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Research Article

Impact of MCCP infections on production and economics of small ruminants in KPK, Pakistan

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Abstract

This study investigated the production and economic impact of *Mycoplasma capricolum* subspecies *capripneumoniae* (Mccp) infection in goats and sheep within the KPK province of Pakistan. Randomly, 1500 samples were obtained from young and adult animals from various sheep and goats. The samples were screened using biochemical and molecular techniques. The data analysis was performed based on estimated feedback comprising of laboratory diagnosed positive cases and designated as potential risk factors. Out of the serum samples tested, only samples positive for anti-Mccp antibodies were considered for this study. The Model predicted coefficient values exhibited significant ($P < 0.05$) influence of clinical severity of the disease in assessed in the herds. Direct production losses in CCPP-infected animals included mortality rates of 8% for kids and 1.50% for adults, meat loss averaging 19.60% per animal, milk yield reduction ranging from 0.31 to 0.7 liters per animal (21.09%), skin loss (3.31%), wool loss (11.71%), and culling rates ranging from 12.44% to 18.07%. Wool production in MCCP-infected animals decreased by 175 to 230 grams compared to non-infected counterparts, with inferior wool quality observed in infected flocks. Indirect losses were estimated, considering diagnosis expenses (Rs 4000-5000), veterinary services (Rs 5000/visit), treatment costs (medication + supplements: Rs 1000-1800/animal), supplementary farm inputs (Rs 200-250/animal), and labor charges (Rs 100-180/animal). The significant ($P>0.05$) impact of MCCP infections was recorded among the infected animal population on production performance. The average cost of culling an animal was calculated based on the loss of value, ranging from Rs 65,000 to 85,000 per culled goat or sheep. Indirect losses such as labor charges, veterinary services, diagnosis and treatment were significant ($P<0.05$) contributing to financial burden in small ruminant population. These findings highlight the substantial economic burden of MCCP infections on small ruminant farming in the region.

Keywords: Economics; Health; MCCP infection; Production losses; Small ruminant

Introduction

Goats are primarily vulnerable to Mycoplasma capricolum subsp capripnemoniae (MCCP) infections, whereas sheep demonstrate a lesser susceptibility to pulmonary mycoplasmosis **[1]**. Mccp strains are involved in high rate of morbidity (100%) and morbidity (60-80%) in goat and sheep

flocks. Small ruminants especially sheep and goat are most venerable to MCCP infection [2]. The disease is highly contagious and influencing and infecting goat and sheep populations and may be a great threat to small ruminant farming communities. In addition, several MCCP infections cases have been diagnosed in natural wildlife reserves [3]. It has been reported that infections have a severe impact on production and economic losses in goat and sheep populations across African, Asian, and European countries [4-7]. The huge economic losses may be attributed to huge mortality in naïve kids in the infected flocks [8]. Due to high morbidity and mortality rate and the widespread of MCCP infections, the small ruminant farming industry was severely affected and reduced in the various regions across the globe [1]. In general, vaccination/immunization expenses of MCCP infections are very low in comparison to average big financial losses incurred by the disease [8]. The estimated cost of contagious caprine pleuropnemonia (CCPP) vaccination is low for animals per day in Kenya. Without CCPP vaccination, a standard flock of 100 animals in the country could incur an average annual huge financial loss [8]. In addition, Sheep and goats represent two of the small ruminant species most vulnerable to CCPP. The occurrence of CCPP outbreaks may result in considerable economic and trade disturbances in the different small ruminant farming countries [9, 10]. Several outbreaks of CCPP infections produced heavy losses in small ruminants were reported in various regions of Pakistan [11-14].

In routine, several clinical Mycoplasmosis cases have been reported in the ovine and caprine population in most parts of the province of Khyber Pakhtoon Khuwa, Pakistan. Considering the situation, the current study is designed to evaluate the impact on health, production, and economic aspects of the disease in the study area.

