

Full Length Research Paper

Epidemiological study of contagious caprine pleuropneumonia (CCPP) in selected districts of Gambella Region, Western Ethiopia

Aklilu Fasil^{1*}, Asfaw Yilkal², Baumann Maximillan³ and Abie Getnet¹¹National Animal Health Diagnostic and Investigation Center (NAHDIC), P. O. BOX 4, Sebeta, Ethiopia.²Addis Ababa University, College of Veterinary Medicine and Agriculture P. O. BOX 34, Debrezeit, Ethiopia.³Ferei University Berlin, Germany.

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A cross-sectional study was conducted in three selected Districts of Gambella Regional State (GRS) namely Lare, Itang and Gambella Zuria from March to October 2011 to determine seroprevalence of Contagious Caprine Pleuropneumonia (CCPP) caused by *Mycoplasma capricolum subsp capripneumoniae* (Mccp) and to identify potential risk factors and to assess community perceptions about CCPP in the study area. Multistage sampling method was used in both agropastoral and sedentary production systems. A total of 1152 goat sera were collected and processed using the Complement Fixation Test (CFT) at the National Veterinary Institute (NVI), Debre Zeit, Ethiopia. A questionnaire survey was also conducted in 80 randomly selected households, and 3 veterinary staff one from each district. The overall mean CCPP seroprevalence in the study area was 18.1% (219/1152), (95% CI: 15.89-20.31). The seroprevalence of the disease in Itang was higher (24.7%) followed by Gambella Zuria (14.7%) and Lare (12.6%) District. Despite the higher seroprevalence in the agropastoral production system (19.2%) the difference with that of the sedentary production system (14.7%) was not statistically significant ($p > 0.05$). Univariate analysis showed that District, PA, sex and age were significantly associated with the seroprevalence result ($p < 0.05$). Itang District showed significant difference in the seroprevalence when compared with Lare District ($p = 0.0001$; Odds ratio: 2.21). Opagna, Anguata, Badyel, Mecode, Meding Zuria, Bonga and Achewa PA's had significant difference in seroprevalences with odds ratio ranging from 2.94 to 6.46. Female goats had a significantly different seroprevalence (19.3%) compared to males (11.5%) ($p = 0.014$; OR=1.84). Adults (age greater than two years) showed higher seropositivity as compared to young goats and kids ($p = 0.001$ and OR=1.92). Age and PA were the only factors that showed statistically significant ($p < 0.05$) associations in multivariate analysis. The questionnaire survey also revealed that CCPP was the 'number one' disease in the study areas; and wet-season presents a major risk factor for CCPP. The findings of this study showed that CCPP is the major disease of goats in the study area and hence there needs to be implemented appropriate control measure to mitigate the problem.

Key words: Contagious caprine pleuropneumonia, *Mycoplasma capricolum subsp capripneumoniae* (Mccp), goats, cross-sectional study, seroprevalence, risk factors, complement fixation test (CFT), Gambella region.

INTRODUCTION

Small ruminants in Africa represent 21% of the world's small ruminant population with goats representing 30% and sheep 17% of the world population (Ibrahim, 1998). Ethiopia has an estimated population of 25,979,919 sheep and 21,960,706 goats (CSA, 2009), equivalent to

4,794,062 tropical livestock units (TLU¹). Small ruminants in Africa are reared in different livestock production systems ranging from mixed crop/livestock systems in the

¹ 1 TLU = 250 kg; 1 sheep/goat = 0.1 TLU

highlands, to pastoral systems in the arid lowlands. Sheep and goats play a significant role in the nation's economy. Goats are major sources of protein (meat and milk), skin and hides; live animals and carcasses account for a significant proportion of Ethiopia's exports. The study area Gambella Region harbors an estimated population of 207,780 goats, and 96,114 sheep.

In Ethiopia, goats and sheep are affected by infectious diseases such as Peste des Petits Ruminants (PPR) (Ibrahim et al., 1999), sheep and goat pox, and contagious caprine pleuropneumonia (CCPP) (Thiaucourt et al., 1992; Pettersson et al., 1998; Ibrahim et al., 1999; Heldtander et al., 2001; Yigezu et al., 2004), brucellosis, pneumonic pasteurellosis/mannheimiosis and Maedi-Visna (Ayelet et al., 2001).

