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Original Research

Evaluation of anemia Haemoprotozoan diseases in goats by using FAMACHA scoring in Barishal district, Bangladesh

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Abstract

Anemia in goats is a prevalent and significant health issue, characterized by pale mucous membranes, tachycardia, weakness, activity intolerance, reduced body weight, and stunted growth. It is often caused by hemoprotozoan diseases, parasitism (both internal and external), and nutritional deficiencies. For small ruminant farmers, anemia poses severe economic challenges by reducing productivity, including slower growth rates and lower milk yields, and increasing mortality if left untreated. This study was conducted in Barishal Sadar Upazila, Barishal district, over a 3 month period from November 2021, to January 2022 Out of 216 goats examined, 37 cases (17.12%) were diagnosed with anemia. The data revealed that Black Bengal goats had the highest prevalence of anemia (62.16%), followed by Jamunapari (29.73%) and crossbreeds (8.11%). Female goats (62.17%) were more affected than males (37.83%). Anemia was most prevalent in goats aged 13-18 months (59.46%), compared to 7-12 months (24.33%) and 0-6 months (16.21%). The FAMACHA scoring system was used to assess anemia severity, offering an affordable, practical, and accessible tool for evaluating conjunctival color on a scale from 1 (no anemia) to 5 (severe anemia). In this study, I standardized the FAMACHA chart for goats in the Barishal district. The results showed that as FAMACHA scores increased, red blood cell (RBC) counts, hemoglobin (Hb) levels, and packed cell volume (PCV) decreased, while white blood cell (WBC) counts increased, indicating more severe anemia. Elevated WBC counts also suggested possible underlying infections. This study underscores the FAMACHA chart's effectiveness in diagnosing anemia and highlights its potential as a valuable tool for anemia management in tropical and subtropical regions.

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1. Introduction

Anemia, characterized by a reduction in red blood cells (RBCs) or hemoglobin concentration, is a common and serious health issue in goats (Rao *et al.*, 2022). Clinically, it presents with pale mucous membranes, weakness, activity intolerance, reduced growth, and, in severe cases, death. This condition is particularly prevalent in tropical and subtropical regions where parasitic infestations, especially caused by the blood-sucking parasite *Haemonchus contortus* (commonly known as the barber pole worm), are widespread (Arsenopoulos *et al.*, 2021; Sunder *et al.*, 2019; Burke *et al.*, 2007). Infections by *H. contortus* can lead to acute or chronic anemia, as the parasite feeds on blood from the host, leading to significant blood loss and compromised health (Besier *et al.*, 2016). Other causes of anemia in goats include haemoprotozoan diseases, poor nutrition, and external parasites (Sudan *et al.*, 2023; Cavele *et al.*, 2009).

For goat farmers, especially those in rural, economically disadvantaged areas, anemia can have far-reaching financial consequences (Kumalo *et al.*, 2014). It leads to a reduction in growth rates, lower milk production, increased mortality, and, ultimately, reduced productivity of the herd. The management of anemia, therefore, plays a crucial role in the sustainability of goat farming. However, accurate diagnosis and timely intervention are essential to prevent the condition from worsening (Lambrecht *et al.*, 2019). Traditional diagnostic techniques such as blood analysis used to measure RBC count, hemoglobin concentration, and packed cell volume (PCV) are effective but can be expensive and inaccessible to small-scale farmers in rural areas (Katsogiannou *et al.*, 2018; Yilmaz *et al.*, 2014).

To address these challenges, the FAMACHA technique was developed by South African researchers as a low-cost, field-friendly tool for diagnosing anemia in small ruminants. The FAMACHA system is based on the visual inspection of the mucous membranes in the lower eyelids, which are compared to a standardized color chart. The chart assigns scores from 1 to 5, with 1 indicating healthy (red) mucous membranes and 5 indicating severe anemia (white or pale membranes). This method provides farmers and veterinarians with an easy and quick way to assess anemia levels without requiring laboratory equipment. By identifying severely anemic animals early,

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targeted treatments can be administered, potentially reducing mortality and improving overall herd health (Maia *et al.,* 2014; Van Wyk and Bath, 2002).

The FAMACHA system has been widely used in various regions, particularly in managing anemia caused by *H. contortus*, and has proven to be a valuable tool in field conditions. However, its effectiveness depends on proper training and local adaptations, as factors such as breed, climate, and environmental conditions can influence its accuracy (Scheuerle *et al.,* 2010). Bangladesh, where goat farming plays a critical role in rural livelihoods, is a region where anemia, largely driven by parasitic infections, is common. Specifically, the Barishal district with its humid subtropical climate provides ideal conditions for the proliferation of parasites like *H. contortus*.

