Sero-Prevalence and Socioeconomic Impacts of Peste Des Petits Ruminants in Small Ruminants of Selected Districts of Afar, Ethiopia

Fikru Gizaw1*, Olana Merera1, Fikre Zeru2, Hailegabriel Bedada3, Mu’uz Gebru4 and Reta Duguma Abdi1,4
1College of Veterinary Medicine, Samara University, Samara, Afar, Ethiopia
2College of Veterinary Medicine, Mekelle University, Mekelle, Tigray, Ethiopia
3College of Veterinary Medicine and Agriculture, Addis Ababa University, Bishoftu, Oromia, Ethiopia
4Department of Animal Science, Institute of Agriculture, The University of Tennessee, Knoxville, USA

Corresponding author: Fikru Gizaw, College of Veterinary Medicine, Samara University, Samara, Afar, Ethiopia, Tel: + 251-910-784909; E-mail: fikrigiza1978@yahoo.com

Rec date: December 28, 2017; Acc date: January 29, 2018; Pub date: January 30, 2018

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Abstract

The aim of this study was to estimate the sero-prevalence of Peste des petits ruminants (PPR) in sheep and goat and its direct socio-economic impact on pastoral community in Afar region, Ethiopia. We sampled sera of 229 of sheep (n=94) and goats (n=135) from two districts and tested the sera for anti-PPR antibody positivity by competitive enzyme-linked immunosorbent assay (cELISA). We also conducted interview with 45 pasturals pertaining to PPR mortality, production losses, costs incurred and impact on animal. The respondents indicated that communal use of available resources (feed, water) and practices of animal gift, flock migration and admixture is common in the area, which could facilitate the spread PPR. They indicated that migration for searching of grazing and water during drought season, contact with wildlife and unknown factors within-flock was associated with the serious PPR disease outbreaks. The serological result showed that the prevalence of anti-PPR virus antibody in sheep and goats was 41.5% (95% confidence interval (CI): 31.4, 52.1) and 39.3 % (95% CI: 31 to 48), respectively. The overall prevalence of PPR was 40.2% (95% CI: 33.8 to 46.8). The total financial losses due to PPR varied during drought and non-drought periods as the monitory value of animals decreases during drought time due to emaciation. Accordingly, the financial loss of PPR was 652, 595 birr (drought time) and 1,683,120 birr (without drought) in a sheep population of 3905 heads in the study area. A systematic intensive surveillance and timely vaccination along the route of migration via herders’ participation could be the best and low-cost preventive measure to control such deadly preventable disease outbreaks.

Keywords: Afar; Economic losses; Goat; Peste des petits ruminants; Risk factors; Sheep; Seroprevalence

Background

Peste des petits ruminants (PPR) is highly contagious viral disease of small ruminants both in domestic and wild life [1]. It is characterized by fever, anorexia, necrotic stomatitis, diarrhea, mucopurulent nasal and ocular discharges, enteritis and pneumonia [2]. The synonyms of PPR include Kata, pseudo-rinderpest, pneumo-enteritis complex and stomatitis-pneumonenteritis syndrome [3]. The PPR virus belongs to Morbillivirus in Paramyxoviridae, which is closely related to the rinderpest virus of bovines and buffaloes, distemper virus of dogs and other wild carnivores, human measles virus and Morbillviruses of marine mammals [4].

PPR was first described in Côte d’Ivoire [5] and soon distributed to Nigeria, Senegal and Ghana [6]. Severe epidemics are recently reported from sub-Saharan Africa, the Middle East and Asia [7]. The prevalence of antibodies to PPR virus in small ruminants and other species is available from Sultanate of Oman, Jordan, Sudan, Turkey and various African countries [8]. The prevalence of PPR was 29% and 49% in Northern Jordan [9] and 35.8% and 49.5% in Pakistan [10] in sheep and goats, respectively. PPR entered Ethiopia in 1989 in the southern Omo River valley, moved east to Borana then northwards along the Rift Valley and reached Awash in 1991. It gained epizootic status during 1994 and 1996 and expanded northwards into the central Afar region and then eastwards into the Ogaden [11]. Widespread distribution of PPR has been reported from different regions of Ethiopia before 10-20 years ago [4,12].

