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Research article

Economic losses associated with peste des petits ruminants in South Kivu Province of Democratic Republic of Congo

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Abstract

Peste-des-petits-ruminants (PPR) is a major economic disease affecting the pastoral herders in Democratic Republic of the Congo, with outbreaks in South Kivu province having devastating effects on the Mwenga, Shabunda, Fizi and Kalehe zones livelihoods. However, there is limited available data on livestock diseases and economic analysis in South Kivu. This study has attempted to estimate the direct economic loses occasioned by outbreaks of *PPR* based on perceived loss of benefits experienced by the South Kivu small ruminants holders from 2011-2016. It therefore targeted only small ruminant's farmers who are keeping both goats and sheep and have reported the PPR outbreaks in their farms. Secondary data, informal interviews and focused group discussions using participatory epidemiology methods were used for the analytical model. Results showed that the daily losses associated with morbidity due to PPR were estimated at US$30.2 for sheep and 37.1$ for goats per farmer and approximatively US$11 for sheep and US$121 for goats due to mortality rate associated with PPR suspicion per farmer. Mortality and morality rates due to PPR in South Kivu were estimated respectively 31 and 22% in sheep and 51 and 49% in goats. PPR has serious economic impacts on pastoral livelihoods in South Kivu especially when you consider its annual economic loss. This study strengthens the basis for developing a system for the economic assessment of livestock diseases.

Keywords: DR Congo; Economic losses; Participatory epidemiology; *Peste-des-petits-ruminants;* South Kivu

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Introduction

Peste-des-petits-ruminants (*PPR)* is a major economic disease of goats and sheep affecting the pastoral herders in Democratic Republic of the Congo. PPR is a highly contagious viral disease primarily affecting goats and sheep and creates epidemics that can cause high mortality of 90% in immunologically naive sheep and goat populations, resulting in significant negative socio-economic impacts (Munir et al., 2013). PPR is a major threat to small ruminant production and is ranked by pastoral communities among the top 10 diseases of small ruminants (Diallo, 2006).

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The economic losses of PPR outbreaks in Kenya during the outbreaks of 2006 and 2007 were estimated to have been over US$ 15 million (Nyamweya et al., 2009). After successful global eradication of rinderpest, there were calls for the progressive control or eradication of PPR at regional or global level (Elsawalhy et al., 2010; Anderson et al., 2011; Baron et al., 2011). In 2011, the World Organisation for Animal Health (OIE) and the United Nations Food and Agriculture Organization (FAO) started to discuss the possibility of progressive control of PPR which could lead to its eradication. A PPR working group was formed and a good number of countries started national PPR control programmes such as India, Pakistan, China and the Kingdom of Saudi Arabia. In March 2015, OIE and FAO officially launched a new programme of Global eradicate of PPR by 2030 (http://www.oie.int/eng/ppr2015/ background.html) and presented a global control and eradication strategy (OIE-FAO, 2015). Simultaneously, the same report has shown that *PPR* can severely affect small ruminants in almost 70 countries in Africa, the Middle East and parts of Asia and the disease can cause the loss from USD 1.5 to 2 billion each year in regions that are home to over 80% of the world's sheep and goats and to more than 330 million of the world's poorest people, many of whom depend on them for their livelihoods. Moreover, 50 other countries are considered to be at risk for PPR and in May 2014, only 48 countries in the world were officially recognized by the OIE as PPR free (OIE-FAO, 2015).

The estimated current expenditure on PPR vaccination ranges between USD 270 and 380 million per year. However, Jones et al. (2016) in their study on the benefit-cost analysis of the economic impact of eradicating PPR suggested strong economic returns from PPR eradication. Based on a 15-year programme with total discounted costs of US$2.26 billion, they have estimated discounted benefits of US$76.5 billion, yielding a net benefit of US$74.2 billion.

