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## Research Article

# PPR in Camels: Sero-Prevalence and Socio-Economics

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**ABSTRACT**

Camels are important livestock species kept mainly by pastoralists to support their livelihoods and other socio-economic needs. Peste des petits ruminants (PPR) is a disease of great economic impact in pastoralist herds, mainly known to affect sheep and goats. Recent serological surveys have confirmed presence of Peste des petits ruminants virus (PPRV) antibodies in camels in Sudan and Ethiopia. Owing to the limited information about PPR epidemiology in camels in Kenya, this study was conducted to determine PPRV seroprevalence using 398 serum samples in camels in the northern region of Kenya (Isiolo, Marsabit, Wajir and Mandera counties) via competitive Enzyme-Linked Immunosorbent Assay (C-ELISA) technique. To complete the study, thirty six questionnaires were administered to camel herders and owners linked to the 398 serum samples to collect information on socio-economic factors related to household characteristics, livelihood activities, livestock production and benefits, camel and camel product sales and income. An overall PPR seroprevalence in camels of 3.0% [95% CI: 1.6%, 5.2%] was estimated. Sex ($P$=0.013) and County ($P$=0.068) were significantly related to the PPR sero-prevalence. The study found that camel keeping is major source of livelihood and nutrition. Respectively, 92% and 86% of the respondents cited sale of camel milk and camels as major benefits derived from camels. Presence of PPRV antibodies in camels in Kenya suggests that camels may be involved in the circulation of PPRV and underscoring the need for more research to determine the epidemiological role of camels in a multi-host environment.

**Key words:** PPR, Camel, Socio-economics, Sero-prevalence

## INTRODUCTION

Arid and semi-arid lands (ASALs) cover approximately 80% of Kenya's land mass (Kitalya *et al*, 2002); it is home to about 30% (approximately 12 million) of the country's human population. The camel is an important livestock species adapted to ASALs and mainly kept by pastoralists (Dowelmadina *et al*., 2015). The world camel population is projected at 19 M. The immense majority of these (about 79%) are found in Africa and 4 million in (Farah *et al*., 2007) Kenya. Kenya is the third African country with largest camel population (3,091,200 camels) (need a reference here). The annual worth of camel meat and milk in Kenya is approximately US$ 11,000,000 (Musinga and Kivolonzi, 2008).

Camels are multipurpose animals in nomadic pastoral production systems of north eastern, Kenya (Noor *et al*, 2013), specifically kept for producing milk, meat, provision of transport and social and cultural functions (Kaufman and Binder, 2002). These functions can be restrained by poor health of the camels greatly impacting household nutritional and socio- economic needs. PPR is a disease of great economic impact as it causes great livestock losses (OIE, 2009). Caused by PPR virus (PPRV) in the family *Paramyxoviridae* and genus *Morbillivirus*, (Balamurugan *et al*., 2012), the disease primarily affects sheep and goats. The disease is acutely characterized by oral erosions and pneumonia reporting mortality and morbidity at 90–100% in naive population of sheep and goats. Whereas camels are known to be affected by many diseases, few viral agents are known to inflict diseases in them. Limited knowledge exist about PPR in camels – for instance, some serological studies in Sudan and Ethiopia have indicated that camels are susceptible to the virus (Roger *et al*., 2001; Haroun *et al*., 2002). In addition, Khalafalla *et al*., (2010) reported positive results for PPR virus with virus isolation in cell culture, Agar gel diffusion test (AGDT) and RT-PCR after a fatal disease outbreak in camels, characterized by sudden death in Sudan. As the health of livestock and the

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household and community economic welfare are closely linked in livestock-dependent pastoralists, this study was conducted to determine previous exposure to PPRV using serology and describe associated socio-economic factors in northern Kenya.

## MATERIALS AND METHODS

### Study area

The study was conducted in four counties in Kenya; Mandera, Marsabit, Isiolo and Wajir counties. The four counties are part of hot ASALs of Kenya where they record minimal rainfall between 300-500 mm per year, and the temperatures experienced range from 13°C to 30°C. The vegetation consists of acacia trees and shrubs. The soil is generally sandy and saline, with low water holding capacity, making it almost impossible to engage in agricultural activities. They practice extensive livestock production, through nomadic pastoralism and camel is the main livestock kept. The site was purposively selected based on the large population of camels which are reared closely with goats and had previously reported CSD outbreaks.