Considerable losses occur frequently as a result of outbreaks of these infectious diseases; however, both outbreaks and losses from such outbreaks are not well documented. Among the goat diseases PPR and CCPP appear on top of the disease control agenda because of their high morbidity and mortality rates. While CCPP clinical cases have been reported in nearly 40 countries in Africa and Asia, *Mycoplasma capricolum* subsp. *capripneumoniae* (*Mccp*) has only been isolated in 20 countries because few laboratories have the expertise for isolating and growing mycoplasmas (Nicholas et al., 2008).

CCPP is characterized by severe fibrinous pleuropneumonia (Nicholas, 2002) and is one of the devastating diseases of susceptible goat population. Mortality and morbidity can be as high as 60 and 90%, respectively (Nicholas and Churchward, 2012). *Mccp* was first isolated and shown to cause CCPP in Kenya in 1976 (MacOwan and Minette, 1976). It has subsequently been isolated from CCPP occurring in Sudan, Tunisia, Oman, Turkey, Chad, Uganda, Ethiopia, Niger, Tanzania, Eritrea, and the United Arab Emirates (OIE, 2008).

In Ethiopia, CCPP was first diagnosed in regions bordering Kenya and Sudan 30 years ago with the first case being reported from Assosa District, Western Ethiopia (Thiaucourt et al., 1992). Since then outbreaks of the disease have been recorded in different parts of the country including Borena, Ogaden, Wollo, Asosa, Gojjam, East Shoa, South Omo and North Omo Administrative Regions. However, the exact epidemiological picture of the disease in Ethiopia has not been well established yet (Mebratu, 1988; Thiaucourt, 1992; Mamo, 1993; Roger and Bereket, 1996).

According to the Gambella Region Bureau of Agriculture and Rural Development, CCPP as the most devastating disease of goats has been a serious problem for the past few years with CCPP-like outbreaks occurring in different parts of the region at different times.

Hence, CCPP is becoming a high priority disease due to its spreading nature, high morbidity and mortality rates, with a lack of vaccines, of effective control measure and high treatment costs of sick animals. However, the epidemiology of CCPP in Gambella Region is unknown. Hence this study was conducted to determine the seroprevalence of CCPP by means of the CFT and to assess potential risk factors associated with disease occurrence and to describe community perceptions about CCPP in Itang, Lare and Gambella Zuria Districts of Gambella Region.

MATERIALS AND METHODS

Description of study area

The study was conducted in three purposively selected Districts of Gambella Regional State (GRS), namely Gambella Zuria, Itang and Lare Districts (*Woredas*). GRS is located in south western Ethiopia, 777 km from Addis Ababa. It extends between 7° N° to 8.17°N° latitude and 33°E° to 35.02° E° longitude (GRBoARD, 2002). The altitude ranges between 300 to 2300 m. However, the elevation declines progressively westward along the Sudan border and the majority of the land is below 1000 m. The region has an average annual rainfall of 800 to 1200 mm within one rainy season, the wet season being from May to October and the dry season from November to April. The annual average maximum and minimum temperature range is 39 to 42°C and 21 to 25°C, respectively; it is one of the hottest areas in the country (GRBoARD, 2002).

GRS borders with South Sudan in the west, Oromia Regional State to the northeast and Southern Nation Nationalities and Peoples Regional State (SNNPRS) to the south-east.

Animal husbandry is the major economic activity of the agro-pastoral communities of the region. Subsistence farming and traditional fishing are other major forms of living in the rural parts of GRS. The three Districts were purposively selected from the existing 13 Districts of GRS considering geographic location, proximity to livestock markets, accessibility, ruminant population density, and the possibility of risk of contact with flocks from other regions within the country and across the Ethio-Sudan border with the neighboring South Sudan.

The study areas, particularly Itang and Lare districts, border Sudan with major routes of animal movement from Sudan to the Region and vice versa. There is no control of movement of animals among and between the different agro-pastoral communities of the two neighboring countries. Moreover, the agro-pastoral community of the region and the neighboring parts of the Sudan share communal grazing lands and watering points which create apparently favorable condition for flock mixing and the introduction and/or transmission of infectious diseases like CCPP to the area. The situation may be further aggravated by the presence of cross-border animal raiding and illegal trade. The third study site Gambella Zuria District borders three zones of the region, namely, Agnuac, Nuer, Mejenger and the neighboring regional states Oromia and SNNPRS. For the purpose of marketing, sheep and goats frequently are transported from various corners of the Region to Gambella Zuria District. Even though detailed studies on the available production systems had not been conducted in the study area; however, agropastoral and sedentary production systems

