Research Article

Relationships between Famacha scores and some blood values in sheep and goats

Özcan ŞAHİN[1],* , İbrahim AYTEKİN[1] , Saim BOZTEPE[1] , İsmail KESKIN[1] ,
Ali KARABACAK[1] , Yasin ALTAY[2] , Mervan BAYRAKTAR[3]

[1]Department of Animal Science, Faculty of Agriculture, University of Selçuk, Konya, Turkey
[2]Department of Animal Science, Faculty of Agriculture, University of Eskisehir, Eskişehir, Turkey
[3]Department of Animal Science, Faculty of Agriculture, Çukurova University, Adana, Turkey

Abstract: In this study, Akkaraman sheep and Hair goats raised extensively on the same farm were scored with the FAMACHA card. Score 1 was not present in both sheep and goats, whereas scores 5 and 2 were not detected in sheep and goats, respectively. While the number of animals with scores of 2, 3, and 4 was 9, 46, and 55 in sheep, the number of animals with 3, 4, and 5 scores in goats was 6, 55, and 41, respectively. In the study, the differences in the amount of RBC, Hct, and Hb in goats according to these score groups were found statistically significant, confirming anemia (p < 0.01). The number of animals with a score of 3–4 was 101 in the sheep population. Compared to the sheep population, a more serious anemic condition was observed in goats. However, differences in Hct and Hb amounts according to these score groups were statistically significant, confirming anemia (p < 0.05). As a result, it was concluded that the relationships between scoring by using the FAMACHA card and hematological blood analysis in the detection of anemia are more effective in goats, whereas it is also possible to use it in sheep.

Keywords: FAMACHA score, goat, sheep, herd management, anemia

1. Introduction

Herd management on production, reproduction, or health, etc. in livestocks includes all kinds of practices from the birth of an animal to culling. In fact, these activities, which start with navel care at birth, mother's care at birth, milking colostrum from the mother, making the offspring drink milk, separating the offspring from the mother, hand lactation or natural lactation, continues in the form of activities such as the control of reproduction, milking, hoof care, shearing, raw material supply for feed, feed preparation and feeding, etc. until the animal is out of breeding or slaughtered. Some scoring studies have been carried out recently in order to facilitate these activities in an economical way. Some scoring of this kind have been developed in cattle breeding. These are applications such as body condition scoring [1], udder hygiene scoring in controlling mastitis [2] [1, 2], rumen fill scoring related to nutrition [3,4], manure scoring related to digestion [5,6], locomotion scoring related to lameness [7] are among the topics studied recently in terms of facilitating the work and

being economical. In addition to some applications such as body condition scoring [8] and faecal soiling (dag score) in herd management [9,10], the FAMACHA card scoring is widely used in sheep and goat breeding in the identification of parasite-based anemia [11,12,13,14,15,16]. FAMACHA eye color chart, FAMACHA card, is a system developed and approved for grading anemia in South Africa; it is an easily accessible, practical, and inexpensive tool that provides information to determine the degree of anemia in tropical and subtropical countries by comparing conjunctival color in sheep and goats with a color chart on a scale of 1–5 [11].

According to Kaplan et al. [17] and Katsogiannou et al. [18], the use of the FAMACHA system helps to make a decision in combating the parasite based on an estimate of the level of anemia in sheep and goats associated with infection of small ruminants. The FAMACHA card developed in South Africa has been used by a small ruminant parasite control consortium (www.acsrpc.org) in the USA. It is a device that matches the color of the eye mucous membranes of small ruminants with a laminated

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color chart showing five color categories corresponding to different levels of anemia. There is a color scale on the card in the form of red (1), red-pink (2), pink (3), pink-white (4), or white (5) associated with PCV values (packed cell volume). This method is a tool to identify quickly the anemic animals from haemonchosis (*Haemonchus contortus*). The main purpose of the method is to prevent the risks that may occur in anemic animals individually and to reduce the use of anthelmintics with selective targets [19,20].

