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| **Epidemiological study on incidence and major causes of pre-weaning kid morbidity and mortality of Abergelle goats in Waghemira zone, Amhara Region, Ethiopia** | | |  |
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|  |  | **ABSTRACT** | |
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| **Received:** February 17, 2023  **Revised:** May 24, 2023  **Accepted:** June 16, 2023  **Available online:** June 28, 2023 |  | *Small ruminants especially goat is very important in the economy and nutrition, and has the potential for using it as a tool for poverty reduction in developing countries. To date, only a very limited number of studies have been conducted on the effect of environmental or flock management factors on morbidity and mortality of kids of goats. To understand the epidemiology of kid mortality, we developed a longitudinal follow-up of kids born in the study area for three years in goat improving model villages of Abergelle (Saziba community goat improvement village) and Sekota (Ayibra site of Sekota Dryland Agricultural Research Center goat multiplication farm) districts. The objectives of the study were to assess the overall incidence of diseases and risk factors and understand and characterize risk factors responsible for pre-weaning kid mortality of Abergelle goats in Waghemira zone. All newborn kids up to weaning age were followed from 2017-2019. Thus, about 1438 kids born in these villages were followed longitudinally in each site by assigning one enumerator to follow the newborn kids. Accordingly, from the total kids, 77.61% were weaned healthy while the rest 21.5% had one or more of diseases. Among diseases, ectoparasites infestations (41%), diarrheal cases (30%), PPR (15%), and physical injury (5%) were diseases frequently encountered. The mortality rates for the total number of kids born were 7.5 percent. It was also found that the risk of being diseased and died was significantly higher among kids who did not receive colostrum within 30 minutes (P< 0.05) compared to those who did. Furthermore, the month of birth also played a role in disease occurrence, with higher incidences of diseases in certain months, such as in December, November, July and March than September, October and February. Additionally, the occurrence of kid mortality was more common in kids born to parities two, three, and five (P < 0.05). The occurrence of mentioned diseases need attention as higher incidence was noted. Diseases symptoms like diarrhea needs further detailed etiologic identification studies.* | |
| ***Keywords:*** *Abergelle goat, Epidemiological study, Incidence, Kid mortality, Pre weaning, Sekota* |  |

1. **INTRODUCTION**

Small ruminants, especially goats, are very important as a tool for poverty reduction in developing countries. Improving the survival of lambs and kids is essential for the viability of a flock and for its long-term genetic improvement. High kid mortality during the first 12 weeks of life or the pre-weaning period causes considerable economic loss and greatly reduces the efficiency and profitability of goat production. Generally, higher kid mortality occurs at birth and from birth to weaning, while mortality is relatively low from weaning to breeding age in many production systems. In order to prevent mortality, risk factors that predispose kids to the development of disease must be identified, followed by adaptation and implementation of management practices that can be helpful for the reduction and elimination of risk factors involved in disease development in kids. In this regard, investigations are recommended to focus on the effect of multiple factors, including, breed, age of dam, parity, sex, type of birth, birth weight, behavior of the kid and dam (doe/kid interaction) after birth, environmental factors such as kidding season, farm management (the feeding of dams particularly during gestation, and good hygiene practices (Ahmed et al 2011; Belay and Haile 2011; Kefyalew 2015; Sharif and Al-ani 2015).

To date, only a very limited number of studies have been conducted on the effect of environmental or flock management factors on morbidity and mortality of kids. The impact of predisposing factors on morbidity and mortality of kids varies from area to area in relation to varying conditions, such as the environment and the breeds raised. However, studies have showed that in Australia, the reported average mortality rates ranged from 5 to 23% with 86.6% deaths occurring within the first three days of life ref. In Ethiopia,19% of kids die before weaning (Tsegaye *et al* 2013). Similarly, a study conducted in Adami Tulu showed that 30.3% of kids died before they reach one month old (Alula *et al* 2014). In our model, village of ICARDA (Sazba) the condition reaches up to 23% ref. Therefore, a longitudinal study of kids born fromAbergelle goats in Waghemira Zone were conducted for more than three years with the objectives of the assessing the overall incidence of diseases and risk factors and understand and characterize risk factors responsible for pre-weaning kid mortality.