Anemia haemoprotozoan diseases in goats, particularly in the Barishal district of Bangladesh, can have significant economic consequences. These diseases reduce the productivity of livestock by affecting growth rates, milk production, and overall health. In a region where agriculture and livestock farming are key components of rural livelihoods, the increased mortality rates and reduced market value of affected goats can result in financial losses for small-scale farmers. Additionally, the costs of veterinary treatments and preventive measures can strain limited resources, hindering the growth of the livestock sector, which is vital to the local economy (Sobur *et al.*, 2024; Pal *et al.*, 2024).

This study assessed anemia prevalence in goats in Barishal Sadar Upazila, Barishal district, and tested the FAMACHA system's effectiveness for diagnosis and management. By correlating FAMACHA scores with RBC count, hemoglobin, PCV, and WBC, it aimed to standardize the method for local use. Additionally, it examined how breed, sex, and age influence anemia risk, offering practical insights for farmers. The findings highlight FAMACHA as a low-cost diagnostic tool, enabling early anemia detection and better herd management, which could reduce mortality, improve productivity, and lower veterinary costs.

2. Materials and Methods

2.1 Ethical approval

No ethical approval is required for this study.

2.2 Study area

The study was conducted in Barishal Sadar Upazila, Barishal district, Bangladesh from November 2021, to January 2022 (Figure 1). The study population consisted of goats, and data were collected from the Upazila livestock office and veterinary hospital, involving 216 goats in total.

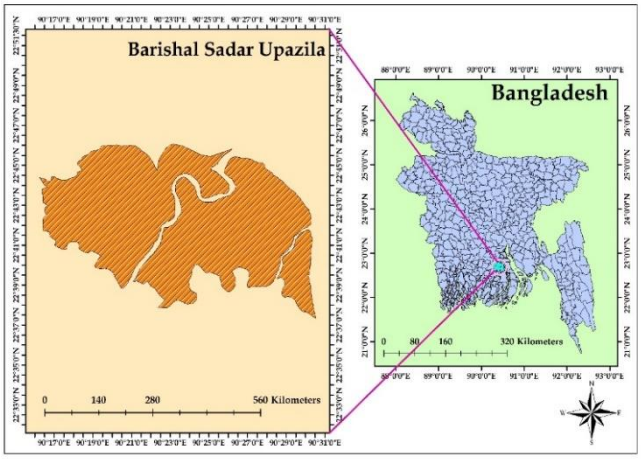

Figure 1. Map of the study area.

2.3 Study design

The study involved a two-step process, first, blood samples were collected from 216 goats to assess the prevalence of anemia. Then, the FAMACHA scoring system was applied to evaluate its accuracy in diagnosing anemia.

2.4 Blood collection and analysis

Blood was drawn from the jugular vein of each goat and stored with anticoagulants for hematological analysis. The parameters measured included erythrocyte count, PCV, hemoglobin concentration, white blood cell (WBC) count, mean corpuscular volume (MCV), and mean corpuscular hemoglobin (MCH). Blood samples were processed in a laboratory, and results were cross-checked with the FAMACHA scores assigned during field assessments.

2.5 Erythrocyte count

Using a hemocytometer, erythrocyte counts were calculated by multiplying the observed count by 10,000 and expressed in million cells per cubic millimeter (million/cu.mm).

2.6 Packed cell volume (PCV)

Blood was centrifuged, and the ratio of packed red cells to total blood volume was expressed as a percentage.

2.7 Hemoglobin concentration

The hemoglobin concentration was measured using a Sahli pipette and expressed in grams per deciliter (g/dL).

2.8 FAMACHA scoring

The FAMACHA technique was applied by inspecting the conjunctival mucous membranes of each goat and assigning scores from 1 to 5, with 1 indicating no anemia (red) and 5 indicating severe anemia (white). The FAMACHA scores were compared with laboratory-based blood analysis results to assess the technique's reliability in diagnosing anemia (Table 1).

Table 1. Relationship between FAMACHA score and RBC value.

FAMACHA score	RBC (10^6/µl) mean value	RBC (10^6/µl) standard deviation
1	5.327	0.0628
2	2.1275	0.0795
3	1.9477	0.1128
4	1.546	0.0939
5	0.87	0.4101

2.9 Statistical analysis

The statistical analysis confirmed a significant correlation between FAMACHA scores and several blood parameters. The differences between FAMACHA scores 3, 4, and 5 for RBC count, hemoglobin concentration, and PCV values were statistically significant, further validating the accuracy of the FAMACHA system in detecting anemia in goats.

3. Results

The study revealed that 37 out of 216 goats (17.12%) were anemic. The incidence of anemia varied across different breeds, sexes, and ages. The Black Bengal breed showed the highest prevalence of anemia (62.16%), followed by Jamunapari goats (29.73%) and crossbreeds (8.11%). Female goats were more affected by anemia (62.17%) compared to males (37.83%). Age also played a role, with goats aged 13-18 months being the most affected (59.46%) (Table 2).