The PPR epidemics can cause mortality proportion of 50–80% in naive sheep and goats populations [13]. Based on assumption that goats experience an outbreak every 5 years, [14] estimated an annual sum ranging from 2,47£ per goat at high loss and 0.36 £ per goat at lowest loss. Effectively, the disease pushed the poorest families into destitution or near destitution and the wealthy families down one or two classes into poverty. It is an economically significant disease of small ruminants such as sheep and goats [15].

There are multiple compelling reasons to start an immediate concerted effort on PPR. These include (i) the need to stop the spread of the disease in already affected countries and at-risk regions, (ii) to mitigate the economic impact of the disease on people relying on small ruminants for subsistence (food and income), and (iii) eliminating PPR is a key to poverty reduction in the world’s most vulnerable pastoral or agro-pastoralist communities [7]. The Afar pastoralists have shown an increasing interest in keeping larger numbers of sheep and goats in recent years. The fact that exports of meat and live animals is increasing in Ethiopia. So, they don’t worry for market demand for their sheep and goats besides providing food (milk) and income to the household. However, the prevalence and endemic nature of the diseases such as PPR are major causes in the decline of this supply [7].
Progressive control or eradication of PPR requires clear information on the epidemiology of the diseases in order to target the intervention to high-risk zones and endemic populations. In addition, economic losses (particularly losses due to mortality outbreaks) caused by PPR of the sheep and goat population in Afar is not adequately studied. Therefore, the aim of this study was to estimate (i) the sero-prevalence of PPR, and (ii) direct economic losses due to PPR infection in sheep and goat population in Afar pastoral area.

Material and Methods

Description of the study areas

The study was conducted in Adar and Mille districts of Afar national regional State of Ethiopia. The Afar national regional state is located in the Great Rift Valley, comprising rangeland in northeast Ethiopia with an estimated area of 95,958 Km² [16]. It is geographically located between 39°34’ and 42º28’ East Longitude and 8º49’ and 14º30’ North Latitude. The region shares common international boundaries with the state of Eritrea in the northeast and Djibouti in the east, as well as regional boundaries with the Regional States of Tigray in the northwest, Amhara in the southwest, Oromia in the south and Somali in the southeast.

Study animals

The study populations was indigenous breed of sheep and goats kept under pastoral husbandry which allows high mobility of animals and these animals are usually kept mixed with other animal species. Blood samples were collected from sedentary non-vaccinated sheep and goats (above 6 months old).

Study design and sample size

**Sampling size:** The sample size for this study was determined by the following formula given by Thrusfield.

\[ n = \frac{1.96^2 \times P(1-P)}{d^2} \]

Where 1.96 is the value of Z at 95% confidence interval, d is desired absolute precision, n is required sample size, and P=expected prevalence. Therefore, by using the above formula and taking into account 95% confidence interval, desired absolute precision of 5% and an expected prevalence of 15.3% [1], the estimated sample size is 199 but to increase precision total sample size is 229.

**Study design:** Cross-sectional study design was used for both sero-prevalence and questionnaire survey between March 2015 to January 2016 to estimate the sero-prevalence and socioeconomic impact of PPR in sheep and goat production system. There is no serological test available to differentiate animals vaccinated with PPR vaccine from animals that had recovered from a natural PPR infection in Ethiopia. Therefore, questionnaire was deemed the best source of information regarding vaccination status of sheep and goats to aid in sampling.

Sampling method and sample collection

Sampling method serology: The Afar region has 5 administrative zones, 32 districts (woredas) and 331 kebeles or peasant associations. The study was begun by identifying the vaccination and PPR outbreak history in zone, districts, peasant associations (PAs) and herds. The zone and districts were selected purposively based on reports of PPR outbreak history, absence of PPR vaccination history, sheep and goat population, and willingness of pastoralists and accessibility to roads for vehicles. The representative kebeles or peasant associations, herds and sheep and goats were selected by simple random sampling. So that, from the five administrative zones, one zone (zone 1) was selected. Then two districts from the zone, four PAs from each districts, and three herds from each PA and maximum eleven animals (sheep and goats) from each respective herd were randomly selected, and included as study population. Proportional allocation i.e., the number of sheep and goat sampled is proportional to the herd sizes. Accordingly, 11 shoats are selected from very large herd sizes, 9 or 10 shoat from middle herd sizes, 8 shoat from the smallest herd sizes. Accordingly, a total of 229 sheep and goat (94 sheep and 135 goats), twenty four herds, eight kebeles or peasant associations and two districts (woredas) were included in the study.