*Corresponding author. E-mail: fasil.akilu@yahoo.com

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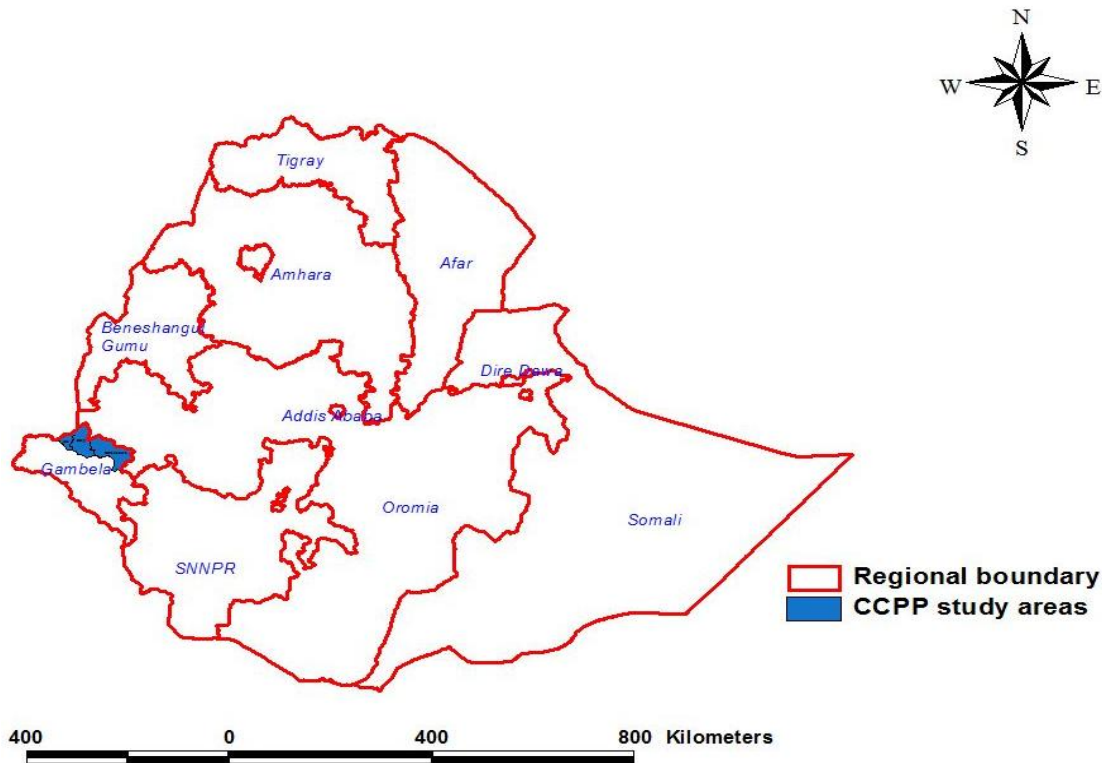


Figure 1. Map of study area and districts.

are the predominant production systems in the study area (Figure 1).

Study design

The study was a cross-sectional investigation of CCPP in none vaccinated all age and sex groups of goats above six months of age.

Study animals

Goats of the local breed kept under traditional grazing management were used in this study. The key identifying features of the breed are a short, straight face, and a fawn or white patchy color (Farm Africa, 1996). At night goats and sheep are housed together in thorn enclosures in the area; smoke is used to repel biting flies at night.

Sampling strategy

Multistage sampling was used according to the following:

- (1) Primary sampling unit: PA's as the smallest administrative unit were used as primary sampling unit. Within each selected District, 20% of PA's were selected randomly from the district PA's list. Since the numbers of PA's in the selected 3 Districts were within the range of 22 to 26 PA's, 4 PAs from each district were randomly selected, totaling 12 PA's.
- (2) Secondary sampling unit: Household flocks were taken as

secondary sampling unit. From each PA, 10% of the household flocks were randomly selected and sampled for the seroprevalence study.

(3) Tertiary sampling unit: Individual goats not vaccinated against CCPP and above six months of age found in a household flock were taken as tertiary sampling unit. From each household flock, 10% of the flock were randomly selected and sampled for until the intended sample size was attained.

