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Fecal Egg Count: A Potent Genetic Marker for Parasitic Resistance in Small Ruminants

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Abstract— *For decades, the severity of parasitic infection in small ruminants has been measured using fecal egg count (FEC). Genetic resistance to parasitic infection varies among individual animals and flocks, making this trait economically important, particularly in small ruminants. Heritability estimates for FEC across different breeds, populations, and time periods range from low to moderate. This paper reviews studies reporting genetic parameter estimates for FEC in different populations. It also focuses on FEC as a genetic marker and a means for selecting small ruminants for parasitic resistance — a threshold trait for which the underlying variable is fecal egg count. Non-genetic factors affecting FEC are also discussed herein.*

Keywords— Small ruminants, fecal egg count (FEC), heritability, parasitic resistance, genetic parameter.

I. INTRODUCTION

Parasitic infections in small ruminants, particularly those affecting the gastrointestinal system, are a significant cause of morbidity and mortality, leading to extensive economic losses. These losses are primarily due to reduced growth rates, lower reproductive performance, decreased milk yield, and increased veterinary costs associated with the treatment of infected animals (Gourley et al., 2016). Moreover, gastrointestinal parasites contribute to a reduced ability of livestock to convert feed efficiently into meat and milk, further impacting the profitability of farming operations.

The primary method of managing and impeding parasite infections is the use of anthelmintics. However, the costs of such therapy are high, and another disadvantage is that the application of these drugs may lead to drug-resistant populations of parasites (Charon et al., 2002). There has also been increasing concern regarding residual drugs in animal-derived food products (Gowane et al., 2019). Several studies indicate that the problem of parasitic infection occurs most frequently in small ruminants (Augad et al., 2024; Malathi et al., 2021; Suarez et al., 2021; Shashank et al., 2019).

Gastrointestinal nematodes (GINs) pose a major threat to the production performance of small ruminants. The best strategy to control GINs is to appraise or breed sheep that are tolerant to parasites (Miller et al., 1998; Kemper et al., 2009). Extensive information is available regarding variation in sheep and goat resistance to GINs. The term "resistance" includes passive and active immunity. Passive resistance includes physical or chemical barriers that inhibit parasite entry into the host body. Active resistance involves innate and/or adaptive immune responses generally produced in response to infection (Coustau et al., 2000). McClure (2000) described host resistance as the ability of an individual animal to eradicate a parasitic infection and to prevent reinfection by utilising innate (non-specific) and acquired (learned and parasite-specific) immunity.

This review aims to: (1) summarize published heritability estimates for FEC in small ruminants, (2) discuss non-genetic factors influencing FEC, and (3) evaluate the potential of FEC as a genetic marker for breeding parasite-resistant animals.

II. FEC AS A GENETIC TRAIT

Several studies have reported genetic variation for resistance to parasites (Prince et al., 2010; Karlsson and Greeff, 2012; Assenza et al., 2014; Brown and Fogarty, 2017; Ngere et al., 2018). Selection of animals for parasitic resistance is key for breeding healthy animals and avoiding losses incurred due to parasitic infestation. Genetic selection is expected to alter the population's genetic structure over the long term (Gowane et al., 2019) and can thus be considered an effective way to address the problem. Parasitic resistance is, however, a threshold trait with the underlying variable associated with fecal egg count (FEC). Genetic parameters for FEC have been estimated by different researchers (Boareki et al., 2021; Ngere et al., 2018; Pollott and Greeff, 2004; Bisset et al., 1992).

The heritability estimates for FEC range from low to moderate. Heritability estimates reported in Merino sheep from Australia varied from 0.3 to 0.5 (Woolaston et al., 1991); 0.34 ± 0.08 in Romney sheep (Bisset et al., 1992); 0.23 ± 0.07 in sheep from Fiji (Woolaston et al., 1995); 0.28 ± 0.16 in sheep from Poland (Nowosad et al., 1992); and 0.20 ± 0.07 to 0.42 ± 0.10 in sheep from New Zealand (McEwan et al., 1994; Douch et al., 1995). Commercial sheep from Ontario, Canada, displayed a heritability of 0.12 ± 0.04 (Boareki et al., 2021), while Katahdin sheep showed heritability ranging from 0.23 to 0.46 (Ngere et al., 2018).

In India, researchers have reported moderate heritability of FEC in Avikalin sheep (0.21 ± 0.06) and Malpura sheep (0.18 ± 0.04) (Gowane et al., 2019). Heritability ranged from 0.24 to 0.47 in Muzaffarnagari sheep (Yadav et al., 2006), 0.11 to 0.16 in Jamnapari goats (Mandal et al., 2012), and 0.05 to 0.13 in Barbari goats (Mandal and Sharma, 2008). It was reported to be 0.35 ± 0.18 in Avikalin sheep (Singh et al., 1999).

For ease of reference, these heritability estimates are summarized in Table 1.