The Southern African Development Community (SADC) report in 2012 showed that since the emergence of PPR in Democratic Republic of Congo from 2010 to June 2012, it has caused the death of almost 120,000 small ruminants (SADC, 2012a). Moreover, an estimation of around one million goats and 600,000 sheep are at risk of contracting PPR, representing one-quarter of goats and two-thirds of sheep throughout the entire country. The annual direct loss due to *PPR*, i.e., value of dead sheep and goats is estimated to be US$5.3 million (SADC, 2012b). Given that PPR has already been targeted by FAO and OIE as a major priority disease for global eradication, and DRCongo is one of the SADC countries where data on the economic impact due to PPR are still not well documented despite several reported sporadic outbreaks. This study aimed at estimating the economic implications of PPR in South Kivu province in Eastern of DRCongo.

Materials and Methods

Survey area

This survey was conducted in four know pastoralist counties including Mwenga, Shabunda, Fizi and Kalehe regions in South Kivu province, located in the East of Democratic Republic of the Congo where several sporadic outbreaks of PPR have been reported since 2008 (Fig. 1) (FAO, 2012a and b). South Kivu province is located at 3.0167° S, 28.2667° E. The size area is about 65070 km^2, total population size of 4614768 (71persons per km^2). Koppen-Geiger Climate classification system classifies its climate as tropical wet and dry (Aw) and the altitude is 1531 m above the sea level with an average rainfall of about 1 500 mm with more than 50 % of the total land used for grazing (Central Intellence Agency, 2014).

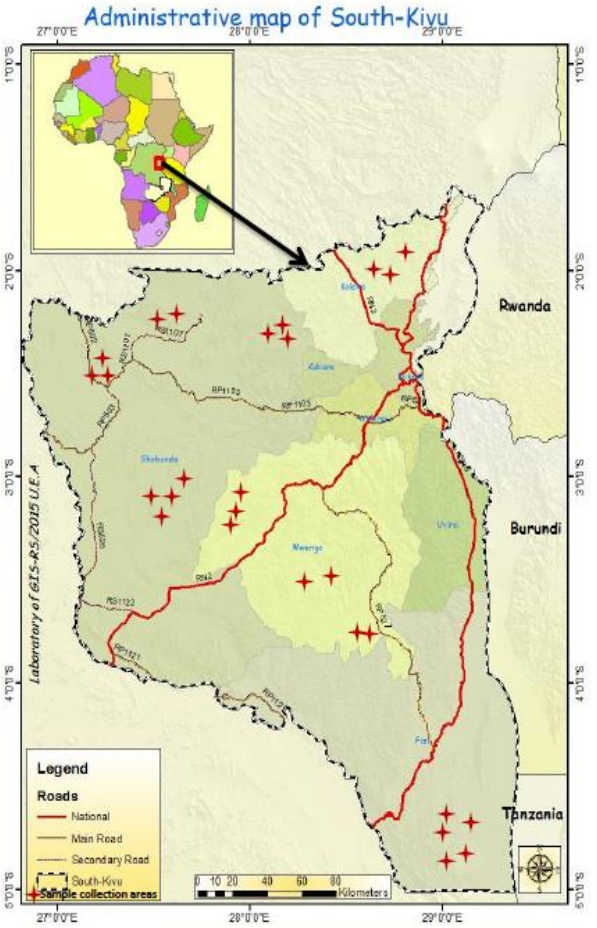

Fig. 1: Map of South Kivu presenting the sampling areas in stars.

Data collection

The four regions (clusters) were selected purposively based on the current or previous reports of PPR in that area. The sample size in each cluster was determined by the proportional probability method using a formula proposed by Jost et al. (2010) and Catley et al. (2012).

$n_{zone} = Pi / Pt \times N$

Where; n_{zone} = sample size per area; Pi is the number of farmers who had experienced the PPR in the past 5 years (2011-2016) and who kept both goats and sheep; Pt is the total population of small ruminant farmers in the whole study environment and N is the total sample size predetermined for the study. Due to accessibility of data and available funds, 50 farmers/respondents respectively in Kalehe and Fizi and 40 were randomly selected in Mwenga and Shabunda. The survey was done using a structure questionnaire.