Sample size determination

The determination of sample size for sera collection was based on the formula given by Thrusfield (1995) for simple random sampling method. The relevant formula for a 95% confidence interval is:

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

Where: n = required sample size; P exp = expected prevalence; d = desired absolute precision 95% confidence level = 1.962 (multiplier).

Sample size calculation was based on a 95% confidence level, 5% absolute precision and 50% expected prevalence. As no estimation for the CCPP seroprevalence in the study area was available we took 50% expected prevalence as suggested in the literature (Thrusfield, 1995).

Thus a total sample size of 384 goats was determined. Since the sampling strategy intended is a multistage random sampling, the sample size was inflated 3 times to increase precision (3 x 384) reaching at 1152 goats to be sampled for the seroprevalence study

(Thrusfield, 2005). To reach at the intended sample size in the selected three Districts the authors first identified the population of goats existed in the study areas from secondary data. Due to the difference in population size in the three Districts and even within PA's in the same district, sample size was also allocated proportionally based on the existing goat population per Districts. Hence 43.3% (n=497) of the sample was drawn from Itang District, 33.7% (n=389) from Lare District and 23% (n=266) from Gambella Zuria District.

Sample processing

Serological samples collection

Five to ten milliliter of blood sample was collected from the jugular vein of each goat using plain vacutainer tubes and kept protected from direct sun light, in slant position, for about 4 h or until the blood clots and the serum is separated. The separated serum was transferred to sterile cryovials labeled appropriately, kept at +4°C before the specimens were transported to the National Veterinary Institute (NVI), Debre Zeit, for analysis.

Complement fixation test (CFT)

To determine the seroprevalence of CCPP CFT was conducted at the National Veterinary Institute (NVI), Debre Zeit, Ethiopia, according to the OIE (2008), with some modification and the kit source Serion/Verion- CFT, Germany. In addition the antigen we used was *Mccp* antigen strain F38 which was a purified antigen supplied by Friedrich-Loeffler-Institute (FLI), Federal Research Institute for Animal Health, Jena, Germany. This is to increase the specificity and minimize the phenomenon of cross-reactions among other *Mycoplasma mycoides* cluster. Before testing, all the reagents were brought to room temperature and the pre-plated test sera were decplemented in a water bath at 58°C for 30 min. Prior to test run standardization of hemolytic serum, complement and antigen was done.

As of the OIE recommendation the cut-off serum dilution 1:10 for CCPP was considered. Scores were classified as follows: 4: complete fixation (no hemolysis), 3: almost complete fixation (very slight haemolysis), 2: partial fixation (partial haemolysis), 1: very slight fixation (almost complete haemolysis) and 0: no fixation (complete haemolysis). Interpretation of the results; samples showing no hemolysis and with very slight hemolysis were considered positive otherwise negative at dilution 1:10. But for most of the tested positive samples a titer end point above 1/40 was observed. Using these technique sera samples were tested for the presence of specific antibodies against CCPP infection with *Mycoplasma capricolum* subsp. *capripneumoniae* (*Mccp*) antigen strain F38.

Questionnaire survey

To collect relevant information pre tested semi structured questionnaire was introduced to animal owners and animal health professionals. To help the respondents clearly refer to CCPP respiratory disease that affects only goats and characterized by contagiousness, sudden death and high mortality rate was focused. The questionnaire were endorsed to 80 randomly selected households in all selected Districts and PAs and to 3 Wereda level Animal Health professionals one for each Wereda. The number of questionnaire collected from the animal owners were proportionally allocated based on sheep and goats population that is, number of serum samples collected in study areas.

Data management and analysis

Data collected in the field were entered and stored in separate spreadsheets in Microsoft Excel version 2007. Data were screened for proper coding and errors, and corrected prior to statistical analysis. Stored data were analyzed using SPSS statistical software (SPSS inc, USA) version 18. Descriptive statistics including frequencies and cross-tabulations (Chi-square test) were carried out to identify missing values as well as likely associations. Multiple response questions from the questionnaire were analyzed using multiple response analysis. 95% CI values was calculated by using Win episcopo 2.0 (Thrusfield et al., 2001).

Univariate logistic regression analysis was employed to assess the association between factors (independent variables) and the outcomes of interest (dependent variables) that is, the CFT result. The degree of association between putative risk factors and CCPP serological status for significantly associated factors was quantified by odds ratio (OR) calculations. Finally factors having significant p-values (< 0.05) were identified as major contributing factors for the seropositivity of goats for CCPP.