### Study design

This was cross-sectional study, involving the use of semi-structured questionnaires, to collect data used to assess socio-economics factors related to camel keeping. Enzyme-linked immune-sorbent assay (ELISA) was used to detect antibodies against PPR in the serum of the sampled camels. Questionnaires were administered to the farmers whose camel herds were bled for serum samples.

### Data collection

#### Questionnaire administration

Questionnaires were administered through in person interviews and interview guides to enable probing by interviewers and In-depth interviews. The answers were prudently recorded in the questionnaire as the interview continued and confirmed well filled before proceeding to the next respondent. Important household and herd-level data collected included household characteristics, livelihood activities, livestock production and benefits, camel and camel product sales and income. Sampling units were the heads of household or any responsible adult in the household at the time whether male or female.

### Blood collection, processing and serum storage

Blood was collected from the jugular vein of each camel using plain vacutainer tube (Becton Dickson, UK). Each sample was labelled using codes describing the specific animal. The tube was set tilted on a table over night at a room temperature to allow clotting. The next morning, the clotted blood in the tubes was centrifuged (at 3000 g for 20 min) and clear serum obtained. The obtained serum was then stored at -20°C, at the University of Nairobi Veterinary virology laboratory until their analysis. A sample of 399 samples of 400 camel sera were realized.

### Serology

Competitive Enzyme-Linked Immunosorbent Assay (C-ELISA). INGEZIM PPR COMPAC, 13.PPR, K3 kit from Spain was used for serology. All the serum samples were tested as described in Kihu *et al*., 2015. The relative level of antibodies (Blocking %) of each sample was calculated as follows (INGEZIM PPR COMPAC, 13.PPR, K3-Technical guide):

Blocking % = 100-[(OD sample / OD negative control) × 100]

All samples with blocking % higher than or equal to 50 were considered positive and those with blocking % lower than 50 were considered negative.

### Data analysis

#### Questionnaire data analysis

The data collected were keyed in a database prepared in Microsoft Excel®. The data was then transferred to the Statistical Package for Social Science (SPSS) in a worksheet format from where the data cleaning process was carried out. Both descriptive and inferential analysis was carried out using the IBM SPSS software. The major analysis outputs from the analysis included tables and charts, which are useful in the interpretation of the findings.

### Seroprevalence

The sero-prevalence of PPR was calculated using Bennette *et al*., (1991) formula;

Prevalence (%) = number of seropositive samples/total number of serum samples examined× 100

This formula was used to compute the overall sero-prevalence and sero-prevalence by sex, age and county. The relationship between PPRV antibody sero-prevalence and individual risk factors for PPRV sero-positivity was assessed by first running univariable logistic regression models. The risk factors assessed included sex, age and county. The significance level was set at $P \leq 0.1$ at this stage. The risk factors that were significant were presented to the multivariable logistic regression model, where backward elimination was done to choose factors for exclusion using the likelihood ratio test ($P<0.05$). Estimation of the strength of association between the risk factor and PPRV sero-positivity was done using the odds ratios (OR) which were derived from the coefficient estimates from the logistic regression models.

## RESULTS

### Socio-economics

#### Socio-demographic characteristics

A total of thirty-six questionnaires were administered in the four counties, with 10, 8, 4 and 14 questionnaires from Mandera, Isiolo, Marsabit and Wajir counties respectively. Of all 36 respondents 97% were men and 3% were women. The education level of the respondents was low, for instance, 63% of the respondents never received formal education. Those who achieved Primary education were 14% and 3% of the respondents completed secondary education; none of the respondents had post-secondary education. Majority of household heads depended on livestock for income, for example, 94%, and 3% each of the household heads relied on livestock,

formal employment and informal employment for income respectively.

**Benefits derived from camels by questionnaire respondents**

Sale of camel milk was cited by all respondents as the main benefit derived from camels. 92% of respondents reported benefiting from sale of camels and 86% of respondents reported using camels in payment of dowry. Other benefits included draught power and provision of meat to a lesser extent (Figure 1).