Materials and Methods

Sample and data collection

The different areas of the province of Kyber Pakhtunkhwa (KPK), Pakistan were chosen for the screening of *Mycoplasma* species in small ruminants. Randomly, 1500 samples were obtained from young and adult animals from various sheep and goat farming areas of the districts of KPK province. The collection followed standard procedures [15], from specified districts: Bannu, Abbottabad, Kohat, Orakzai, Buner, DI Khan, Karak, Mardan, Charsadda, Nowshera, Peshawar, Bajaur, Kurram South, and North Waziristan. A survey form (questionnaire) was used to record data related to history, clinical, and production parameters. Nasal discharge and throat secretions were obtained from diseased animals, while lung tissue and pleural fluid were sourced from deceased animals, with mortality rates documented. The samples were preserved in tubes with PPLO broth and transported to the Veterinary Research Institute (VRI), Peshawar for culturing and molecular analysis. Out of the 1500 collected samples, 750 animals from fifteen herds (consisting of 50 animals each) were selected from every district under investigation to assess production losses. The incurred losses were estimated per herd and/or per sheep/goat, encompassing direct losses (meat, milk, skin, wool) and indirect losses due to treatment and management. Sheep herds infected with MCCP, aged 2 years and above, were considered for wool production analysis. Calculations were based on the infection levels within sheep/goat herds, utilizing available records/history from farmers. Additionally, production losses were measured in terms of SI units of measured parameter and market value in Pakistani Rupees (PKR). Each herd's data was analyzed independently. Considering mortality rate data obtained from the farm records. Information regarding indirect losses, including veterinary services,

treatment expenditures, supplementary farm inputs, and labor expenses, was extracted from farm records.

Bacterial growth and molecular screening

The swabs were placed into 3 ml of PPLO medium and then kept at 37°C with 5% carbon dioxide for duration of 7-15 days. Cultures showing positive signs such as turbidity, swirling motion, and a color change from red to yellow were considered viable, while negative cultures were discarded. Positive cultures were filtered and streaked onto PPLO agar plates, followed by another round of incubation at 37°C for 3-15 days. Mycoplasma colonies were observed daily using a stereo microscope. To ensure purity, individual colonies were subculture and passed through a 0.45µm membrane. Each colony represented a clone originating from a single cell. These clones were preserved in PPLO broth for further analysis, including PCR testing **[15-17]**.

Biochemical profile

To isolate and identify *Mycoplasma* organisms, biochemical tests were performed, including assessments for film and spot production, sensitivity to digitonin, tetrazolium reduction, urea hydrolysis, phosphatase activity, and glucose breakdown. These tests were conducted following the methodologies described by Shahzad *et al*. and Houshaymi *et al*. **[18, 19]**.

Estimation of economic losses

The sample size was carried out to balanced/ maintained predetermined estimates for diagnosis of the MCCP occurrences (not prevalent) within estimated herds and animal-level presence versus financial constraints. The methods applied for the estimation of production losses were recorded as previously reported by Manlove *et al*. **[20]**. A total of economic losses were measured using various parameters (differences in before and after Mycoplasma species infection) including body weight, meat production, milk and wool yield, treatment and control of infections in small ruminants. The differences in body weight were calculated based on decrease in weight gain, history and weight of contemporary flock in the herd. The cost estimation of meat was measured on basis of dressing percentage (40%) of body weight of the sampled animal. The information regarding the various production parameters from positive infected flocks were recorded during the survey period at different interval. The data analysis was performed based on estimated feedback comprising of laboratory diagnosed positive cases of MCCP infected flock (pooled survey level samples) and designated as potential risk factors; management, herd size, culling, infection burden, bio-security, treatment costs and veterinary services. Other estimated feedback was consisting of predictor based on uninfected/negative flock (pooled survey level samples) include production performance parameters. In addition, the estimates of differences of production losses were calculated based on various geographical/climatic conditions of the regions. The variables comprising of were generated by feedback obtained history, clinical survey, laboratory screening and estimated production performance and uni-variate distribution of each parameter **[18]**. The association between uni-variate and infected herds were calculated according to Wilcoxon rank-sum test and logistic regression model consisted of positive sample pool. Further the feedback variables linked to presence of the disease, health status and production performance **[19]**. The study generated model based on presence or absence of the disease (1st predictor) in the screened samples from flocks. The 2nd predictor consisted of feedback associated variables, herd size, management, veterinary services, culling and production losses **[20]**. The production loses were assessed and accounted in terms of clinical and local

commercial values associated to different estimated variables. The average production losses were quantified /expressed in percentage (%) on a herd/animal basis.