Table 2. Occurrences of anemia in goat according to breed, age and sex.

Category	Group	Total	Percentage	95% CI (+-)
Breed	Black Bengal	23	62.16%	±15.46%
	Jamunapari	11	29.73%	±14.97%
	Cross	3	8.11%	±8.84%
Sex	Male	14	37.83%	±15.58%
	Female	23	62.17%	±15.46%
Age	0-6 Months	6	16.21%	±11.37%
	7-12 Months	9	24.33%	±13.66%
	13-18 Months	22	59.46%	±15.50%

3.1 Correlation between FAMACHA scores and blood parameters

Hematological parameters varying across FAMACHA scores. As the FAMACHA score increases from 1 to 5, indicating worsening anemia, there is a notable decline in RBC count, hemoglobin (Hb),

and packed cell volume (PCV), reflecting a reduction in oxygen-carrying capacity. Specifically, RBC values drop from 5.327 (10^6/µl) at FAMACHA 1 to 0.87 (10^6/µl) at FAMACHA 5, while Hb decreases from 9.71 g/dL to 3.5 g/dL, and PCV decreases from 12.62% to 3.035%. Mean corpuscular volume (MCV) remains relatively stable around 36-37 fl, but both mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC) increase as FAMACHA scores rise, suggesting a shift in red blood cell characteristics. White blood cell (WBC) counts show an upward trend, increasing from 9.06 K/µL at FAMACHA 1 to 24.315 K/µL at FAMACHA 5, likely indicating an inflammatory response. Platelet counts also increase, ranging from 280.19 K/µL at FAMACHA 1 to 389.5 K/µL at FAMACHA 5, potentially as a compensatory response. Overall, the data illustrates a decline in RBC-related parameters with increasing anemia severity, alongside rising WBC and platelet counts. The relationship between FAMACHA scores and blood parameters was analyzed to determine the effectiveness of the FAMACHA system in diagnosing anemia (Table 3).

Table 3. Standardization of FAMACHA techniques.

FAMACHA Score	RBC (10^6/µl)	WBC (K/µL)	Hb (g/dL)	MCV (fl)	PCV (%)	MCH (pg)	MCHC (g/dL)	Platelets (K/µL)
1	5.327	9.06	9.71	36.22	12.62	65.37	94.7	280.19
2	2.1275	12.59	7.09	37.435	7.745	62.55	127.675	319.75
3	1.9477	16.27	6.73	34.41	6.56	49.95	147.9	296.66
4	1.546	19.87	5.65	37	5.66	42.78	155.52	326.4
5	0.87	24.315	3.5	37.15	3.035	33.85	162.95	389.5

3.2 Red blood cell (RBC) count

RBC counts declined as FAMACHA scores increased, with a mean RBC count of 5.327 million/cu.mm for FAMACHA score 1 and 0.87 million/cu.mm for FAMACHA score 5. This clear trend suggests that higher FAMACHA scores correspond to more severe anemia (Table 3; Figure 2).

3.3 White blood cell (WBC) count

WBC counts showed an increasing trend with higher FAMACHA scores. The mean WBC count was 9.06 K/µL for FAMACHA score 1 and 24.315 K/µL for FAMACHA score 5, indicating a potential immune response to parasitic infection (Table 3; Figure 2).

3.4 Hemoglobin concentration (Hb)

Hemoglobin levels also decreased with increasing FAMACHA scores. Goats with a FAMACHA score of 1 had a mean hemoglobin level of 9.71 g/dL, while those with a score of 5 had only 3.5 g/dL, indicating a severe drop in hemoglobin concentration in severely anemic goats (Table 3; Figure 2).

3.5 Packed cell volume (PCV)

PCV values followed a similar trend, with higher FAMACHA scores corresponding to lower PCV values. The mean PCV for FAMACHA score 1 was 12.62%, while that for score 5 was only 3.035% (Table 3; Figure 2).

3.6 Mean corpuscular volume (MCV) and mean corpuscular hemoglobin (MCH)

MCV and MCH values increased slightly with higher FAMACHA scores, possibly reflecting the body's compensatory mechanisms in response to anemia.

4. Discussion

In the present study, the overall occurrence of anemia in goats was found to be 17.12%, with 37 out of 216 goats identified as anemic. Anemia was observed to vary based on breed, with Black Bengal goats being the most affected. Female goats also appeared to be at a higher risk. Diagnosing anemia in a laboratory setting typically involves procedures that assess several blood parameters, such as hemoglobin levels and red blood cell counts. Among these parameters, white blood cell (WBC) counts help determine the presence of infections, while red blood cell (RBC), haematocrit (Hct), and hemoglobin (Hb) levels are critical for anemia diagnosis (Agnello *et al.,* 2001; Prashanth *et al.,* 2020; Glaji *et al.,* 2014). Additionally, mean corpuscular volume (MCV) and mean corpuscular hemoglobin concentration (MCHC) values are essential for determining the responsiveness of anemia to treatment and assessing its severity (Al-Bulushi *et al.,* 2017).