**Camel milk production and sale**

Data on milk production was sought in "good" times - times when there are no major challenges of production, e.g. diseases or drought and "bad" times - times when there are major challenges of production, e.g. diseases or drought. The mean milk production in "good" time was 4.8 liters with a median of 3.5 liters. The minimum and maximum production reported was 1.4 and 15 liters respectively. The mean milk production in "bad" time was 2.5 liters with a median of 1.8 liters. The minimum and maximum production reported was 0.35 and 10 liters respectively. Data on milk sale was also sought in the same manner. The mean milk selling price in "good" time was Ksh 56 with a median of Ksh 50. The minimum and maximum selling price in "good" time was Ksh 20 and Ksh150 respectively. The mean milk selling price in "bad" time was Ksh 39 with a median of Ksh 30. The minimum and maximum selling price in "bad" time was Ksh 10 and Ksh100 respectively. Data on camel sale was also sought in the same manner. The mean camel selling price in "good" time was Ksh 71,515 with a median of Ksh 70,000. The minimum and maximum selling price in "good" time was Ksh 20,000 and Ksh150, 000 respectively. The mean camel selling price in "bad" time was Ksh 38150 with a median of Ksh 30000. The minimum and maximum selling price in "bad" time was Ksh 10,000 and Ksh100, 000 respectively.

All respondents indicated that upon camel sale, the household head was responsible for the sale proceeds. However, only 5 respondents (14%) indicated that the household head was responsible for sale of camel milk-the rest (84%) reported that other members of the household (wife and or children) were responsible for sale of camel milk (Table 1).

**Serology**

**Characteristics of sampled camels**

A total of 398 camels were sampled, with Isiolo county recording the highest number of camels sampled (120 out of 399). Majority of sampled camels were adults (59%). The proportion of sampled females was higher than that of males (Table 2).

**PPR sero-prevalence by Age group**

Sero-prevalence by age group was ranging from 2% to 5%. The sero-prevalence was increasing from adults (2.11%) to calves (5.71%), (Table 3).

**PPR Sero-Prevalence by Sex**

PPR sero-prevalence was higher in males (6.54%) compared to females (1.72%), (Table 4).

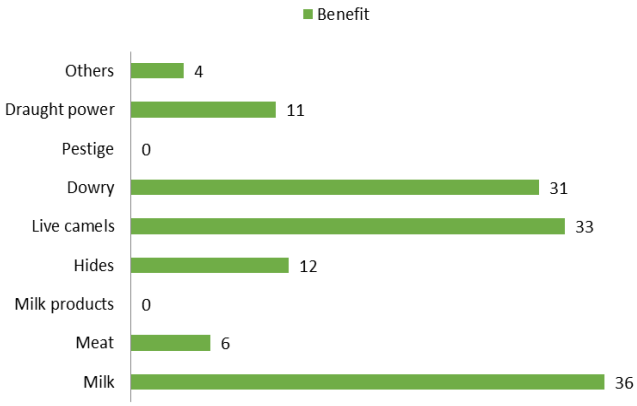


**Fig. 1:** Benefits derived from camels.

**Table 1:** People responsible for sale proceeds of live camels and camel milk

| Person responsible for sale proceeds | Live camels | | Camel milk | |
|---|---|---|---|---|
| | Frequency | Percentage | Frequency | Percentage |
| Household head | 20 | 57.1 | 5 | 15.2 |
| Owner | 7 | 20.0 | 4 | 12.1 |
| Men | 8 | 22.9 | 2 | 6.1 |
| Women | 0 | 0 | 21 | 63.6 |
| Any family member | 0 | 0 | 1 | 3 |
| Total | 35 | 100 | 33 | 100 |

**Table 2:** Characteristics of sampled camels

| Variable | Frequency | Percentage (%) |
|---|---|---|
| Sex | | |
| Male | 107 | 26.88 |
| Female | 291 | 73.12 |
| Age | | |
| Calf | 70 | 17.59 |
| Middle age | 91 | 22.86 |
| Adult | 237 | 59.55 |
| County | | |
| Isiolo | 120 | 30.15 |
| Marsabit | 88 | 22.11 |
| Wajir | 105 | 26.38 |
| Mandera | 85 | 21.36 |

**Table 3:** PPR Sero-Prevalence by Age

| Age | Frequency | Sero-positive | Sero-prevalence (%) |
|---|---|---|---|
| Calf | 70 | 4 | 5.71 |
| Middle Age | 91 | 3 | 3.30 |
| Adults | 237 | 5 | 2.11 |
| Total | 398 | 12 | 3.11 |

**Table 4:** PPR Sero-Prevalence by Sex

| Sex | Frequency | Sero-positive | Sero-Prevalence (%) |
|---|---|---|---|
| Male | 107 | 7 | 6.54 |
| Female | 291 | 5 | 1.72 |
| Total | 398 | 12 | 3.02 |

**Table 5:** PPR Sero-Prevalence by County

| County | Frequency | Sero-positive | Sero-prevalence (%) |
|---|---|---|---|
| Isiolo | 120 | 3 | 2.50 |
| Marsabit | 88 | 6 | 6.81 |
| Wajir | 105 | 3 | 2.86 |
| Mandera | 85 | 0 | 0.00 |
| Total | 398 | 12 | 3.02 |

**PPR Sero-Prevalence by County**

PPR sero-prevalence by counties ranged from 0% to 7%, with overall sero-prevalence of 3%. Marsabit County recorded the highest sero-prevalence while Mandera County recorded the lowest (Table 5).

