Caprine coccidiosis in semi-arid India: Dynamics and factors affecting fecal oocyst counts

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Objective: This study envisages dynamics and factors affecting fecal oocyst counts (FOC) in natural infection in goats in semi-arid India.

Materials and methods: A total of 1152 fecal samples from Jamunapari goats in semi-arid India were collected, processed and examined for fecal oocysts over a period of 3 years for prevalence and severity of the disease through FOC using modified Mc Master Technique. The log transformed FOC data on 912 animals from 59 sires were used for subsequent analyses for genetic and non-genetic factors affecting FOC. Fixed effects included were years of collection (1-3), seasons of collection (summer, rainy, winter), sex (male, female), age group (0-3, >3-6, >6-12, adults). Least squares analysis of variance for fitting constant was applied to data set.

Results: The overall prevalence of coccidian infection in goats was 86.71% (n=999/1162). Highest incident was found in winter season (91.74%) and >6-12 M age (97.95%). *Eimeria arloingi* and *E. ninakohlyakimovae* were the most frequently occurring species. The heritability of FOC was found to be 0.06±0.06. The effect of sire on FOC was not significant; however, effects of animal age, year, season of collection and sex on FOC were found to be significant.

Conclusion: Coccidiosis in goats is seasonally occurring disease, most commonly affecting animals of less than one year age. FOC in coccidiosis affected animals is lowly inherited trait for selection of goat against this disease.

KEYWORDS

*Eimeria*; Goats; India; Prevalence

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INTRODUCTION

Coccidiosis is one of the important protozoan diseases in goats. Studies in recent past revealed the prevalence of coccidiosis in goats as high as 85% or more (Wang et al., 2010; Radfar et al., 2011; Kahan and Greiner, 2013; Zainalabidin et al., 2015). Though all age groups can carry coccidial infection, yet the disease is more important in young growing kids in whom it is a common cause of diarrhea and anemia along with poor growth rate, suppressed resistance, high morbidity and mortality (Anumol et al., 2012). Severe damage of intestinal lining due to coccidiosis causes improper or reduced absorption of nutrients and weight loss (Ozmen et al., 2011). Lack of proper management can enhance the incidence of coccidiosis. The stress conditions like poor nutrients containing diet, weaning and transportation are very likely to precipitate the clinical coccidiosis in goats (Khaleel et al., 2013). Further, stocking rate and togetherness of young and adults in intensive system of management exposes the young animals to infection and reinfection. Though epidemiological study of coccidial infection in small ruminants dealing management and husbandry practices are not exceptions (Sharma et al., 2009; Rehman et al., 2011a), the role of various factors, specially the genetic, needs further investigations in light of reports of non-genetic factors affecting FOC, the trait used to determine the susceptibility of the animals against the coccidial infection. Fixed effects included were years of collection (SOC) (j = 1, 2, 3), seasons of collection (summer, rainy, winter), sex (male, female), age group (0-3, >3-6, >6-12, adults). FOC data, having wide range variables and skewed distribution, was applied a set of logarithms transformation and resulted transformed data variables were tested for normalcy before analysis. The most suitable log transformation to be applied was log_{10}(FEC+100) to correct for heterogeneity of variance and resulting approximately normal distribution in data. Data resulted after analysis in the form of least squares means (LSM) were back transformed by taking anti-logarithm and subtracting 100 and presented as geometric means (GFEC).

Fecal oocysts count (FOC): Fecal samples were collected aseptically from rectum of goats of both sexes and different age groups. The samples were processed for coccidial FOC using modified Mc Master Technique.

Data and statistical analyses: The data generated on FOC being skewed and uneven were put for normalization through log transformation (Log_{10}(n+100)). A total of 1152 observations on FOC were considered to study the prevalence of coccidial infection. However, FOC data generated on 912 animals from 52 sires were used for subsequent analyses for genetic and non-genetic factors affecting FOC, the trait used to determine the susceptibility of the animals against the coccidial infection. Fixed effects included were years of collection (1-3), seasons of collection (summer, rainy, winter), sex (male, female), age group (0-3, >3-6, >6-12, adults). FOC data, having wide range variables and skewed distribution, was applied a set of logarithms transformation and resulted transformed data variables were tested for normalcy before analysis. The most suitable log transformation to be applied was log_{10}(FEC+100) to correct for heterogeneity of variance and resulting approximately normal distribution in data. Data resulted after analysis in the form of least squares means (LSM) were back transformed by taking anti-logarithm and subtracting 100 and presented as geometric means (GFEC).