Multivariate logistic regression using a stepwise approach (forward selection and back ward elimination) was employed to analyze further those putative risk factors identified in the univariate analysis based on a p-value ≤ 0.25 as the significance threshold for entry or removal into the final model.

RESULTS

Serological results at the individual animal level

All samples were tested for the presence of specific antibodies against CCPP infection using CFT with *Mycoplasma capricolum* subsp. *capripneumoniae* (*Mccp*) antigen strain F38. The overall prevalence was 18.1% (95% CI = 15.89-20.31) (209/1152) in the study areas (Table 1).

The highest seroprevalence was found in Itang District with almost two times as high as the rates observed in Gambella Zuria and Lare. Higher rates were recorded in Opagna (30.2%) followed by Badyel (29.3%), Mecode (25.2%), Anguata (24.3%), Meding zuria (20.6%) and Bonga (19.0%) PA's while lower prevalences were observed in Achewa (16.2%) followed by Tong dol (12.1%), Nibnib (9.7%), Zero-5 (8.5%), Rake (7.9%) and Zero-1 (6.5%).

Univariate logistic regression analysis results

Statistically significant differences were observed between seroprevalence and the risk factors: District, Peasant Association, sex and age. However, the difference between flock size categories and production system and seroprevalence was not statistically significant (Table 2).

Statistically significant differences were observed between seroprevalence and the risk factors district, peasant association, sex and age. However, the difference between flock size categories and production system and seroprevalence was not statistically significant.

Table 1. Seroprevalence of CCPP in goats by Districts using Complement Fixation Test (CFT).

District	Sample		Seroprevalence (%)	95% CI
	Tested	Positive		
Lare	389	49	12.6	9.46-15.72
Itang	497	121	24.3	20.63-27.77
Gambella Zuria	266	39	14.7	10.60-18.72
Total	1152	209	18.1	15.89-20.31

Table 2. Chi-square analysis results between the dependent variable (CFT result) and the assumed risk factors (independent variables) of CCPP.

Assumed risk factors	X ² (Chi-square) value	Degree of freedom (df)	P- value	Sig.
District	22.625	2	0.0001	Sign.
PA	49.014	11	0.0001	Sign.
Sex	6.023	1	0.014	Sign.
Age	13.528	2	0.001	Sign.
Flock size	1.695	2	0.429	Ns
Production system	2.749	1	0.97	Ns

Significant - Sign. ($p < 0.05$); Not significant- Ns. ($p > 0.05$)¹.

Table 3. Final multiple logistic regression analysis on seropositivity using CFT.

Variables	Coefficient of regression (B)	P-value	OR	(95% CI)
Age	0.786	0.0001	2.195	1.432-3.363
Location (PA)	1.863	0.0001	6.446	2.214-18.767
Constant	-3.639	0.0001		

The seroprevalence result between the two sexes was significantly different ($P < 0.05$) in univariate analysis. Seropositivity in female goats is 1.8 (95% CI = 1.123-3.006) times more likely to occur as compared to male goats. Seroprevalences for CCPP F38 increased with age from 12.7% in kids, 14.7% in young goats to 21.8% in adults. The likelihood of seropositivity in the adult age category was 1.9 times greater than in the kids age category. The difference in seroprevalences among the twelve PA's was statistically significant ($P < 0.0001$).

Multivariate logistic regression analysis

To this analysis all variables whose p-value were smaller or equal to 0.25 in the univariate analysis that is age, districts, sex, and PA were subjected to a multivariable logistic regression analysis.

After a series of back-ward step wise selection, the final logistic regression model disclosed two factors, that is, location (peasant association) and adult age that are the main contributing factors for CCPP seropositivity in the study Districts (Table 3).

As there was no interaction observed among age and peasant association (PA), these two factors could be used to construct the regression model to predict the occurrence of CCPP in the study area. Hence the regression model for the seroprevalence (occurrence) of CCPP in the study area based on the major risk factors identified is:

$$\text{Log (p)} = 0.786 \text{ age} + 1.863 \text{ PA} - 3.639$$

Seroprevalence result for CCPP at flock level

A flock was considered as seropositive when at least one animal reacted positive in the CFT. Seroprevalences based on flock levels are shown in Table 4.