TABLE 1
HERITABILITY ESTIMATES OF FECAL EGG COUNT (FEC) IN SMALL RUMINANTS

Breed/Population	Location	Heritability (h^2) ± SE	Reference
Merino	Australia	0.30–0.50	Woolaston et al. (1991)
Romney	New Zealand	0.34 ± 0.08	Bisset et al. (1992)
Merino	Fiji	0.23 ± 0.07	Woolaston et al. (1995)
Polish sheep	Poland	0.28 ± 0.16	Nowosad et al. (1992)
Commercial sheep	New Zealand	0.20–0.42	McEwan et al. (1994); Douch et al. (1995)
Commercial sheep	Ontario, Canada	0.12 ± 0.04	Boareki et al. (2021)
Katahdin	USA	0.23–0.46	Ngere et al. (2018)
Avikalin	India	0.21 ± 0.06	Gowane et al. (2019)
Malpura	India	0.18 ± 0.04	Gowane et al. (2019)
Muzaffarnagari	India	0.24–0.47	Yadav et al. (2006)
Avikalin	India	0.35 ± 0.18	Singh et al. (1999)
Jamnapari goats	India	0.11–0.16	Mandal et al. (2012)
Barbari goats	India	0.05–0.13	Mandal and Sharma (2008)

III. NON-GENETIC FACTORS AFFECTING FEC

3.1 Age of Sheep

In general, young and growing lambs are more vulnerable to the effects of parasitism than adults. Furthermore, adult ewes are less susceptible to the negative effects of parasitism and better able to cope with infection. Reports also suggest that adult ewes generally have lower FEC than lambs when samples are collected at the same times and on the same pastures. Vanimisetti et al. (2004a) reported that adult ewes, sampled following weaning of their lambs and after artificial parasite challenge, had much lower fecal egg counts than their lambs. German sheep demonstrated fecal egg counts negatively correlated with age of lambs (−0.23; $P < 0.001$) (Idris et al., 2012). It has also been reported that development of acquired immunity to parasites is positively related to the age of animals.

However, conflicting findings exist. In a study conducted on Brazilian sheep breeds by McManus et al. (2009), age of the sheep did not affect FEC. Similarly, Dappawar et al. (2018) reported a non-significant effect of age on parasitic infection in kids, young, and adult sheep in a survey of 753 sheep from the Udgir area of Maharashtra, India. These contradictory findings may reflect differences in breed susceptibility, management practices, sample size, or the specific parasite species prevalent in different geographic regions. Studies reporting non-significant effects may have had lower infection pressures or smaller sample sizes, limiting statistical power to detect age-related differences.

3.2 Sex of Animals

Male sheep are known to be more susceptible to GINs than female sheep when exposed to natural and experimental infections (Barger, 1993). This difference is evident before puberty (Courtney et al., 1985). Different hormonal statuses between sexes affect the immunological responses of sheep to nematodes. Testosterone has immunosuppressive effects, which may explain higher susceptibility in males, while estrogen tends to enhance immune responses. Greater resistance in ewe lambs following secondary challenge infection was reported compared to ram lambs by Yazwinski et al. (1981) and Diaz-Rivera et al. (2000). Klein (2000) also found that male Rhön lambs had higher FEC compared to female lambs. Idris et al. (2012) demonstrated that in German sheep breeds, male lambs were more susceptible to infection than females ($P < 0.001$).

However, Dappawar et al. (2018) reported a non-significant difference between sexes of sheep on FEC in the Udgir area of Maharashtra. Similar results were reported by McManus et al. (2009), where sex of the sheep did not affect FEC. As with age effects, these discrepancies may be attributed to differences in breed, management, infection pressure, or statistical power across studies.

3.3 Birth Type

It has been reported that ewes giving birth to twins or triplets show a higher rise in FEC than ewes with singletons (Bishop and Stear, 2001). In German sheep breeds, multiple-born lambs displayed higher FEC than singleton-born lambs ($P < 0.05$) (Idris et al., 2012). Similar findings were reported by Haile et al. (2007). This may be due to competition among multiples for colostrum, which provides passive immunity to newborns against parasitic infection.

However, Gauly and Erhardt (2001) as well as McManus et al. (2009) did not find a significant effect of birth type on FEC following natural infections. McManus et al. (2009) reported that lambs born as twins had slightly higher levels of FEC than those born as singletons, though their results were statistically non-significant. The lack of statistical significance in some studies may reflect smaller sample sizes or lower statistical power to detect modest birth type effects.

3.4 Season

Nieto et al. (2003) studied lambs from crosses of Corriedale ewes with Bergamasca and Hampshire Down rams and reported that month had a significant effect on FEC ($p < 0.05$). McManus et al. (2009) observed lower FEC during the dry season (May to September) in Brazilian sheep and higher FEC during the rainy season. Dappawar et al. (2018) reported that peak infection was observed during the monsoon, followed by winter, with the lowest infection during summer. Similar results in the Indian context were reported by Swarnkar and Singh (2014) in Rajasthan and by Molla and Bandyopadhyay (2016) in the Bonpala breed of Sikkim. High humidity and temperatures during the monsoon favor the survival and development of nematode larvae on pasture, explaining the seasonal pattern observed across studies.

IV. CONCLUSION

Many traits in farm animals are complex and threshold in nature, meaning they cannot be measured directly. Parasitic resistance is one such trait, and fecal egg count (FEC) is considered a reliable indicator of this trait in livestock. Most research on parasitic resistance has been conducted in sheep and goats, as these species suffer major economic losses due to nematodes. They are more susceptible to gastrointestinal parasites due to the grazing nature of their management systems.

FEC, along with molecular genetic markers, can be effectively used for the selection of disease-resistant animals, thereby benefiting livestock owners. Incorporating FEC into breeding programs offers a sustainable approach to parasite control that reduces reliance on anthelmintics, thereby mitigating the development of drug-resistant parasite populations. For smallholder farmers in resource-limited settings where diagnostic facilities may be unavailable, simplified FEC protocols and genetic selection indices that include FEC as a trait could be developed. Future research should focus on establishing breed-specific FEC reference values, validating genetic markers associated with low FEC, and developing decision-support tools for integrating FEC into routine flock management.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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