Therefore, a longitudinal study of kids born fromAbergelle goats in Waghemira zone were conducted for more than three years with the objectives of assessing the overall incidence of diseases and risk factors and understand and characterize risk factors responsible for pre-weaning kid mortality.

1. **MATERIALS AND METHODS** 
   1. **Description of the Study Areas**

The study was conducted in two sites: Ayibra abergelle breeding station, sekota zuria district, and sazba community-based breeding program village, Abergelle district, Waghimra, Ethiopia. Waghimra zone is located between 12° 23' and 13° 16' N latitudes and 38° 44' and 39° 21' E longitudes, in the eastern part of the country. The maximum and minimum temperature of the area is 26.6oC and 31.6oC respectively with an altitude of ranging from 989 to 4043 m above sea level. The annual rainfall, which is erratic in distribution, varies between 350 and 650 mm. The area is characterized by more massive livestock production than agriculture due to recurrent draught in which local zebu cattle and Abergelle breed goats are the main livestock types reared. The production system was hence semi-intensive for the Ayibra main breeding site and mixed crop production in Sazba, Abergelle District. The small ruminants in Sazba village were allowed to graze only throughout the year.  Meanwhile, the goats at Ayibra's main breeding site were let to graze all the daytime and supplemented with concentrates during the harsh season in the morning and afternoon. This grazing strategy with supplementary feeding allowed for optimal utilization of available resources and ensured that the goats' were able to meet their health and productivity needs, ensuring a steady supply of milk for their kids to thrive and grow.

**Study Population and Study Design**

All newborn kids up to weaning age were our study subjects. About 1438 kids born in the two study sites were followed longitudinally for three years. At each site, one enumerator was recruited to follow the newborn kids up to weaning age. The occurrence of disease symptoms was recorded on prepared data checklists. Immediately after birth, kids were identified by the dam’s ear tag, and the following risk factors were recorded: body weight at birth, colostrum intake of the newborn, vaccination status of the doe, type of disease they diagnosed, season of birth, sex of the newborn, body condition score of the doe, parity of the doe and type of birth, and management of the herd.  By closely monitoring these variables, the farmers were able to identify any potential risks or deficiencies early on and take necessary measures to ensure the wellbeing of the kids. Besides, the occurrence of death was recorded, if any. The data collected was analyzed to determine any association between the risk factors and the occurrence of disease symptoms in the kids. This study aims to provide valuable insights into the factors that contribute to disease susceptibility in newborn goats and to inform future management and preventative measures.

**Data Analysis**

The occurrence of diseases and associated risk factors were coded and entered to Microsoft Excel. STATA version 16 software was used to process the data (STATA 2016). Logistic regression was used to predict the association between disease occurrence and mortality with respective hypothesized risk factors. AUC (ROC curve) was done to evaluate the performance of the model to fit the data. Significance cut off p<0.05 value at 95% confidence level was considered to determine the presence of statistical significance. If the p-value obtained from a statistical test is less than 0.05, it implies that the observed results are statistically significant at a 95% confidence level. This means that there is a 5% chance of obtaining such results by random chance alone. In addition, descriptive statistics and graphical presentation were used to summarize the characteristics of the study population, while chi-square test was conducted to assess the association between categorical variables.

1. **RESULT AND DISCUSSION**
   1. **Descriptive Summary of Diseases Observed**

Over the past three years, longitudinal study followed 1438 kids born at the Ayibra and Sazba study locations. Out of the total, 77.61% were weaned healthy, while 21.5% had single or mixed disease symptoms. The results was supported by the report of 28% (Asres *et al* 2014), but lower than 53.3% (Hunduma *et al* 2010), 0.42 (index metrics) (Tsegaye *et al* 2013) in Ethiopia, and 74.7% in Bangladesh (Kashem et al 2011). This finding was also higher than the report of 13.2% (Tifashe *et al* 2017) in southern Ethiopia. These findings suggest that there is variability in the health outcomes of weaned individuals across different regions in Ethiopia and Bangladesh. The discrepancies in percentages could be attributed to various factors such as differences in research methodologies, sample sizes, and variations among the populations studied. Additionally, it indicated that the level of disease incidence is relatively lower compared to some other reports. This suggests that there may be underlying factors contributing to the lower rate of disease transmission, such as effective healthcare systems, vaccination programs, or public health initiatives.