Questioner survey: A cross-sectional survey of sheep and goat producers was done to assess the nature, extent and impact of disease across randomly selected eight PAs to study the nature of disease in different spatial locations. Accordingly, a total of forty five (24 farm owners from were serum was collected and 21 herds were selected from the same kebele or PAs randomly to increase the sample size of questionnaire) farm households/pastorals constituted the sample from where the data were collected for analysis were interviewed. A questionnaire was used to collect information on flock size and structure, sources of income and costs, disease outbreaks and impacts on farm productivity. Further, data on movement of the animals and farm products, feeding and watering habits and source of grazing were also collected. The collected data were tabulated, classified and further categorized for systematic and suitable statistical analysis.

Sample collection for serology survey: Overall, 229 whole blood samples were collected from sheep and goats. All herds that contributed blood samples were from the herds that contributed information for the questionnaire. Serum samples were collected from animals, which had no history of PPR vaccination. Data related to previous history of the PPR and vaccination was obtained from Ministry of Agriculture, Regional Agricultural Center or district clinic records and/or by interview with the owner of the farms. All factors including number of animal vaccinated in each district, vaccinated age group, vaccine quality, and month/season of vaccination, facility such as icebox, human resources and personal quality (experience and professional status) was carefully recorded. Age, sex, species and type of breed of sampled animals was also recorded.

Approximately 10 ml of blood from each sheep and goat was collected aseptically using sterile plain vacutainer tubes and needles. The samples were properly labeled and vacutainer tubes having blood was left for 24 hours at room temperature for clotting. The next day, the sera was separated and transferred to other sterile vials, and kept at −20°C until tested for presence of PPR antibody.

Laboratory examination

All sera were transported to National Veterinary Institute laboratory in icebox and stored at −20°C until processed. Samples were processed based on standard and appropriate laboratory procedures of each specimen for the desired test in National Veterinary Institute, Bishoftu, Ethiopia. The nucleoprotein-based cELISA kit obtained from IDvet, 310, rue Louis Pasteur-Grabels-France, has been used and the test was carried out according to the manufacturer’s protocol [17]. Accordingly, first calculate the Optical Density of the negative control (ODNC) and the test is validated if the mean value of the Optical Density of the negative control (ODNC) is greater than 0.7. Also the
test is validated if the mean value of the optical density of the positive control (ODPC) is less than 30% of the ODNC.

The interpretation of the result is depends on calculation of the competition percentage

\[
\text{(Sample/Negative control} \times 100) = \frac{\text{S/N\%=OD sample/ODNc}}{\times 100} \times \text{100.
}
\]

- Less than or equal to 50% are considered positive result.
- Less than and greater or equal to 60% is doubtful and
- Greater than or equal to 60% are considered as negative result.

The data collected through questionnaire survey and serology test results of the collected samples were entered into Excel databases and analyzed using SPSS software package (SPSS 20.0 for window 7, SPSS Inc, Chicago, Illinois). Descriptive statistics such as percentages, proportions and frequency distributions were applied to compute the nature and the characteristics of the data. The sero-prevalence was calculated as the number of serologically positive samples divided by the total number of samples tested. The difference between the effects of different risk factors on prevalence was analyzed using the Pearson chi-square ($\chi^2$) test. Logistic regression analyses were used to assess the strength of association and were calculated to quantify the association of different risk factors (district, species, sex and breed) with the prevalence of PPR diseases by adjusting herd as a cluster effect. A statistically significant association between variables was said to exist if the calculated P-value is less than 0.05 and if the 95% confidence interval (CI) for OR does not include 1.

**Economic impact assessment methods**

A static and structured spreadsheet model was used to assess the costs of inaction on PPR in sheep and goats. The direct costs of this disease refer to the monetary values of physical losses due to the disease [18]. Since PPR is more acute disease, these physical losses are only the results of mortality associated with disease. Mortality induces losses associated with the cost of dead animals. Disease burden is defined as the sum of direct costs of the disease, which include cost of mortality, and the incurred costs of treatment and additional feed cost.