Least squares analysis of variance for fitting constant (Harvey, 1990) was applied to analyse the data. Preliminary model includes all main effects and interactions. In the final model, all non-significant fixed effects and their interactions were ignored, which was as follows:

\[ Y_{ijkmn} = \mu + s_i + p_j + T_m + b (X_{ijkmn} - X) + e_{ijkmn} \]

Where, \( Y_{ijkmn} \) is the record for the \( p^{th} \) animal, \( \mu \) is the overall mean, \( s_i \) is the random effect of the \( i^{th} \) sire, \( p_j \) is the fixed effect of the \( j^{th} \) sire, \( T_m \) is the fixed effect of the \( m^{th} \) season of sample collection (SOC) (\( j = 1, 2, 3 \)).
$T_m$ is the effect of the mth years of sample collection (YOC) ($m = 1, 2, 3$),

$b$ is the linear regression coefficient for the age of animal

$x_{ijklmn}$ is the record for the nth kid

$X$ is the mean for the trait

e$_{ijkmnp}$ is the residual error elements with standard assumptions

**RESULTS**

A total of 1152 fecal samples from Jamunapari goats were collected, processed and examined for FOC over a period of 3 years. Of these, 999 were found positive for coccidian oocysts showing an overall occurrence of coccidian infection to be 86.71%. Over the period, the incidence of coccidian infection varied ranging from 84.91 to 90.03%. Observations revealed the incidence of infection being highest in winter season (91.74%) followed by rainy (83.9%) and summer (80.89%) seasons. Age wise, highest infection incidence was found in 6-12 M age group (97.95%) followed by adult (92.02%). The lowest coccidian incidence was, however recorded in youngest age group i.e., 0-3 M. Further age wise seasonal incidence was highest in adults irrespective of seasons. Male goats showed slightly higher coccidian incidence (90.31%) as compared to female (84.27%).

The speciation of Eimerian oocysts on morphological and sporulation characteristics revealed mixed infection as a rule with *Eimeria arloingi* (89.10%), *E. ninakohlyakimovae* (85.57%) and *E. christenseni* (50.64%) being the most predominantly occurring coccidian oocysts. While the other species observed were *E. aljivae* (38.78%), *E. birci* (38.14%) and *E. capriovina* (25.00%).

The results of analyzed transformed FOC data have been shown in Table 1. The random effect of sire was not significant on log-transformed FEC (LFEC) of goats. The heritability of FOC was found to be 0.06±0.06, which indicates the trait is lowly heritable. The non-genetic factors like year of collection, seasons of collection and age were highly significant ($P<0.01$) to influence the variations in FEC. Effect of sex, on the other hand, was non-significant.

**Table 1.** Least-squares means (with back transformed means shown in brackets) for log-transformed Fecal oocysts count (LfOC), Geometric mean of FOC in Jamunapari Goats.

| Source of Variation               | No. of Obs. | LFOC (GFOC)     |
|----------------------------------|-------------|-----------------|
| Total                            | 912         | 4.91±0.02 (7019)|
| Year of collection               |             |                 |
| 2011                             | 129         | 4.95±0.04a (8122)|
| 2012                             | 236         | 4.95±0.03a (8150)|
| 2013                             | 547         | 4.83±0.03b (4967)|
| Sex of animals                   |             |                 |
| Male                             | 286         | 4.95±0.03a (8122)|
| Female                           | 626         | 4.87±0.02b (5986)|
| Seasons of collection            |             |                 |
| Summer                           | 277         | 4.91±0.03ab (7209)|
| Rainy                            | 493         | 4.95±0.02a (8291)|
| Winter                           | 142         | 4.85±0.04b (5650)|
| Age group                        |             |                 |
| 0-3 M                            | 40          | 5.02±0.06a (10161)|
| >3-6 M                           | 398         | 4.86±0.03b (5727)|
| >6-12 M                          | 108         | 4.98±0.04a (9094)|
| Adult                            | 366         | 4.77±0.04a (3654)|

Means with different superscript differed significantly ($P<0.05$) from each others.
DISCUSSION

Coccidian infection in goats is a serious problem specially in intensive system of goat management. Reports on prevalence of Eimerian infection were varied and rate of infection ranged widely (Bagde et al., 2010; Iqbal et al., 2012; Ramisz et al., 2012; Kahan and Greiner, 2013; Hashemnia et al., 2014) reaching as high as almost 100% during some period of the year. Overall Eimerian prevalence of 86.71% in goats in present study was similar as reported by Singh et al. (2015) from Madhya Pradesh India. Also it was similar as described from Sudan (Yousif, 2009), Portugal (Silva et al., 2014), China (Wang et al., 2010), Iran (Radfar et al., 2011) and Malaysia (Zainalabidin et al., 2015).