Data were gathered from key informants through interviews and pastoralists through discussions guided by lists of open and closed questions pre-tested and adjusted prior to the start of the study. Animal value parameters were estimated from secondary data where the value of sheep and goats per unit of tropical livestock (TBU) were estimated at $ 150 (Mude et al., 2010).

Data analysis

The mortality and morbidity rate due to PPR was determined using the following formulas:

Mortality rate (%) = Number of dead animals (past 5 years) due to PPR / Total number of animals possessed × 100

Morbidity rate (%) = Number of survived animals with low economic value due to PPR / Total number of animals possessed × 100

The evaluation of the economic impact of PPR was carried out through two strategies: Direct and indirect costs due to PPR. Direct costs were those related to mortality or morbidity. The direct costs related to mortality included: The number of dead animals by age group **(n),** the average selling price of an animal **(pa)**. The monetary value of mortality losses M was the product of these two parameters and it was calculated using the following formula;

$M = n \times pa.$

The direct costs related to morbidity were characterized here by the weight losses linked to the disease but also the abortions. In one hand considering the weight losses, these costs included the estimated average loss of weight per animal expressed in kg (na), the number of animals that have lost weight (N), the average selling price of kg to market (p). The calculation of direct costs related to morbidity by weight loss P was therefore:

$P = N \times n \times p$

In the other hand considering morbidity due to abortions, these costs included the number of females having aborted (Na), the cost of abortion (C), generally estimated from the cost of a lamb / kid. The calculation of direct costs related to morbidity due to abortions A was therefor;

$A = Na \times C$

Thus the direct costs associated with morbidity M' was then calculated using the following summary formula;

$M' = P + A$

The indirect costs had negative impacts on PPR, other than mortality and production losses. These costs were not taken into account because of they are difficult to quantify.

The raw data collected during the survey were encoded in the Excel spreadsheet. The analysis was done with XLSTAT and STATIX software. Apart from the descriptive statistics, the KHI TWO test was used to determine the statistical relationship between the qualitative values. The ANOVA test helped to check whether some quantitative parameters varied significantly according to the surveyed zones and species.

Results

Trade of small ruminants

Small ruminants "considered as mobile banks" and referred to "poor's man cow", are for income generation for many African farmers. Moreover, goats and sheep can easily and quickly be mobilized to ensure household expenditures. Very little has been documented on the trade of goats. However, very little has been documented on the trade of goats in many African countries. It was found that 99.5% of investigated farmers were selling their animals due to the financial need of the household. The animals sold were in cash (98.75%). The selling periods varied, but in general, 80.32% of farmers confirmed that animals were sold throughout the year (p-value> 0.05). Only 11.3% of farmers were selling the animals strictly during the annual start of school, which occurrs usually in September every year and 8.06% of interviewed were selling their animals only during the busy days (Table 1).

Table 1: Trade of small ruminants (goats and sheep) in South Kivu

Parameters	Levels	South Kivu				Mean	$\chi 2$	p-value
		Kalehe	Fizi	Mwenga	Shabunda			
Animal selling	*No*	0	2	0	0	0.5	2.61	0.46
	Yes	100	98	100	100	99.5		
Animal Selling period	*Not selling*	0	2.00	0.00	0.00	0.5	9.40	0.40
	Busy days	6	10.0	5.88	10.34	8.06		
	Starting school	10	4.00	9.80	20.69	11.1		
	Whole year	84	84.0	84.3	68.96	80.3		
Selling purpose	*Not selling*	0	2	0	0	0.5	2.61	0.45
	Need of money	100	98	100	100	99.5		
Terms of sale	*Paid in debts*	0	5	0	0	1.25	2.60	0.46
	Paid in cash	100	95	100	100	98.7		
Selling place	*Not selling*	0	2	0	0	0.5	6.32	0.71
	Home	12	14	19	17.2	15.5		
	Near Market	26	34	31.4	20.7	28.1		
	Market far	62	50	49.1	62.1	55.8		
Selling methods	*Not selling*	0	2	0	0	0.5	-	-
	Based on weight and sex	100	98	100	100	99.5		

