1 (0, 2.37)	1.9 (0, 3.01)	1 (0, 3.01)	1 (0, 3.32)	1.92 (0, 4)	1.92 (0, 4)	2 (0, 4.48)
Finance commitmemt	0 (0, 2.23)	0 (0, 2.18)	0 (0, 2.52)	0 (0, 2.12)	4 (0, 6)	0 (0, 4.2)	3 (0, 6)
Final aggregate score	**9.83**	**12.79**	**11.91**	**13.00**	**15.92**	**15.74**	**12.00**

Discussion

The Turkana community listed and described various diseases that affected their sheep and goats. A key disease that featured prominently in their description of diseases was Peste des petits ruminants (*Lomoo).* Peste des petits ruminants was described as disease that made the sheep and goats depressed hence the *Lomoo* naming which etymologically is derived from action of looking sickly and depressed. Other names used to describe depression in goats and sheep, associated with PPR were *Ekitowo* and *Loutogonyen,* literally meaning sick goat syndrome though condition named *Loutogonyen* had other signs such as sunken eyes and emaciation (Kihu *et al*., 2012a; Ohta, 1984).

The PPR disease was associated more with goats where it was highly ranked after contagious caprine pleuro -pneumonia. In sheep, the PPR disease was ranked the sixth among other sheep diseases. The Turkana community clearly characterized PPR by associating the disease with key clinical signs signifying that the community had witnessed and experienced the disease in their herds. In both sheep and goats, the Turkana community prominently associated PPR with migration, herd mixing and raids. This must have come from observation and realization that some goats and sheep, individually or as herds, introduced into new herds must have spread the PPR infection to the herds that hosted them. The community analyzed the seasonality of PPR where the disease in goats was associated with all seasons while the disease in sheep was associated with dry season only. However, even in the goats, PPR disease was significantly noted to be associated with dry season. Activities associated with dry season such as migration and herd mixing in formation of *adakars* for search of pastures and water, were seen to encourage the emergence of PPR in small stock. Livestock raids were known to be practiced throughout the seasons and could contribute to the emergence of PPR disease in all seasons. Key environmental features associated with PPR disease in goats were: toxic plants and mountainous pasture and water during dry season. However after probing of respondents, it was established that during dry season the small stock, particularly goats, were migrated to the high mountainous ranges that had some remaining pastures and water trapped between rocks. These dry season grazing areas in the mountains offered

opportunity for extensive mixing of small stock from different herds during watering and grazing, providing for opportunity of infected small stock to make contacts with susceptible herd thus spread PPR infection. Such PPR infection, got during grazing in highlands, were thus blamed on the mountainous plants and water trapped in the rocks. Though the community's appraisal of PPR associated the disease with all age groups in goats and sheep, except lambs, it was interesting to note that discussion on morbidity and mortality due to PPR included all age groups in both sheep and goats. Despite PPR being ranked sixth in sheep diseases, the community perceived PPR to have higher morbidity, mortality and case fatality than any other sheep disease. Same appraisal of PPR morbidity, mortality and case fatality was observed in goats.

The Turkana community has devised ways of controlling the rampaging PPR disease. Their approach to disease control is based on local knowledge of what works best either for PPR or other diseases. The local hot stones and herbs used by Turkana such *Cissus guadrangularis (Egis), Euhorbia Uhligiana (Emus)* and Aloe *(Aloe Turkanensi)* are also used for treatment of other livestock disease and therefore are not specific treatment for PPR. Human antibiotic capsules are commonly used by local community in treatment of contagious caprine pleura-pneumonia and other bacteria ailments with varying degree of success. It is from this experience that community experimented and treated against PPR with the herbs, capsules and hot stones. It was observed that the community had recognized two scientifically proven control measures; being community imposed quarantines to keep away sick herds and create sanitary cordon as well as vaccination. However these two control measure were ranked lowly in the sustainability matrix. The reason for ranking community imposed quarantines lowly was established to be the high cost of policing and ensuring sanctioned herds were kept away. Enforcing the sanctions at times resulted to insecurity as sections of community with sick herds felt marginalized and curtailed from accessing grazing resources due to a disease that was not their fault. Vaccination though scored highly on effectiveness and community being ready to commit financial resources in undertaking vaccination; was overall scored poorly on other criteria. It was noted that the community had little knowledge about the

PPR vaccination process and it was perceived as high technology that was only available from Nairobi on request by local veterinarian. Experience with forced vaccination for other diseases particularly during dry season when community was more bothered by drought has also created negative perception of vaccination.

It is thus important that local development actors, county government and national government should strengthen local structures in enforcing community lead quarantines and movement control because when government institutes quarantines a lot of criticism is generated from civil societies that support livestock market development accusing government of creating artificial market barriers for pastoral livestock. Similarly livestock extension services should be enhanced to demystify and create positive perception of PPR vaccination process particularly now that community appreciate that vaccines are effective and are ready to commit resources towards vaccination process.

This appraisal of PPR by the Turkana community, through the various participatory epidemiology appraisal tools, yielded a description of the PPR disease that was compatible with veterinarian scientific description of PPR.

Conclusion

Peste des petits ruminants is a plague that has seriously affected the Turkana community. As such the disease could not escape community scrutiny since it touched on livestock, the core of Turkana community survival. The Turkana community has thus developed a very comprehensive description of PPR disease based on how they have observed the disease affect their small stock. In the marginal arid pastoral areas of Kenya, where insecurity is prevalent alongside poor communication infrastructure, hard scientific and socio economic data is difficult to come by. However it has been observed from this study that pastoral communities who live in these marginal areas have wealth of knowledge which can be

tapped using appropriate participatory tools. Peste des petits ruminants, being a disease of major international concern, its control and eradication will depend partly on strong surveillance system. It has also been established local community appreciate vaccination as effective control method of PPR and are ready to commit themselves financially in control process if guided well and provided necessary information.

It is worth noting that this study has illuminated further the need to utilize the wealth of indigenous knowledge on diseases of livestock that reside with pastoral communities, for purposes of understanding diseases in the community and setting up strong participatory surveillance systems that involve the communities as the basic element of disease surveillance intelligence gathering.

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