Ectoparasite infestations were the highest, followed by diarrhea cases (30%), PPR (15%), and physical injury (5%) (Figure 1). This indicated that ectoparasites, particularly mange mites and ticks, pose a significant threat to the health of small ruminants in the study areas. Previous reports on the incidence/prevalence of small ruminant diseases particularly in goats and kids in Ethiopia and abroad found contradicting. Some studies reported a higher prevalence of PPR in goats and kids (Donkin and Boyazoglu, 2004; Tsegaye *et al* 2013).   However, a counterexample to these was reported by (Hunduma *et al* 2010; Asres *et al* 2014; Bahiru and Assefa 2018) which found that the prevalence of ectoparasite infestation in goats and kids in Ethiopia was actually higher than PPR. These conflicting results could be due to variations in sampling methods, geographical locations, or the time of the study. Both diseases are highly contagious and can have a significant impact on the health and productivity of goat populations. Diarrheal cases were found the second most important causes of illness in kids. The disease was also reported as the prominent cause of illness in kids (Kashem et al 2011; Alula *et al* 2014; Sharif and Al-ani 2015). Diarrheic diseases are multifactorial that can be caused by viruses, bacteria and other microorganisms. Due to lab facility and logistics limitations, we did not conduct etiologic identification of diarrheal causes. Instead, diarrheal cases and PPR cases were identified based on the predefined description of each disease given by small ruminant herders and enumerators as "*tekma*t” to mean diarrheal cases without typical respiratory and ocular abnormalities and "*desta messel*" to PPR, which means like "rinder pest" in *Amharic*.

These names were given due to the similarity in symptoms observed in the animals affected by the respective diarrheal and PPR cases. This identification process helped in fairly classifying and recording the cases during the study. The diseases PPR was also found the third most prevalent cause of illness in kids (Figure 1). Other reports showed that it is the priority disease of kids in Ethiopia (Bahiru and Assefa 2018; Tsegaye *et al* 2013). PPR, caused by a morbillivirus, primarily affects the respiratory and gastrointestinal systems of goats and can lead to high mortality rates. This disease has been a major cause of concern for the country's small ruminant production and efforts have been made to improve access to vaccinations to prevent further spread of the disease. However, kids are not receiving vaccines until they are weaned, their fourth month of life. Even sometimes, we miss vaccinating at this age due to logistical limitations. This is one of the gaps that we should fill in the near future. Besides, the OIE is planning to eradicate the disease by 2030. To achieve this goal, member countries have their share of responsibilities to fulfill , including strengthening vaccination programs and ensuring timely and widespread distribution of vaccines (Assefa *et al* 2021).



Figure 1: Disease frequency of goat kids in Aybira and Sazba sites of Waghimra zone, Ethiopia (2017-2019)

**Kid Mortality Rate and Major Causes of Deaths**

The mortality rate from the total kids born was 7.5% (108/1438). This was similar with a report 12.3% (Tifashe *et al* 2017) in southern Ethiopia and higher than (3.2%) in Jordan (Sharif and Al-ani 2015). Fentie (2016) reported the mortality of kids as 17.6–24% in mixed crop production system in Ethiopia. However, the finding was lower than the reports 69.2% (Yitagesu and Alemnew 2022), 42.3% (Alemnew *et al* 2020), and 35.5% (pastoral production systems) (Fentie 2016). A study in South Africa reported that diseases were the most contributing factor to kids mortality (Slayi *et al* 2014). The most frequently associated diseases with mortality were PPR, diarrhea, and Anthrax. In newborns, the chance of survival is low if they contract PPR due to the acute severity and nature of the disease (Kashem *et al* 2011). Diarrheal cases on the other hand, claims lives of many kids as it leads to severe dehydration and electrolyte imbalances as supported by Fentie (2016) in Ethiopia, Sharif and Al-ani (2015) in Jordan, Slayi *et al* (2014) in south Africa. Anthrax, although less common, is a highly fatal disease that can affect the survival of kids. On the other hand, ectoparasite infestation, caused by external parasites such as ticks and lice, can cause skin irritation, anemia, and reduced growth rates in goats and kids.