Table 2: Selling price of small ruminants in South Kivu

Regions	Animals sell annually	Selling Price (USD)	Minimum selling price	Average Selling price	Maxim selling price
Kalehe	1.5±0.6	52.2±8.3	27.9±5.4	37.8±5.4	63.6±6.2
Fizi	1.7±0.8	49.1±10.2	27.02±6.3	34.7±8.5	61.4±14.1
Mwenga	1.9±0.8	51.8±7.1	28.4±4.0	36.8±6.4	62.8±5.6
Shabunda	1.8±0.8	55.5±7.6	27.9±4.5	36.7±5.5	64.3±4.7
Gen. Mean	1.7±0.8	52.2±8.3	27.8±5.1	36.5±6.5	63.0±7.7

USD: United state of American dollars.

Moreover, we found that animals are sold in most cases in the market located at a far distance (55.77%). About 28.02% of farmers brought their animals to a near market within the same village and only 15.56% of farmers were selling the animals at home (Table 1). 99.5% of farmers in the study area confirmed that animals were sold and the price were determined based on the animals weight, sex and age. The difference between all the evaluated parameters regarding the sale of animals and their specific levels were not significant (P>0.05).

Selling price of small ruminants

The results showed that there was a low rate of selling animals (1.7 ± 0.8) per year during the last 5 years. This might to be due to high mortalities and morbidities rates observed during the past five years due to diseases. The selling price was valued at an average of $ 52.2. The average minimum selling price was $ 27.8, the average selling price being $ 36.5 and the maximum selling price was $ 63 (Table 2).

Mortality and morbidity rate due to suspected PPR

The average mortality rate of small ruminants observed during the last 5 years (2011-2016) due to suspicion of PPR was high in gaots (60.4 and 41.6%) respectively in animals aged above 1years compare to animals of less than 1 year old (Table 3). Similarly the morbidity rate was estimated high in goats of more than 1 year old (76.3%) compared to goats of less than a year (22.7%). Mortality and morbidity rates in sheep aged above 1 year were respectively 42.5 and 23.5% while it was 18 and 20.5% for sheep of less than a year.

Table 3: Cumulative Mortality and Morbidity rates of animals suspected with PPR

Species	Mortality rate (%)			Morbidity rate (%)		
	Old	Young	Total	Old	Young	Total
Sheep	42.8	18.5	31	23.5	20.5	22
Goats	60.4	41.6	51	76.3	22.7	49.5

Old animals (>1year), Young animals (<1year)

Estimated loss cost due PPR mortality and morbidity

Loss cost due to mortality

The price of the animals in the market depended on the breeds, the physio-ecological status, age and health. Results showed that the economic loss due to the mortality rate of animals suspected with PPR was approximatively 11$ for sheep and 121$ for goats (Table 4).

Loss due to morbidity

Socio-economic losses associated with PPR influenced by the morbidity rate as is the case for the mortality rate. Unlike morbidity, costs due to weight loss remained the same in both species (32662 Congolese francs equivalent to $ 20.4) (Table 5).

Table 4: Economic loss due to mortality (M) of animals suspected with PPR

Species	Age group	n	Pa	M=(n*pa)
Sheep	Old	0.17	20.8	3.54
	Young	0.14	48	6.72
	Total	0.31	68.8	11
Goat	Old	1.14	23.1	26.4
	Young	1.81	52.1	94.4
	Total	2.95	75.2	121

Old animals >1year, Young animals <1 year; n: number dead animals by age group, pa: average selling price of an animal.

Table 5: Costs related to Morbidity (P) due to Weight Loss (in Congolese franc)

Espèce	Age group	n	N	p	P= (n*N*p)
Sheep	Old	3.3	2.99	3310.2	32662
	Young	3.3	2.99	3310.2	32662
	Total	3.3	2.99	3310.2	32662
Goat	Old	3.3	2.99	3310.2	32662
	Young	3.3	2.99	3310.2	32662
	Total	3.3	2.99	3310.2	32662

Old animals >1year, Young animals <1 year n : Average loss of weight per animal in kg, N : Number of animals that have lost weight, P : Average selling price of kg to market; 1USD equal to 1600 Congolese franc.