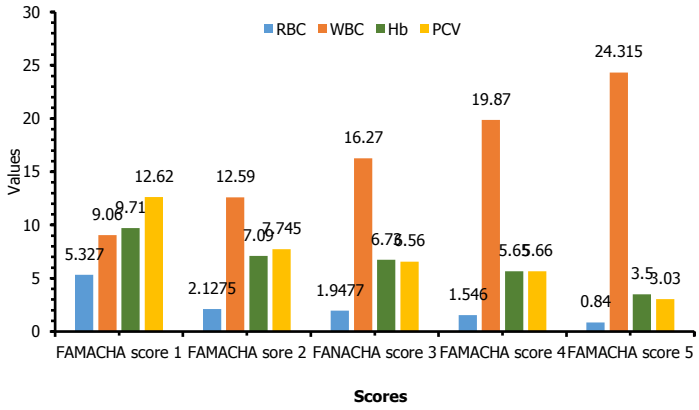

Figure 2. Relationship between FAMACHA score with different blood parameter.

The severity of anemia can be gauged using FAMACHA scores, which correlate with anemia risk. Scores of 1, 2, and 3 indicate minimal risk, whereas a score of 4 requires immediate attention, and a score of 5 carries the risk of severe, potentially fatal outcomes (Kaplan *et al.,* 2004). Laboratory tests measuring RBC values revealed significant differences between scores 5, 4, and 3, although the difference between scores 3 and 4 was not statistically significant. In terms of hemoglobin levels, values decreased from 6.73 g/dL at score 3 to 5.65 g/dL at score 4 and 3.5 g/dL at score 5. These differences were statistically significant and align with FAMACHA card scores, reinforcing the card's utility in diagnosing anemia in goats (Kaplan *et al.,* 2004).

Studies by Egbe-Nwiyi *et al.* (2000) explored the effects of age and sex on blood parameters in goats, reporting higher WBC values in younger males, which may indicate infection within the herd. In the current study, hemoglobin levels were slightly lower than those reported by Egbe-Nwiyi *et al.* (2000), with hemoglobin levels in goats with FAMACHA scores of 4 and 5 falling within the 8–12 g/dL range established by both Egbe-Nwiyi *et al.* (2000) and Al-Bulushi *et al.* (2017). These scores are indicative of anemia, as are the haematocrit (Hct) values, which fell below 22%, the threshold identified by Egbe-Nwiyi *et al.* (2000). These findings suggest the presence of tick-borne hemoparasitic infections, consistent with studies that identified lower Hb, RBC, MCV, MCH, and MCHC values in infected goats.

Al-Bulushi *et al.* (2017) provided reference ranges for various blood parameters, including WBC, RBC, Hb, and MCH, among Omani-Damascus goats. These values align with those observed in the current study, which highlights the role of hematological parameters in anemia diagnosis. Additionally, Santos *et al.* (2017) reported similar lymphocyte and monocyte values, though monocyte values were slightly elevated in the present study. Kaplan *et al.* (2004) found significant correlations between FAMACHA scores, packed cell volume (PCV), and faecal egg counts (FEC), underscoring the connection between *H. contortus* infections and anemia in goats. The parasite burden, particularly from *Haemonchus* spp., leads to erythrocyte loss, which is reflected in reduced PCV and Hb values, further validating the use of FAMACHA scoring as a reliable tool for anemia detection in small ruminants (Santos *et al.,* 2023; Şahin *et al.,* 2021).

5. Conclusions

The FAMACHA system proved to be a valuable and practical tool for diagnosing anemia in goats in the Barishal district. The strong correlation between FAMACHA scores and blood parameters, such as RBC count, hemoglobin concentration, and PCV, suggests that FAMACHA can be effectively used in field conditions to manage anemia caused by *H. contortus*. Regular use of this technique could help farmers identify anemic animals early and take appropriate measures, thereby improving animal health and productivity. The study recommends the integration of FAMACHA scoring into routine veterinary care and goat management practices in the region.

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Data availability

All relevant data are within the manuscript.

Informed consent statement

No informed consent was required to conduct the study.

Conflict of interest

The authors declare no conflict of interest.

Authors' contribution

Conceptualization, study conduction, data collection: Avijit Mondal; **Data analysis, methodology:** Md. Asib Abdullah Al Razi; **Formal analysis, manuscript editing:** A. A. Jabir; **Data collection, validation:** Fahad Bin Islam; **Data collection, methodology:** Md Salman Mostafa; **Formal analysis, methodology, writing original draft and review:** Kazi Abdus Sobur. All authors critically reviewed the manuscript and agreed to submit final version of the article.

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