Statistical analysis

The data collected during the study were entered into a Microsoft Excel spreadsheet and analyzed statistically. Data analyses associated to variable, linear, negative regression, mixed poised regresssion binomial models, were applied using bayesglm technique in arm package **[18-20]**.

Results

Assessing production losses and quality in CCPP-affected herds

Direct production losses, including mortality rates for kids (8%) and adults (1.50%), meat loss (2-5kg/animal) at 19.60%, milk yield reduction (0.31-0.7 liters /animal) at 21.09%, skin loss (3.31%), wool loss at 11.71%, and culling rates ranging from 12.44% to 18.07%, were recorded for CCPP-infected goats and sheep (Fig. 1). Findings from the survey revealed a reduction in wool production ranging from 175 to 230 grams among MCCP-infected animals compared to their non-infected counterparts. Additionally, the wool quality in infected flocks was notably inferior. Overall, the findings indicated MCCP infected positive cases were shown low production performance in comparison to negative screened tested small ruminants that may likely influenced by clinical severity of the disease. Overall, in small ruminant herds, Mycoplasmosis significant ($P<0.05$) did produce impact on direct production performance including reduced quantity of wool, milk yield and meat production and substantial increase in culling rates. Also, significant ($P<0.05$) effect of inferior quality on skin and wool was observed in the MCCP infected animals.

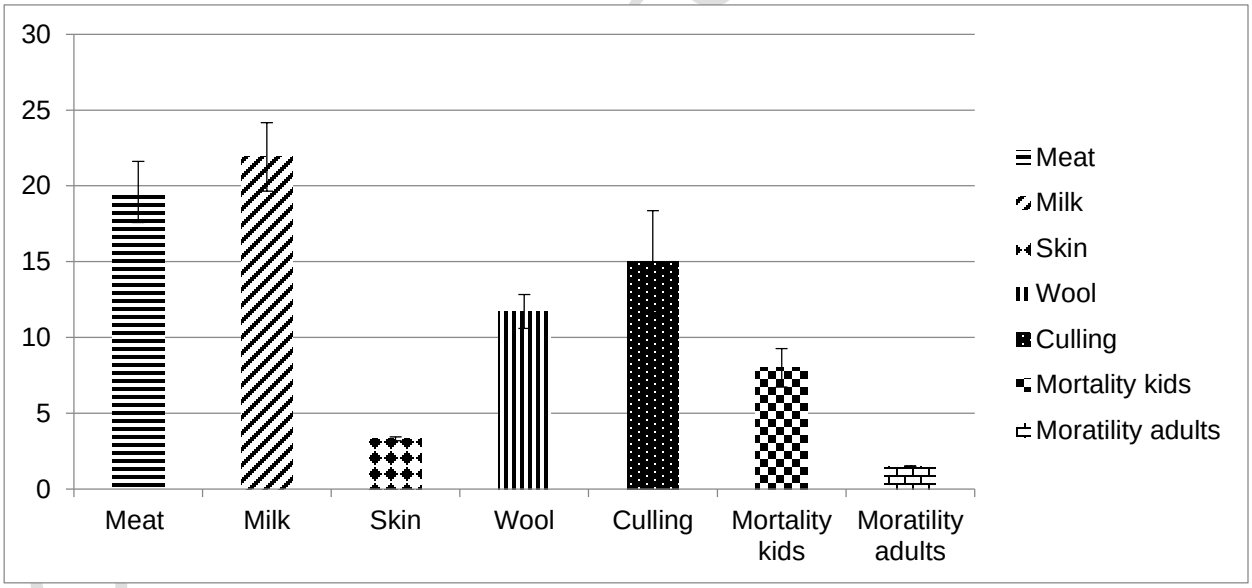

Figure 1. Estimated direct production Losses were caused by MCCP Infections in Small Ruminants. The average production losses were quantified/expressed in percentage (%) on a per-animal basis