The mean flock seroprevalence for CCPP in the study area was 54.3%; about every second flock harboured at least one sero-reactor. In Table 4 it also became apparent that the highest numbers of positive flocks were found in the agropastoral areas of Itang (73.9%) and Lare (44.8%) and the lowest in the sedentary area of Gambella Zuria District (35.0%). The overall within flock

Table 4. Flock level seroprevalence of CCPP in selected districts of Gambella region.

District	Flocks tested	No. flock positives	Flock seroprevalence %	95% CI
Gambella Zuria	60	21	35.0	23.05-49.95
Lare	67	30	44.8	32.99-56.61
Itang	92	68	73.9	65.01-82.79
Total	219	119	54.3	47.76-60.84

Table 5. Ranking of the major goat diseases by 80 goat farmers/pastoralists in the study Districts by means of a questionnaire, Gambella Region, Ethiopia, 2011 (n=80).

Name of the disease	Frequency of responses (%)	Rank of importance
CCPP (<i>Zom/dom</i>)	47(58.7)	First
Internal parasites	24 (30%)	Second
Orf (contagious ecthyma)	5 (6.3%)	Third
PPR	2 (2.5%)	Fourth
Abortion problems	2 (2.5%)	Fourth

Table 6. Major contributing factors for CCPP outbreaks as given by 80 goat farmers/pastoralists in the study districts by means of a questionnaire.

Putative risk factor	Frequency of responses (in %)	Rank
Wet-season (summer)	80 (41.6%)	First
Grazing area	36 (18.7%)	Second
Watering points	27 (14.1%)	Third
Large flock size (>20 goats)	25 (13.0%)	Fourth
Introduction of sick/diseased animal	21 (11.0%)	Fifth
Purchased animals	3 (1.6%)	Sixth

level seropositivity ranged from 0 to 6 positive goats and did not vary considerably ($p>0.05$) between the 2 production systems.

The logistic regression analysis for flock size categories and seropositivity indicated no significant differences.

Questionnaire survey results

From 80 respondents, 47 (58.7%) ranked CCPP as the number one disease that causes severe effects on the goat population in their area, 32 (40%) consider CCPP as the second important disease in the study area and only 1 (1.3%) of the respondent gave CCPP the third rank among the prevalent goat diseases in the study area. All the animal owners and herders were also asked about risk factors associated with CCPP outbreaks. Each respondent was asked multiple answers question in this particular case. The multiple answer scores were compiled as frequency of responses and then the factor that had highest score was ranked first (Table 5).

Accordingly, wet season (summer) was by far the first ranked risk factor, followed by grazing area, watering points, large flock size and introduction of sick/diseased animal contributing to a CCPP outbreak and spread (Table 6).

The main reasons for raising goats in the study areas were cash income, dairy and meat consumption which accounted 53.0, 43.7 and 3.3%, respectively. Important areas where flocks do contact were grazing areas (51.2%) and watering point (48.8%). With regard to disease control measures treatment of sick goats ranked first (52.5%), followed by isolation/segregation of sick goats from apparently healthy ones (44.3%) and marketing of affected/healthy goats ranking third (3.2%). None of the interviewees encountered CCPP cases or outbreaks during the study period in their flocks, neighboring flocks, in their districts and zones. Apparently they have a good knowledge about CCPP, which they locally call the disease as 'Zom' in their area. The respondents were aware of the high contagious nature, morbidity and mortality of the disease, clinical signs such

as coughing and difficulty in breathing were familiar to them; and most importantly they understood that CCPP only affects goats. About 71.1% of the respondents were not aware of vaccine and vaccination of goats. Those who knew about vaccines (28.9%) said they used it against PPR. According to their observation, the vaccine used for PPR was effective, that is, no goat became sick or died after vaccination.

DISCUSSION

Seroprevalence at individual animal level

The overall individual animal seroprevalence of CCPP in the study area was 18.1%. The finding in the present study is similar to the work of Mekuria and Asmare (2009) and Ayelet et al. (2007), who reported seroprevalence rates of 18.62% in South Omo and Arbaminch areas and of 18.92% in Dire, 15.38% in Liban, and 21.05% in Yabello areas, respectively. However, our findings are substantially different from the seroprevalence rate of 51.5% reported by Mamo (1993) in East showa, 35% at Konso (Bereket, 1995), and 32.68% in selected districts of Tigray and Afar (Birhanu et al., 2009). In acute outbreak areas of Afar and Borena Sharew et al. (2005) using CFT and b-ELISA reported even seroprevalence of 52% up to -100%. The high level of sero-reactors in the latter reports can be attributed to the ongoing CCPP outbreaks at the time of sampling and/or purposive sampling of goats for diagnostic purpose. On the other hand the relatively low seroprevalence observed in this study may be explained by the subclinical level infections.