Loss due to abortion

Loss associated with morbidity due to abortions varied among species. Low costs were found for sheep compared to goat species (Table 6).

Table 6: Costs related to morbidity (A) due to Abortions

Espèces	Na	C	A= (Na*C)
Sheep	0.47	20.8	9.78
Goats	0.69	24.1	16.6

Na: number of females having aborted, C: cost of a lamb/kid

Total loss direct loss due to mortality

Finally, it was observed that the economic losses due to PPR associated with morbidity rate were low in sheep (48294 francs / 30.2 $) compared to goats (59270 francs/37.1 $) per herd and per day during a PPR outbreak, where 1600FC = 1 $) (Table 7). These values increased where the outbreak last for long in a farm without taking into account indirect costs.

Table 7: Total direct cost due to morbidity (M') associated with PPR

Species	Formule	Losses (cost)
Sheep	M_1'= P_1+A_1	M_1'= 32661.74+9,78*1600Fc = 48294 Fc
Goats	M_2'= P_2+A_2	M_2'= 32661.74+16,63*1600Fc = 59270 Fc

P: Direct costs related to morbidity by weight loss, A: Direct costs related to morbidity due to abortions, Fc: Congolese franc, 1USD=1600 Fc.

Discussion

The variations in animal trade system found in South Kivu (Table 1) are more or less the same as those found by Elsawalhy et al. (2010) and FAO (2009). Elsawalhy et al. (2010) reported that goats and sheep provide a high social status to individuals and household and also serve as the much envied symbol of wealth and respect amongst pastoral communities, as the weight of animal increase, the selling price increase as well. Kihu et al. (2015) reported that considering animals of same age, females were more expensive compare to males.

The low selling animal's rate (1.7 ± 0.8) and price USD$36.5 of matured animal (Table 2) could be attributed to the loss of weight and health status of animals. Similar results were reported by Kihu et al. (2015) in goats and sheep selling rate in Kenya pastoralist community. Variation in the selling prices of the animals was observed as the sale takes place at the various animal's physiological stages. Mude et al. (2010) showed in their study higher selling value of sheep and goats per unit of tropical livestock (TBU) estimated at USD$150. However, this selling price is more depend on weight (kg) and sex rather than age.

The results showed a high estimated mortality (22% for sheep and 49.5% in goats) and morbidity (31% in sheep and 51% in goats) rates observed for the past 5 years (between 2011-2016) in South Kivu due to suspicion of PPR (Table 3). Several authors confirmed the high mortality and morbidity rates in goats compared to sheep which generally undergo a mild form of the disease (Zhao et al., 2010). This might be due to their natural immunity. However, the differences in mortalities and morbidities rates found could also be explained by other factors rather than PPR, including farm management, breeds and nutrition. Rossiter (2004) reported high morbidity and mortality rate goes respectively up to 90 and 100% in goats and sheep. De Nardi et al. (2012) found mortalities and morbidities to the tune of 99% in the outbreak in Algeria. Moreover, Dundon et al. (2015) found morbidity and mortality rates of 80% in Kenya. However, this rate might increase in case of mixed infection. In endemic countries, morbidity rates ranged from 6.2 to 65% in Somalia and 48.4 to 56.6% in Cote d'Ivoire. During epidemics, these rates rose to 86 to 100% (reported in Kenya, Ethiopia and Eritrea). Mortality rates also varied with reports 0-97% in Cote d'Ivoire; 69 to 74% in Tanzania; 33 to 90% in Kenya, Ethiopia and Eritrea. However, the rates depended on methodology used in data collection, species and farming systems (Diallo, 2006; Nyamweya et al., 2009; Elsawalhy et al., 2010; Kihu et al., 2015).