Assessment of indirect losses

The study estimated indirect losses caused by MCCP infections in small ruminants, considering factors such as diagnosis expenses (Rs 4000-5000), veterinary services (Rs 5000/visit), treatment costs (medication + supplements: Rs 1000-1800/animal), supplementary farm inputs (Rs 200-

250/animal), and labor charges (Rs 100-180/animal) at the livestock farm (Fig. 2). The average cost of culling an animal was calculated based on the loss of value, ranging from Rs 65,000 to Rs 85,000 per culled goat or sheep. The information was collected from several livestock farms experiencing outbreaks of Mycoplasmosis among sheep and goats in the KPK province of Pakistan. Significant ($P<0.05$) effect of indirect losses such as labor charges, veterinary services, diagnosis and treatment were contributing to financial burden to small ruminant farming community.

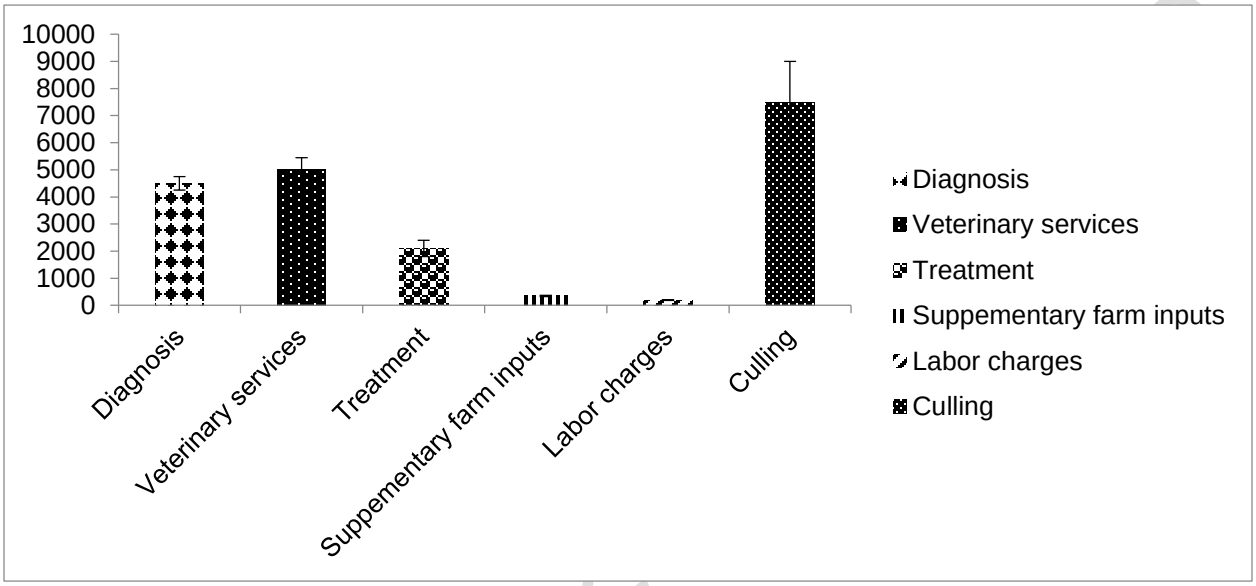

Figure 2. Estimated Indirect Losses Caused by MCCP Infections in Small Ruminants. The average expenses in Pak rupees (Rs) were quantified/expressed on a per-animal basis

Assessment of the disease severity and production losses

Data obtained from the estimated positive infected and non-infected herd exhibited coefficient of linear relationship to the disease intensity and production losses in the flock at various regions KPK, Pakistan. The Model predicted coefficient values exhibited significant ($P < 0.05$) influence of clinical severity of the disease in assessed in the flocks (Fig. 3).