It was observed that the prevalence of seropositive goats increases with age which was also observed by the community (and recorded in the questionnaire). This finding of the study is contradictory to Gizawu et al. (2009), but in agreement with the report of Mamo (1993), who observed the presence of significant variation between age groups.

Moreover, adults also tend to be infected repeatedly since they are exposed and stayed longer in a flock than both young goats and kids. Therefore, the probability to be seropositive at older ages for CCPP would be higher as compared to kids and young goats.

In addition, the relatively low seroprevalence of CCPP may be related to the ability of the test to detect antibodies that appear first and span for a short duration in the blood. IgM is the first to appear and has little specificity which giving risk to pronounced cross-reactions, and remains in the blood for short duration, while IgG is produced lately and lasts much longer than IgM antibody isotypes (Staak et al., 2001). The CFT has clear limitations: March et al. (2000) observed that 80 to 100% of animals experimentally infected with *Mccp* in their acute phase were not detected. Based on this report seropositives detected by CF test indicated that there

were recent infections and circulation of the causative agent within the flocks.

Flock level seroprevalence

The overall flock level seroprevalence of CCPP was 54.3% in this study implying the presence of the disease in the majority of the flocks in the study area. This result agrees with the result of Mekuria and Asmare (2009) who reported an overall flock level seroprevalence of 54.8%. Difference in seroprevalence at flock level between the agropastoral and sedentary production system were observed in the present study. Flock seroprevalence in the agropastoral area was 61.6% as compared to 35% in the sedentary area. The range of seroprevalences of 0 to 100% between flocks which could be attributed to the differences in husbandry practices in the different districts and production systems. Also there could be differences among herders themselves to react and take measures against the occurrence of diseases within their flocks.

Slightly higher individual seroprevalence differences were seen in the agropastoral areas Itang and Lare (19.2%) when compared to 14.7% in the sedentary area Gambella Zuria. However, nearly twice the number of flocks in the agropastoral areas (61.6%) showed at least one serological reactor for CCPP when compared to the sedentary areas (35%).

The difference in seroprevalences in the various flock size categories was not statistically significant ($p>0.05$). The finding of this study contradicts with the works of Bekele et al. (2011); flock sizes found in the present study area were relatively small, with an average flock size of 11 to 12 goats (Farm Africa, 1996), as compared to flock sizes found by Bekele et al. (2011), who considered a large flock as a flock having greater than 160 goats per household in the study conducted in Borena and Gujji areas. The flock size variation between the two study areas might be due to different animal husbandry practices and purpose of production.

Risk factors

In the Districts where the production system is agropastoral, especially in Itang and Lare, most of the communities living around the river banks move to dry areas from August to December due to flooding. In this period of time animals congregate in certain areas coming from different localities, thus, favoring the transmission of CCPP from a sick or carrier animal to a healthy animals. Furthermore, during transportation and at temporary waiting pens, goats are kept in close proximity to each other resulting in increased contact rates between animals and, thus enhancing transmission (Lefevre et al., 1987; Crespo, 1994). CCPP transmission by direct contact (by aerogenic route, through droplets released during coughing) is common and a very short

period of contact is sufficient to transmit the disease but intimate contact is needed (Thiaucourt and Bolske, 1996). Therefore, a high stocking density in grazing areas in agropastoral production systems (McDermott and Arimi, 2002; Mekasha, 2007) as well as overcrowding and confinement proved to favour circulation of the agent (Lefevre et al., 1987) and thus contributed to the relatively higher CCPP infection as serologically determined by CFT in the agropastoral production system although the finding is not statistically significant ($p > 0.05$). Therefore, one could conclude that CCPP seems to be equally important in both production systems. However, in the period from August to September animals encounter highly stressing conditions and are more likely exposed to diseases like CCPP, pasteurellosis and endoparasites, as carrier animals may shed more organisms (Thiaucourt and Bolske, 1996).