The first step in this process was to determine the population at risk, which depends on the degree to which livestock population is protected by existing prophylactic measures. In that regard, background information on livestock across agro-ecological zones, vaccine availability, treatment availability and the degree to which disease surveillance programs are implemented are important. The data required are livestock population number, livestock production parameters, price/cost data and epidemiological parameters. The livestock population data are disaggregated by species, age and sex. Livestock production parameters are also collected by species and agro-ecological zones. The price/cost data to use as inputs in the spreadsheet model include cost of feed, price of live animals by species and age category, cost of treatment. The data used in this study are presented in Appendix part and are all for the year 2001/16 or adjusted to that year when applicable. The epidemiological parameters involve disease incidence rate, affection rate (i.e., morbidity proportion and mortality proportion), rate of vaccination coverage, extent of disease surveillance, disease treatment rate and impact of affection on productivity. These data were gathered from secondary sources, published studies and through interview.

In this exercise, data collected through questionnaire were compared and contrasted with data collected from secondary sources and judgments were made about the magnitude of the parameter estimates to use. Hence, the incurred costs of treatment and additional feed used to calculate the disease burden are elective, based on data collected through questionnaire, or from secondary sources, or from our assessment based on the two. The costs of treatment and feed were referred to as actual intervention costs and include for activities conducted by private and public entities.

**Results**

**Social attributes of respondents**

The respondents indicated that no specific housing system (86.67%) was available for sheep and goat in the area. Grazing and watering resource management was communal among all (100%) households. Majority of respondents were illiterate (98%), followed by some (2%) with primary level education. Peoples in the study area are engaged in subsistence livestock production for the social and cultural values as well as life it renders to kinship groups and the society (40%). High (91.1%) mobility was common in search of grazing and water. Majority (77.8%) of the owners treat sick animals by themselves. The respondents (78.5%) indicate that modern medications are used as a management method of most of common diseases. Most of them (75.6%) also isolated sick animals from the flock. Most of the respondents (86.67%) indicated that their flocks had the chance to meet wildlife. The respondents associated the incidence of PPR with emergence of drought, within flock unknown factors, and contact with wildlife. The status of flock management practices and possible risk factors for the occurrence of PPR in small ruminants in the study area was summarized in Table 1.

| Variables                                      | Categories | Numbers | %  |
|------------------------------------------------|------------|---------|----|
| Have you had enteritis-stomatitis syndrome in your flock? | Yes        | 45      | 100|
|                                                | No         | 0       | 0  |
| Have you had PPR (Local name) in your flock?    | Yes        | 45      | 100|
|                                                | No         | 0       | 0  |
| When did the disease commence in the area (PA)? | <2 months  | 11      | 24.44|
|                                                | 2-5 Months | 15      | 33.33|
|                                                | Before 1 year | 19  | 42.22|
| Have you seen such outbreak in the area before this time? | Yes        | 45      | 100|
|                                                | No         | 0       | 0  |
| How frequent PPR reoccurs in the area?          | Related with drought | 45 | 100|
|                                                | Every 1 yr | 0       | 0  |
|                                                | Every 2 yrs | 0     | 0  |
|                                                | >3 yrs      | 0       | 100|
| Origin of PPR outbreak in to your village?      | neighboring PA or District | 11   | 24.44|
|                                                | From market | 0     | 0  |
Do you move your shoats to other place for grazing seasonally? Yes 41 91.1
If yes, No 4 8.9
when, Dry season 41 100
where, Neighbor 41 100
how long did you keep them there? Until raining 41 100
Did season changing that lead to movements resulting to share grazing? Yes 41 91.1
No 4 8.9
Do you consider PPR as an important disease and how do you score it? Very severe 43 95.56
Severe 2 4.44
Moderate 0 0
Low 0 0
Housing system Fenced stable 4 8.89
House barn 2 4.44
Free/no house 39 86.67
Have purchase feed Yes 20 44.4
No 25 55.6
Did you separate sick and health animals? Yes 34 75.6
No 11 24.4
Grazing and watering resource managements Communal 45 100
Private 0 0
Did you separate different age groups of small stock? Yes 25 55.6
No 20 44.4
Did you mix shoat with other species of animals? Yes 24 53.3
No 21 46.7
Have you bought new shoats or introduced new shoats since 3 months before the onset of the outbreak? Yes 18 40
If yes, origin of the shoats? No 27 60
From market 9 50
Gift 9 50
Did you vaccinate your shoats for PPR? Yes 21 46.67
No 24 53.33
If yes, when? <3 month 0 0
3 month-1 years 0 0
>3 years 21 100
What do you do when the shoat fall sick due to PPR? Treat them my self 35 77.8
Call in the vet professional 4 8.9
Kill them immediately 0 0
Sell them immediately 0 0
Traditional healer 6 13.33
Have you received sheep and goat as gifts? Yes 18 40
No 27 60
Did your flock Contacts with wildlife? Yes 39 86.67
No 6 13.33

Table 1: Descriptive statistics of qualitative variables.