Discussion

Contagious caprine pleuropnemonia (CCPP) has resulted in significant production losses among the small ruminant population across Africa, Asia and Europe **[4, 6]**. Due to the widespread devastation and high mortality rates linked to MCCP infections, goat farming was scaled back in certain countries **[1]**. The production and economic losses were aggravated by increased mortality in newly born kids and the severity of the disease in adult animals **[8]**. The results of current research illustrate the substantial impact of CCPP infection on both goats and sheep farming in the studied region. Direct production losses are evident across multiple facets of livestock farming. The direct production losses and/or indirect financial expenses/ recourses depreciation were assessed and expressed due to the impact of *Mycoplasma* infections in dairy herds. The data indicated that significant fatalities rate in young/naive kids (8%) and adults (1.5%) among the infected goat and sheep flocks. The infected flock's significant decrease in milk yield 0.31-0.73 liter (average 19.60%) per animal signifies the production

repercussions of dairy products ultimately. Similarly, a considerable reduction in meat production at the rate of an average of 19.60% per animal negatively impacts the quantity of meat from the flocks available for sale and/or consumption..

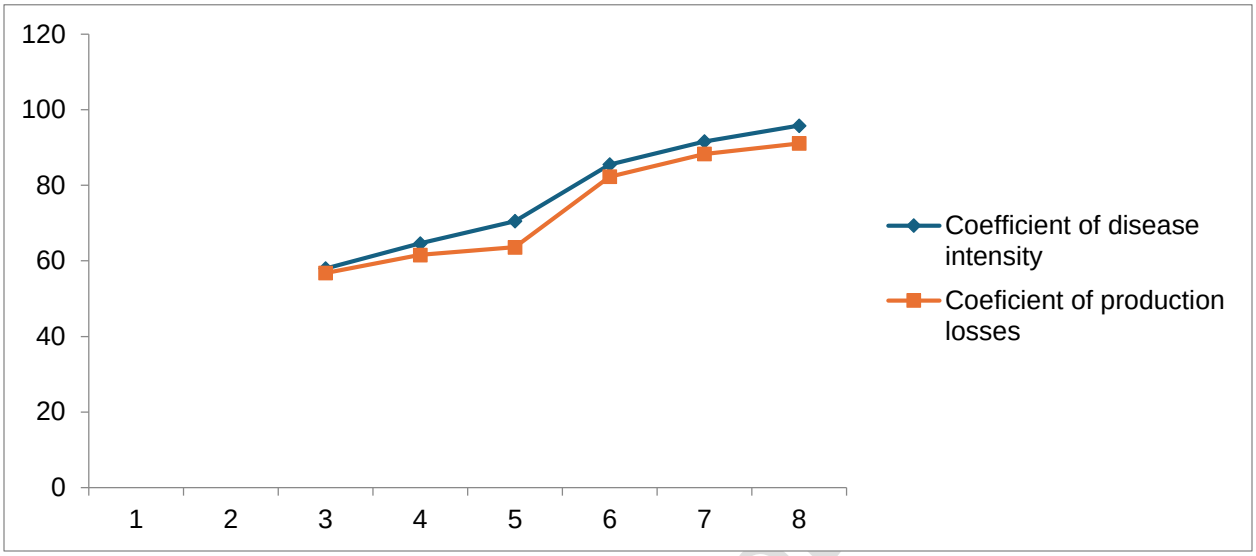

Figure 3. The predicted model indicating the correlation between disease severity and production loses in small ruminant flock