**Association of Risk Factors with Incidence of Diseases and Mortality**

A logistic regression model was fitted with a likelihood ratio test.  The p-value from the likelihood ratio test was found to be significant at 0.05, suggesting that the logistic regression model significantly improved the fit compared to a null model. The ROC analysis further confirmed the model's predictive power, as an AUC value of 0.85 is considered quite high and indicates a strong ability to discriminate between positive and negative outcomes. Furthermore, the analysis revealed a statistically significant relationship between some predictor variables and the outcome variable (Figure 2).

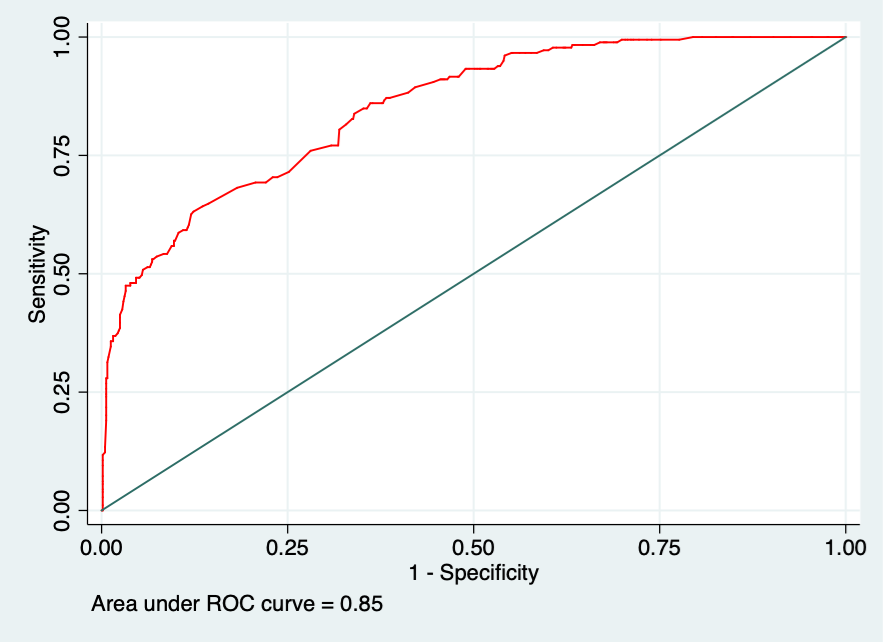


Figure 2: The area under the receiver-operating curve depicting the models AUC value of the model

The logistic model output indicated that the year and season of birth, parity of the dam, and colostrum intake immediately after birth had a significant association with disease occurrence (P < 0.05). The study found that kids born in December (P = 0.00), March (P = 0.006), August (P = 0.017), November (P = 0.00), and July (P = 0.006) had a significantly higher rate of being diseased than the reference month of April (Table 1). On the other hand, kids born in October, February, and September had higher odds of being healthy than the reference month of April, indicating a possible connection between birth month and overall health outcomes. Overall, significant diseases occurrence was observed in autumn (November and December) followed by winter (January and March), and summer season (July, August and September) (Table 1). This could be attributed due to higher proportion of the study animals give birth from late September to December. This finding was in contrast with the previous report of more diseases incidence occurrence noted in winter season followed by spring, autumn and summer, respectively (Tifashe *et al* 2017).