We found approximatively 11USD$ and 121$ as economic loss due to the mortality rate of animals suspected with PPR respectively for sheep and goats (Table 4). The high loss rate in goats may be due to their susceptibility to the disease compare to sheep (Zhao et al., 2010), which also explain the high mortality and morbidity rates observed in goats compared to sheep in Table 3. Similar results were observed by Diallo (2006) i.e., mortality cost due to PPR was high in goats compared to sheep and more affected young animals compared to old due to strong immune system. Two studies from India indicated that while the mortality rate was relatively low per animal, the overall losses were high even when the animal recovered. The loss per animal affected was Rs. 523 (US$ 8.44) in Madhya Pradesh (Awase et al., 2013) and Rs. 918 (US$14.81) and Rs. 945 (US$ 15.24) respectively for sheep and goats in Maharastra (Thombare et al., 2009).

An estimation of USD $20.4 was found to be the economic loss associated with daily mortality rate per farmer during the PPR outbreaks in South Kivu province (Table 5). Rushton et al. (1999) and Rushton (2002, 2009) showed the impact of PPR and animal health resulted in in one hand in visible losses (Dead animals, thin animals, poorly developed animals, low returns and poor quality products) and invisible loses (Fertility problems, change in herd structure, delay in the sale of animals and products, public health costs, high prices for livestock and livestock products). On the other hand, the expenditure and reaction from which there are additional costs (Medicines, vaccines, insecticide, time, treatment of products) and lost revenue (Access to better markets denied and Suboptimal use of technology). Perry et al. (2002) and Khalafalla et al. (2010) ranked PPR in the top ten diseases of small ruminants by inflicting high losses to the small livestock due to high mortality and morbidity rate. Diallo (2006) reported a daily loss of USD$ 30.4 in a farm which experienced a PPR outbreak in Africa.

Low costs associated with morbidity due to abortions were found for sheep compared to goat species with respectively USD$ 9.78 and USD$ 16.6 (Table 6). Kihu et al. (2015) reported similar results showing the loss of 900Ksh per farmer due to morbidity caused by abortion associated with PPR in Tukana County in Kenya. Moreover, Diallo (2006) showed that the increase of abortion rate affected significantly the estimation of morbidity rate. In Tanzania it was estimated that 330910 kids/lambs were not borne due to abortions. In Kenya and Tanzania 10% of households lost their entire herd or flock (Rushton, 2009).

The total daily economic losses per farmer due to morbidity rate associated with PPR were low in sheep (48294 francs equivalent to USD$30.2) compared to goats (59270 francs/ USD$ 37.1). The SADC report in 2012 showed an annual direct loss due to *PPR*, i.e. value of dead sheep and goats was estimated at US$5.3 million (SADC, 2012a). Chauhan et al. (2009) estimated and annual economic losses due to PPR in India at US$ 39 million. A previous study in Nigeria reported losses induced by PPR of US$ 1.5 million (Hamdy et al., 1976). The OIE-FAO Global PPR eradication program estimated the direct annual losses between USD 1.2 and 1.7 billion with the estimated current expenditure on PPR vaccination ranges between USD 270 and 380 million and annual impact of PPR alone valued at between USD 1.45 and 2.1 billion per year (OIE-FAO, 2015).

We conclude that the agro-pastoralist community of South Kivu province of Democratic Republic of Congo recognises *peste-des-petits ruminants (PPR)* as a major economic disease affecting goats and sheep and it has the potential of disrupting cultural set up and local economy. The mortality and morality rates due to PPR in South Kivu are estimated respectively at 31 and 22% in sheep and 51 and 49% in goats causing a daily economic losses cost due to morbidity rate of USD$ 30.2 for sheep and USD$37.1 for goats and approximatively USD$ 11 for sheep and USD$121 for goats due to mortality rate associated with PPR suspicion in South Kivu.

Conflicts of interest

Authors certify that there is no conflict with any financial organization regarding the material discussed in the manuscript.

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