The negative influence of the disease on skin quality (3.31%) and wool losses (11.71%) underscore the poor production performance by herd. Recent outbreak of MCCP infections in sheep flock of Germany produced considerable distress among animals and lead to acute death, pleuropneumonia, mastitis, and arthritis, The MCCP strains were consistently detected in several small ruminants [6]. Furthermore, the culling rates 12.44- 18.07%, suggest the need of removing infected and/or weakened animals from the herd to prevent further spread of the infections. These findings entail profound negative effects of CCPP on both the productivity and profitability of small ruminant farming. The data regarding wool production indicated substantial reduction 175-230 gm in wool yield in sheep suffering from Mycoplasmosis in comparison to non-infected counterpart flock. This decrease in wool production and quality mark the loss of wool yield in herds. Furthermore, these findings highlight the Mycoplasma infected herd indicator of inferior and poor production performer. It has been reported that directed losses including reduction in meat, wool and milk yield, increased mortality rate, and costs associated to diagnosis of MCCP infections, treatment and control of the disease in goat and sheep flock. Moreover, indirect losses may inflict to long term local business and trade restrictions [20].

The findings in current research explore the considerable indirect losses due to Mycoplosmosis in small ruminant herds in various regions of province KPK, Pakistan. The estimated indirect production losses were based on different contributing factors, involved in economic impact on farmed flocks. Veterinary services expenses approximately Rs 5000/visit constituting outlay for animal health and disease management. The findings demonstrated that diagnostic screening of MCCP strains expenses Rs 4000-5000, indicating

considerable financial loss on the farming community for identification and addressing Mycoplasmosis concerns in their small ruminant flocks. Moreover, MCCP infections are involved in the decrease of kidding and lambing rates. Furthermore, the infections have been associated to a reduction of annual lamb production 4.3% approximately **[21]**. Respiratory infections pose a serious threat in small ruminant production losses including mortality, environmental stress, and digestive and lambing problems in USA **[25]**. In this study, the predicted variations in clinical severity of disease significantly influenced production using the models.

Estimated medication expenses including antibiotics, mineral and vitamin supplements amounted to Rs 1000-1800 per animal emphasis on the considerable amount needed for prevention and control of the disease in sheep and goat herds. Furthermore, supplementary farm inputs encompassing nutritional supplements and feed additives expenses is an additional financial burden on dairy farmers during and after the outbreak of the infection. Also, substantial additional labor charges Rs 200-250/ animal for managing and controlling the infection lead to increase financial pressure to farming community. In accordance to results of this study, it has been reported that the infections of Mycoplasma contagious agalactia in small ruminant flocks contributed to severe influenced production and economic losses including premature culling, poor growth, morbidity, mortality, and expenses control of infections **[26]**. The data analyses indicated that herds with and without the MCCP infection linear promotional relationship between the disease severity and production losses in animal herds in various districts of Province KPK, Pakistan. The model predicted significant ($P< 0.05$) influence on coefficient values among various disease severity and production losses in the small ruminant population at herd level. The findings suggested the severity of MCCP infection severely impact production performance in the flocks. The model predicted severity of the disease directly proportional of the effects of variations in production parameters. Low coefficient values in severity of infection, the effects of altering in milk yield, skin quality, reduced body weight and meat production. In general, the findings demonstrated indirect losses due to the MCCP infection in herds were of a multifaceted nature.

Conclusion

In summary, the research reveals significant, multifaceted direct losses including mortality rates for kids and adults, meat, milk yield reduction, skin and wool production a and indirect losses diagnosis expenses, veterinary services, treatment costs, supplementary farm inputs, labor charges and culling of the animals. The production and economic losses incurred due to mycoplasma infections in sheep and goat herds in various regions of Province KPK, Pakistan.

Authors' contributions

Conceived and designed the experiments: HA Yousafzai, SH Abro, A Sajid & R Abro, Performed the experiments: HA Yousafzai & A Sajid, Analyzed the data: DH Kalhoro, H Wagan & AR Bhutto, Contributed materials/ analysis/ tools: HA Yousafzai & A Sajid, Wrote the paper: HA Yousafzai, SH Abro, A Sajid, R Abro, DH Kalhoro, H Wagan & AR Bhutto

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