The high prevalence at time described the seriousness of the problem and advocated the need to its proper management. Higher prevalence of coccidian infection in winter and rainy seasons than summer in present study can be attributed to be due to huddling in winter and break in sanitation in rains leading to increased chances of reinfection. Such finding was, however, in contrast to Reshi and Hidaytullah (2013) from Kashmir valley who reported maximum prevalence of eimerian infection in summer in caprines followed by autumn and winter. Difference in findings may be attributed to the local conditions and duration of study.

The highest eimerian prevalence rate in >6-12 M age group was in contrast to author’s previous study (Sharma et al., 2009) in which highest prevalence was recorded in >3-6 M age group in Jamunapari goats. However, our finding was in contrast to Radfar et al. (2011) who could not find any association between prevalence of the disease and age/sex of animals. As the correlation in OPG and Mean monthly temperature and RH (separately) was non-significant, the variation in epidemiology can be attributed to change in breed, herd/sample size, management and environmental conditions (Yousif, 2009) and due to interaction of these many factors. Higher Eimerian prevalence in male than female goats in present study was in contrast to some earlier studies (Sharma et al., 2009; Rehman et al., 2011b) who reported higher prevalence in female. In the light of Kheirandish et al. (2014) report that sex is non determinant factor in prevalence of coccidiosis. Present findings of significantly higher LFOC in male might have resulted due to small sample size or/and due to different animal group constitution sex wise in this study.

Among various factors analyzed for their effect on FOC in eimerian infection in present study, the effect of sampling year was highly significant (P<0.01) and can be attributed to variations in environment, physiological state, supplement feeding, body score, treatment of animals (Yousif, 2009). Higher FOC in summer (March-June) and rainy season (July-October) in present study corroborates author’s previous findings (Sharma et al., 2009) (Figure 1).

Results of this study also support Bakunzi et al. (2010) findings who observed highest FOC in hot and wet season than during dry and cold season. Similar to some previous reports, the effect of age of animal in present study on FOC was highly significant (Harper and Penzhorn, 1999; Sharma et al., 2009; Kheirandish et al., 2014; Zvinorova et al., 2016). While Sharma et al. (2009) reported highest FOC in >3-6 M age group Kheirandish et al. (2014) described highest rate of oocysts count in goats over 3 years of age. Chartier and Paraud (2012) also described the maximum oocysts (FOC) around weaning period and receding thereafter with advancing age. Present results were in agreement with Kahan and Greiner (2013) who reported high FOC in goats with less than one year of age. Difference in various reports can be attributed to variations in breed, physiological and nutritional stress, high stocking rate (Chartier and Paraud, 2012), age-wise grouping of animals, management like frequency of treatment and body score.

Rehman et al. (2011a) reported higher coccidiosis prevalence in female goats. Their observations were supported by similar findings in author’s previous report (Sharma et al., 2009). However, the effect of sex on FOC (quantum of infection) in present study was significant and male animals showed higher FOC in comparison to female. Such finding in present study was however, in contrast to author’s previous report (Sharma et al., 2009) wherein no significant change in FOC was observed in two sexes.

The heritability estimates of fecal oocysts count in the present study were low (0.06). Bouix et al. (1992) reported somewhat high heritability, ranging from 0.10 to 0.20 in lambs. Rout et al. (2015) reported heritability for FOC was 0.05 and 0.15 at 3 and 6 M of age. The low heritability estimates of this trait indicate slow genetic progress and better performance can be possible through selection for this trait.

CONCLUSION

Based on the results we can conclude that coccidiosis in goats was seasonally occurring disease most commonly affecting animals of less than one year age. The Fecal
oocysts count (FOC) in coccidiosis affected animals is lowly inherited trait for selection of goat against this disease. Further studies on molecular level are required for identifying better marker for disease resistance.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

AUTHORS’ CONTRIBUTION

DKS designed the study, interpreted the data, and drafted the manuscript. SP and PKR were involved in collection of data and also contributed in manuscript preparation. AM, SB, NS and YKK took part in preparing and critical checking of this manuscript.

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Sharma et al./ J. Adv. Vet. Anim. Res., 4(1): 52-57, March 2017
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