Sex of the animal was associated with seropositivity in the univariate analysis of risk factors. However, the seroprevalence difference between male and female goats is not biologically plausible but rather due to higher number of female goats in the flocks included in the study area and also most of the females being adults. Thus, the chances of sampling a female and adult goat were quite high. However, the difference due to sex was not statistically significant in the multivariate logistic regression analysis, which is in agreement with the report of Zenebe (2004) and Mekuria and Asmare (2009).

The questionnaire survey and the serological test results indicated the occurrence of *Mccp* antibodies in all age groups. In both the univariate and multivariate logistic regression analyses the seroprevalence of adult goats was statistically significant different from the seroprevalence in kids. Goats of adult age were 1.84 times more likely to be seropositive than kids. This higher risk could be explained by the fact that the older animals get longer exposure in infected areas and, thus a greater likelihood of infection with the causative agent of CCPP. This finding is in agreement with Mekuria and Asmare (2009) and Bekele et al. (2011) but contrary to Nigatu (2003) and Eshetu et al. (2007) where age was said to play no role in the CCPP epidemiology.

Statistically significant difference in seroprevalence among locations was recorded in the present study. This is in agreement with the report of Mamo (1993); Mekuria and Asmare (2009); and Nigatu (2003). The observed difference might not be accounted due to the difference in agro-ecology for all study areas are in the lowland agroecology; but rather is attributed to the differences in level of accessibility to veterinary services, other infrastructure (road) and the animal husbandry practices. Also from our observation and personal communication to local experts, PA's that had higher seroprevalence such as Opagna, Badyel, Bonga and Meding Zuria are within a range of 15 to 40 kms distance and thus far from the respective district capital where the animal health service delivery center is located. In addition, from the

questionnaire survey we know that in Opagna, Badyel, Bonga and Meding Zuria PA's most of the respondents used the communal animal management system, significant proportions of the respondents treated their goats by themselves and even some used traditional medicine to treat their goats. All the above conditions and traditional practices that are found in the respective PA significantly contributed to the higher seroprevalence in that particular PA. In addition, the higher prevalence in some PA's could be attributed to the presence of endemic foci in this area; the odds for seropositivity of goats in Opagna PA were 6.4 times greater than for goats in Zero-1 PA.

The questionnaire survey findings from pastoralist/farmers and from district animal health professionals revealed that CCPP, internal parasitic diseases and contagious ecthyma (Orf) were ranked first, second and third problems, respectively. In South Omo and Arbaminch areas Mekuria and Asmare (2009) also reported CCPP as the first priority disease.

Among the contributing factors for the presence and transmissions of CCPP infection, wet-season, grazing areas and watering points were identified as the major contributors followed by large flock size, introduction of diseased and purchased goats as also reported by other authors (Thiaucourt and Bolske, 1996; Nicholas, 2002). This may be explained by the fact that a new CCPP infection needs proximity to an infected goat (acutely or chronically), latent carriers such as goats which recovered from infection without becoming bacteriologically sterile, and are considered to be responsible for the perpetuation of the disease in a flock. An increasing number of susceptible animals within the population also contributes much to CCPP transmission. The aggregation of goat flocks during watering, grazing and resting times will favor the spread of infection within the flock. In extensive husbandry systems, communal grazing areas and watering points are known to be the major sites for disease transmission (Seifert, 1996). Community knowledge and perceptions about CCPP, with the local name *Zom* and its signs described were highly related with those indicated in text book such as coughing, weight loss, sudden death and high mortality (Nicholas, 2002; Bereket, 1995).

CONCLUSION AND RECOMMENDATION

CCPP is identified as one of the most economically important diseases in GRS. This study has shown that CCPP is endemic and apparently exists at sub-clinical level in the study areas. Factors such as age and location (PA's) assist in explaining CCPP occurrence and distribution. The overall seroprevalence and questionnaire survey findings suggested that a wide distribution of CCPP infection in both agropastoral and sedentary production system in the study area. The

questionnaire survey findings suggested that the indigenous knowledge of the community is very crucial in the management and husbandry practice of small ruminants in the study areas of GRS. Therefore, an integrated control and prevention program on CCPP should be conducted through multidirectional approaches which include minimizing stress factors, isolation of clinical cases, care during restocking, vaccination before September (outbreak month) and early treatment of clinical cases. Indigenous knowledge of the community is also worth full in CCPP control if supported through scientific evidences.

Conflict of Interest

The authors have not declared any conflict of interest.

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