## DISCUSSION

PPR is mainly a disease of sheep and goats. Although the clinical manifestation of the disease is not pronounced in camels, this study found that camels in Kenya are indeed exposed to PPRV, meaning camels are susceptible to the disease. The sera samples tested in this study gave an overall sero-prevalence of 3.02%, which was similar to findings by (Abraham *et al*., 2005) which recorded PPR sero-prevalence was 3% in Ethiopian camels. However, the results were lower likened to those reported by Ismail *et al*., (1992) in Egypt and Roger *et al*., (2001) of 7.9% in Ethiopia. The camels tested were never vaccinated against PPR, this results therefore indicate that the camels have had natural exposure to the disease, and there could be possibility of natural transmission of the disease between camels and sheep and goats, considering the camels are reared closely with sheep and goats which are the most susceptible hosts.

We were not expecting to find sex as a variable to be a significant risk factor for PPR sero-prevalence in camels. While male camels had high sero-prevalence compared to female camels, the opposite holds true for PPR in goats (Kihu *et al*., 2015). In goats, the explanation for this finding was straightforward about population structuring and turnover (Kihu *et al*., 2015). The females were 75% not likely to have PPRV antibodies compared to males. There is no known sex-related factor that can be attributed to such differences, and this calls for concerted empirical inquiry in to camel husbandry practices that would expose camels of separate sexes differently or physiological mechanisms that lead to such variation in epidemiology between sexes.

Sero-prevalence by county was ranging from 0% to 7%, with Marsabit County recording the highest sero-prevalence and Mandera County recording the lowest. With logistic regression, Marsabit County showed to be 2 times more likely to have camels with PPRV antibodies compared to Isiolo County. These variations in PPRV sero-prevalence between the counties suggest spatial variations in exposure between counties. socio-ecological factors may be responsible for PPRV sero-prevalence (Kihu *et al*., 2015). PPR can affect the health of camel directly or indirectly and therefore impacting on household nutrition and socio-economic needs. This study completed the picture by collecting socio-economic information.

The study found out that the camel keeping was major source of livelihood and nutrition. Camel keepers derived many benefits from the camels, the main benefit being Sale of milk (100%). 92% of respondents benefited from sale of camels and 86% of respondents used camels in payment of dowry. Other benefits included draught power and provision of milk and meat for home consumption. This corresponds with findings by Noor, (2013) and Farah, (1996) stating that camels are primarily kept for production of milk and meat and also used for transportation and socio-cultural functions.

Camel milk was found to be the main source of income for buying food with fibre, since vegetables are not grown in the region. Furthermore, the study found out that the milk prices keep fluctuating, experiencing low prices when there are major market challenges, this corresponds with findings by KCA (2009) that camel products prices depended on several factors, including body condition, demand and market supply. The seasonal milk prices may lead to fluctuating provisions affecting socio-economic constant needs and fluctuating nutritional provisions to the community.

The literacy level in the population was pitiable, this is indicated by the fact that majority of the respondents (n=36, 63%) had no formal education and none attained tertiary education. This agrees with the findings of a study in Isiolo County by Elhadi Y. *et al*., (2015) that reported most of the respondents (81.2%) had no formal education, whereas only 1.5% had attained tertiary education. Possible explanation for the poor education level of the camel keepers can be the inaccessibility of education services in the area, given its pastoral ASAL nature and the belief that the livestock management doesn't need special skills. Also, the poor income from livestock keeping is not enough to afford higher levels of education.

This study established that camels are key in food provision, income, social status, and as a store of wealth. Camel milk and meat are direct source of food, camel and milk sale provides income for buying other source of nutrients, fund education and other household needs. Evidence of camel susceptibility to PPRV means PPR disease may affect camel health directly resulting to loss of source of livelihood and nutrition. The relationship between livestock health and socio-economics is complex, and there is need for further studies to understand it in quantitative to develop improved livelihoods and animal health interventions.

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