Sero-prevalence of PPR
Sero-prevalence calculation of PPR was carried out by cELISA kit obtained from IDvet, 310, rue Luouis Pasteur-Grabels-France, and the result was interpreted according to [17]. Accordingly, the prevalence of PPR was 92 (40.2%) out of 229 analyzed serum samples. The seropositive rate of the sample from Ada’ar district was 41.1% (95% CI of 32, 50.3) and those from Mile district had 39% (CI of 29.7, 49.1) as shown in Table 2.

| District | Species of animals | No. examined | No. positive (prevalence, %) | 95% CI |
|----------|--------------------|--------------|------------------------------|--------|
| Ada’ar   | Goat               | 66           | 27(40.9)                     | 29     | 53.7 |
|          | Sheep              | 58           | 24(41.4)                     | 28.6   | 55.1 |
|          | Total              | 124          | 51(41.1)                     | 32     | 50.3 |
| Mile     | Goat               | 69           | 26(37.7)                     | 26.3   | 50.2 |
|          | Sheep              | 36           | 15 (41.7)                    | 25.5   | 59.2 |
|          | Total              | 105          | 41(39.0)                     | 29.7   | 49.1 |
| Total    | Sheep              | 94           | 39(41.5)                     | 31.4   | 52.1 |
|          | Goats              | 135          | 53(39.3)                     | 31     | 48   |
|          | Sheep and goats    | 229          | 92(40.2)                     | 33.8   | 46.8 |

Table 2: Sero-prevalence of PPR in sheep and goats of two districts of Afar.

Risk factors for positive serological status against PPR
Area, species, age groups and sex showed the prevalence of PPR seropositive animals. All of the factors (age, sex, species and area) did not significantly associate with PPR sero-positivity status of the animal (Table 3).
### Table 3: Association between some of the factors with occurrence of PPR in small ruminant farm.

**Costs and financial burden of PPR**

The estimated annual physical losses of sheep and goats due to PPR were presented in Table 4. The total numbers of dead sheep and goats were 1,280 and 1,195, respectively. About 63.3% of the total population of sheep and goats were lost each year due to PPR. The financial loss due to mortality in the affected animal farm was on an average 2,146,875.00 birr/92,140.56$ (cost of animals when showing clinical sign and cost of animals when not showing clinical sign) both in sheep farm and in goat farm (Table 4).

| Species | Age group       | N   | dead | price/shoat (when showing clinical sign) | price/shoat (when not showing clinical sign) | Cost of animals (when showing clinical sign) | cost of animals (when not showing clinical sign) |
|---------|-----------------|-----|------|-----------------------------------------|---------------------------------------------|--------------------------------------------|-------------------------------------------------|
|         |                 |     |      | EBr          | US dollars                     | EBr          | US dollars                     | EBr          | US dollars                     | EBr          | US dollars                     |
| Sheep   | <3 month male   | 225 | 25   | 1.073        | 25                            | 135          | 5.794                        | 5625         | 241.416                       | 30375        | 1303.648                       |
|         | <3 month female | 225 | 25   | 1.073        | 25                            | 135          | 5.794                        | 5625         | 241.416                       | 30375        | 1303.648                       |
|         | Male 3 m-1 yr   | 100 | 265  | 11.373       | 950                          | 40.773       | 26500                        | 1137.339     | 4077.253                      | 95000        | 4077.253                      |
|         | Female 3 m-1 yr | 195 | 265  | 11.373       | 950                          | 40.773       | 26500                        | 1137.339     | 4077.253                      | 95000        | 4077.253                      |
|         | Female>1 yr     | 255 | 320  | 13.734       | 750                          | 32.189       | 81600                        | 51675        | 2217.811                      | 185250       | 7950.644                      |
|         | Male>1 yr       | 120 | 650  | 27.897       | 1650                         | 70.815       | 78000                        | 3347.646     | 8497.854                      | 191250       | 8206.155                      |
|         | Pregnant        | 160 | 320  | 13.734       | 800                          | 34.335       | 51200                        | 2197.425     | 128000                        | 5493.562     | 5493.562                      |
|         | Sub Total       | 1280|      | 3,00,225     | 12885.19                     | 8,58,250     | 36834.76                     |                                           |                                           |                                           |
| Goat    | <3 month male   | 240 | 25   | 1.073        | 25                            | 135          | 5.794                        | 6000         | 257.511                       | 32400        | 1390.558                       |
|         | <3 month female | 180 | 25   | 1.073        | 25                            | 135          | 5.794                        | 4500         | 193.133                       | 24300        | 1042.918                      |
|         | Male 3 m-1 yr   | 75  | 265  | 11.373       | 950                          | 40.773       | 19875                        | 853.004      | 71250                         | 3057.94      | 71250                         |
|         | Female 3 m-1 yr | 175 | 265  | 11.373       | 950                          | 40.772       | 46375                        | 1990.343     | 7135.193                      | 166250       | 7135.193                      |
|         | Female>1 yr     | 355 | 320  | 13.734       | 750                          | 32.189       | 113600                       | 4875.537     | 266250                        | 11427.04     | 11427.04                      |
Table 4: Estimated physical losses (heads) and direct costs of sheep and goats due to PPR. *price in birr. 1 US $=23.3 Ethiopian birr (EBr).