Furthermore, it is plausible that the occurrence of diseases varied depending on geographical location and climatic conditions. In regions with colder temperatures and harsh winters, it was common to see an increase in diseases during the winter months. Conversely, in areas with milder winters and hotter summers, the occurrence of diseases peaked during the summer season. These discrepancies highlight the importance of considering regional factors when studying disease patterns and developing appropriate prevention and treatment strategies. Additionally, the model showed that dams with a parity 4 (P=0.031) had a higher risk of their offspring developing diseases. Moreover, the study highlighted that colostrum intake immediately after birth played a crucial role in disease occurrence, with kids who received adequate colostrum having lower chances of falling ill. These findings emphasize the importance of considering birth season, dam parity, and colostrum intake in disease prevention strategies for newborn kids.

**Table 1:** Regression vs chi square Risk factor analysis for incidence of occurrence of diseases

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Factors** | **Category** | **AOR (95% CI)** | ***X2*** | **p-value** |
| Date of birth | April | Reference | 111.31 | - |
| August | 0.3(0.09-0.8) |  | 0.017\* |
| December | 0.06(0.02-0.2) |  | 0.000\*\*\* |
| February | 0.25(0.04-1.5) |  | 0.131 |
| January | 0.2(0.08-0.6) |  | 0.006\*\* |
| July | 0.3(0.13-0.7) |  | 0.006\*\* |
| March | 0.2(0.05-0.6) |  | 0.004\*\* |
| November | 0.22(0.09-0.5) |  | 0.001\*\* |
| October | 1.2(0.47-3.4) |  | 0.63 |
| September | 0.8(0.34-2.2) |  | 0.764 |
| Year | 2017 | Reference | 113.2 | - |
| 2018 | 20.8(11.5-37.6) |  | 0.000\*\*\* |
| 2019 | 6.4(3.2-13) |  | 0.000\*\*\* |
| Parity | 1 | Reference | 12.58 | - |
| 2 | 1.07(0.7-1.6) |  | 0.735 |
| 3 | 0.9(0.5-1.5) |  | 0.773 |
| 4 | 0.5(0.3-0.9) |  | 0.031\* |
| 5 | 0.9(0.5-1.5) |  | 0.682 |
| 6 | 0.8(0.41-1.69) |  | 0.619 |
| 7 | 1.09(0.5-2.3) |  | 0.812 |
| 8 | 0.8(0.3-2.3) |  | 0.759 |
| Sex | 10 | 0.8 (0.1-6.04) |  | 0.831 |
| Female | Reference |  | - |
| Male | 0.9(0.7-1.3) |  | 0.955 |
| Location | Abergelle |  | 3.6336 |  |
| Aybira | 0.9(0.6-1.4) |  | 0.826 |
| Colostrum intake | Yes |  |  |  |
| No | 0.19(0.13-0.28) |  | 0.000\*\*\* |

Study years were also found associated with the occurrence of diseases that 2018 (P = 0.000) and 2019 (P = 0.000) were found the years with significance occurrence of diseases than the baseline year, 2017. The likely occurrence of diseases in 2018 and 2019 was 20.8 (P = 0.00; CI 11.5–37.6) and 6.4 (P = 0.00; CI 3.2–13) times higher than the reference year of 2017, respectively (Table 1). Study location and sex of kids were not found statistically significant to influence the occurrence of diseases.

The mortality rate of kids was associated with the year of birth, parity of the doe, and colostrum intake immediately after birth (Table 2). These factors played a crucial role in determining the survival rate of the kids in the study. The parity of the doe, or the number of times she has given birth, may affect her ability to provide adequate care and nutrition to her offspring, thus affecting their survival.