| Species | Local name of sheep and goats | Age group           | Total animal in the group | No. infected in the group | No. dead in the group | IR%   | MR%   |
|---------|--------------------------------|---------------------|---------------------------|----------------------------|-----------------------|-------|-------|
| Sheep   | Mana’atu                        | <3 month male       | 265                       | 225                        | 225                   | 84.91 | 84.91 |
|         | Mana’atu                        | <3 month female     | 265                       | 225                        | 225                   | 84.91 | 84.91 |
|         | Sibene                          | Male 3 m-1 yr       | 160                       | 130                        | 100                   | 81.25 | 62.5  |
|         | Sibene/virgin sheep             | Female 3 m-1 yr     | 285                       | 250                        | 195                   | 87.72 | 68.42 |
|         | iiii                            | Female>1 yr         | 455                       | 395                        | 255                   | 86.81 | 56.04 |
|         | iiii                            | Male>1 yr           | 185                       | 145                        | 120                   | 78.38 | 64.65 |
|         | iiii                            | Pregnant            | 260                       | 190                        | 160                   | 73.08 | 61.54 |
|         | Over all MR and IR of sheep     |                    | 1875                      | 1560                       | 1280                  | 83.2  | 68.27 |
| Goat    | Barkilo                         | <3 month male       | 335                       | 310                        | 240                   | 92.54 | 71.64 |
|         | Barkilo                         | <3 month female     | 305                       | 275                        | 180                   | 90.16 | 59.02 |
|         | Rihido                          | Male 3 m-1 yr       | 190                       | 140                        | 75                    | 73.68 | 39.47 |
|         | Rihido                          | Female 3 m-1 yr     | 305                       | 255                        | 175                   | 83.61 | 57.38 |
|         | Wadar/Riya                      | Female>1 yr         | 570                       | 500                        | 355                   | 87.72 | 62.28 |
|         | Wadar/Riya                      | Male>1 yr           | 90                        | 55                         | 40                    | 61.11 | 44.44 |
|         | Wadar/Riya                      | Pregnants           | 235                       | 165                        | 130                   | 70.21 | 55.32 |
|         | Over all MR and IR of goat      |                    | 2030                      | 1700                       | 1195                  | 83.75 | 58.87 |
|         | Over all MR and IR of sheep and goat |                | 3905                      | 3260                       | 2475                  | 83.48 | 63.38 |

Table 5: Direct costs, cost of intervention and financial burden of PPR (Ethiopian birr). *price in birr. 1 US $=23.3 Ethiopian birr (EBr).