**Table 2:** Regression analysis of associated risk factors mortality of kids

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Risk factors** | **Category** | **AOR (95% CI)** | ***X*2-value** | **p-value** |
| Year | 2017 | Reference | 19.4 |  |
| 2018 | 0.49 (0.19-1.24) |  | 0.135 |
| 2019 | 0.025 (0.003-0.2) |  | 0.001 |
| Parity | 1 | Reference | 54.74 |  |
| 2 | 0.11(0.16-0.6) |  | 0.001\*\* |
| 3 | 0.082(0.079-0.4) |  | 0.000\*\*\* |
| 4 | 0.31 (0.36-1.7) |  | 0.548 |
| 5 | 0.116(0.1-0.6) |  | 0.002\*\* |
| Colostrum intake | Yes | Reference | 37.4 | 0.001\*\* |
| No | 0.217(0.13-0.36) |  |  |
| Diseases | Anthrax | Reference | 167.6 | - |
| Ecto-parasites | 1 |  | - |
| PPR | 0.4(0.14-2.4) |  | 0.488 |
| Anomaly | 1 |  | - |
| Diarrhea | 0.08(0.034-0.48) |  | 0.003\*\* |
| Immature birth | 0.08(0.01-0.6) |  | 0.017\*\* |
| Location | Aybira | Reference | 27.6 | 0.001\*\* |
| Abergelle | 4.09(2.3-7.06) |  |  |
| Treatment | No | Reference | 30.5 | 0.001\*\* |
| yes | 0.14(0.06-0.3) |  |  |

The study found that doe at parity one (reference) had a higher chance of its kid to die than parity three, four, and five (Table 2), which is associated with lower milk feeding capabilities, leading to lower survival rates for kids. Additionally, colostrum intake immediately after birth was found significantly influenced the survival of kids than not received (P<0.001). Any deficiencies in this regard may increase their vulnerability to diseases. Previous study reports have shown that if newborns consume colostrum within the first few hours after birth, before the closure of their gut, they receive essential maternal antibodies that provide protection against a wide range of infections (Bashir *et al* 2019; Hammon *et al* 2020). This early immunity boost significantly reduces the mortality rate among kids and improves their chances of reaching weaning age successfully. Year wise, the mortality rate in 2017 was higher than the rest of the other years. This could be due to the number of studied animals in this year were lower than others. The finding suggests a significant increase in the prevalence of diseases during baseline year compared to 2019 (P = 0.001).

This could be because the number of animals studied this year was lower than in others, resulting in a smaller sample size. Additionally, external factors such as changes in environmental conditions or the presence of diseases could have influenced the mortality rate. Mortality was significantly influenced by location, such that it was higher in Abergelle than at the Ayibra site (P= 0.001) which was supported by other previous reports of kid mortality at different locations (Tsegaye *et al* 2013 Sharif and Al-ani 2015; Tifashe *et al* 2017; Alemnew *et al* 2020; Yitagesu and Alemnew 2022). This could be due to intensive follow up of newborns in Ayibra since it is the farm responsible for the generation of Buck to other locations. Feed availability and seasonal harshness can be also considered reasons for variations in disease occurrence. Besides, the numbers of newborns in Abergelle were higher than in Ayibra, so the flock size difference between these two locations may be another reason for the difference in mortality rate. Additionally, Abergelle experienced harsh weather conditions during the study period, which could have contributed to the higher mortality rate. On the other hand, Ayibra had better infrastructure and facilities, providing a more conducive environment for the newborns and thereby reducing the mortality rate. Overall, a combination of factors such as intensive follow-up, flock size differences, and weather conditions likely influenced the disparity in mortality rates between the two sites. The higher mortality rate in Abergelle suggests that there may be a need for improved healthcare infrastructure and resources in that area.

1. **CONCLUSION**

The study identified that ectoparasite infestation, diarrheal cases, and Pest des petits ruminants were the major causes of kid morbidity in the Abergelle goat breed.  Besides PPR, diarrhea and anthrax were the primary causes of death in kids. Colostrum intake, parity, season and year of birth, and location significantly influenced the occurrence of diseases. These findings highlight the need for effective control measures against ectoparasites and the implementation of proper hygiene practices to prevent diarrheal cases in the Abergelle goat breed. Furthermore, it is crucial to prioritize the vaccination of kids against PPR, and anthrax to reduce mortality rates and ensure the overall health of the kids. Disease symptoms like diarrhea need further detailed etiologic identification studies. By addressing these major causes of morbidity and mortality, the Abergelle goat breed can thrive and contribute to the sustainable development of the livestock industry.

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