The proportion of animals dying (mortality proportion) in a population due to PPR disease was found to be 68.27% in sheep and 58.87% in goat (Table 6).
In this study, the overall prevalence of PPR was 40.2%. It was higher than the 6.1% prevalence reported from the neighboring district of Gewane [19], 1.7% before outbreak and 36.6% after outbreak from other district of Awash Fentale [20]. Lack of vaccination for the last three years in the study area can explain the higher prevalence of active viral infection in our findings. Our current sero-prevalence finding of 39.3% in goats and 41.5% PPR in sheep was in agreement with previous reports in the country and outside. Accordingly, a seroprevalence of PPR was 30.9% in Afar [15], 9% in goat and 13% in sheep in Borena [1]. The report from eastern Amhara was 28.1%, 64.5% and 56.5% in vaccinated, unvaccinated and unknown vaccination status of small ruminants and up to 54.8% in Gambella reported by [21] and Megersa et al. [22] respectively. A study in India reported 41.35% PPR prevalence in sheep and 34.91% in goats. However, our current finding was higher than the previous findings of PPR prevalence in sheep and goat. For instance Megersa et al. [22] reports 31.3% in goats and 29.5% in sheep in Gambella and Delil et al. [20] reports prevalence of PPR 7.3% in sheep and 42.6% in goats in Awash Fentale. Contrast findings have been also documented in other countries. Contrary to our findings, higher prevalence in goats than in sheep was reported from India [8], from northern Jordan in sheep (29%) and goats (49%) [9] and from Pakistan 35.8% in sheep and 49.5% in goats [10]. In another study in Pakistan goats were more susceptible than sheep to PPR with an overall prevalence of 40.9% [23]. This indicates within and between nation’s variation in PPR prevalence among sheep and goats. The variation can be attributed to the variations in sheep and goat husbandry practices in different countries, agro-climatic conditions, socio-economic status of individual farmers, difference in vaccination program and the migration of livestock in countries.

Since the production losses due to PPR were conceived to be different for different age groups of small ruminant, herd structures for goats and sheep were established through discussions with the herders. The mortality proportion due to PPR disease in Maharstra was found to be 13.50% in sheep and 8.53% in goat [24]. Recent study in Turkana indicated that mortalities due to diseases were 70% and 74.2% in sheep and goats, which was higher than our finding [25]. However, previous studies had reported lower percentages, for example 41% mortalities in

### Table 6: Mortality and incidence rate of sheep and goats. Note: MR=mortality rate, IR=incidence rate.

**Discussion**

Small ruminant production system in the study area is associated with agro-ecological zones. The area is too dry to sustain crop production. High mobility in search of grazing and water for animals is common in the area. According to our questionnaire results, all respondents migration for searching of grazing and water during drought season is related with acquisition of serious diseases mainly PPR. All the selected farms scored PPR as very important disease for the last previous reports in the country and outside. Accordingly, a PPR. All the selected farms scored PPR as very important disease for three years in the study area can explain the higher prevalence of active viral infection in our goats since three years.

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small stock due to various causes, including disease [26] and 62% to 68% losses due to drought and diseases [27]. The annual loss due to goat disease with 11% mortality was estimated to be of Tk 870 million in Bangladesh [28].

Based on farmer's response and animal's price, the loss was estimated to be of over one million birl/43,478.35 in this study. Only the value of animal was considered for estimating the loss due to mortality in a farm in our study: In Afar regional state, sheep and goat population is around 6.73 million (4.27 million goats and 2.46 million sheep) [29]. Therefore, death of 68.27% in sheep and 58.87% in goat population can provide a loss not in millions but in billions to small and poor farmers.

Conclusions and Recommendations

In Afar area, animal mobility is high in search of feed, water, trading and gift year-round, but particularly animal migration increases during drought season in search of pasture and water. Communal use of available resources (feed, water) and flock admixture is a common practice, which can facilitate the spread PPR. The respondents associated the incidence of PPR with the emergence of drought, with contact with wildlife and with unknown factors within the flock. In the area, our serological test indicated that PPR virus infects 41.5% of sheep and 39.3% of goat populations. However, respondents claimed that the population that contracted PPR was high in sheep (83.2%) and goat (83.74%), which is about twice of our serological findings. They also indicated that 68.27% in sheep and 58.87% in goat population die due to PPR disease. Vaccination coverage against PPR in Afar region for the last three years is lacking. Waves of PPR outbreaks are associated with massive illnesses and mortality. Thus, PPR is currently a major socio-economic animal health problem in the area. Our study provides preliminary information on PPR sero-prevalence, socio-economic impact and possible associated risk factors. Therefore, we recommend a more systematic intensive and active serological and virological surveillance programs in the area in addition to implementing intensive vaccination campaigns.

Competing Interest

The authors declare that they have no competing interests.

Ethical Clearance

Ethics approval and consent to participate Permission on ethical approval was obtained from the College of Veterinary Medicine Samara University (Ref. ERC 0012/2015).

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