The aim of this study was to determine the relationship between Famacha scores and some blood values in sheep and goats.

2. Materials and methods

The animal material of the study consisted of 110 Akkaraman sheep and 110 Hair goat raised under extensive conditions by a smallholder farm in the Sızma village, within the boundaries of Konya province, 40 km far from the city center. Since the values could not be determined in some animals, the results of the animals whose values were determined are presented in the tables.

In the study, blood samples were taken from the *vena jugularis* of the animals at the beginning of the pasture period at the end of March 2019 using vacuum EDTA blood collection tubes and were transported under cold chain and brought to the Central Laboratory of the Animal Hospital of Selçuk University Veterinary Faculty. The collection of blood samples and the animal care practices used in the experiment were compatible with animal welfare rules stated in Article 9 in government law in Turkey (No. 5996).

The FAMACHA scoring technique involves exposing the lower eye mucous membranes and matching them with the equivalent color on the FAMACHA card. Animals were individually scored using the FAMACHA score card [11]. The conjunctival colors of the animals were scored on a scale of 1–5 using the FAMACHA score card by the assessor. Ocular mucous membrane colors of each animal according to FAMACHA graphic color scale were scored as follows: 1 = red, non-anemic; 2 = red-pink, non-anemic; 3 = pink, slightly anemic; 4 = pink-white, anemic; 5 = white, severely anemic (Figure 1).

Blood samples taken from the animals caught during scoring were mixed homogeneously on the BioClinica shaker. Hematological analyzes were performed in whole blood on Hemocell Counter MS4e (Melet Schloesing Laboratories, France) within two hours. As a result of the hemogram analysis, blood parameters including red blood cells (RBC), hemoglobin (HGB), hematocrit (HTC), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC) were evaluated.
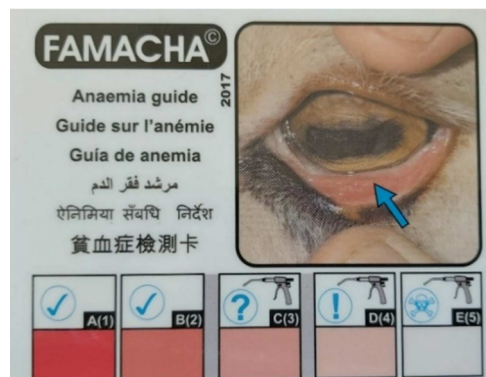

Figure 1. FAMACHA scoring card. Colors are not likely to be accurate in this article. Cards are provided from Prof. G.F. Bath.

Statistical analyzes were performed by the GLM procedure in Minitab 16.1.1 and the differences between the FAMACHA score groups were tested by the Duncan comparison test [21].

3. Results and discussion

According to the FAMACHA scoring, no animals with a score of 1 or 2 were detected in goats. The number of animals with 3, 4, and 5 scores was 6, 55, and 41, respectively. While no animals with 1 or 5 scores were detected in sheep, the number of animals with 2, 3, and 4 scores were found to be 9, 46, and 55, respectively.

Hematological blood values were obtained for 102 animals out of 110 goats and 110 sheep, and they were evaluated below.

Hematological blood analysis results for 102 goats are grouped according to FAMACHA scores and presented in Table 1.

Figure 2 was created in order to better understand the distribution of some hematological blood analyses in goats in Table 1.

Among these features, for example, WBC is used to decide whether an individual is exposed to an infection, while RBC, Hct, and Hb amounts are effective criteria in the diagnosis of anemia that is studied. MCV and MCHC properties are taken into consideration to determine the severity of anemia, and they are also important as other features that determine whether anemia will respond to treatment. Table 1 includes 6 animals with a score of 3 according to FAMACHA scores, 55 animals with a score of 4, and 41 animals with a score of 5 . The higher the FAMACHA scores, the higher the severity of the anemia. In other words, scores 1, 2, and 3 do not pose much danger, while score 4 requires absolute treatment, and although the score is 5, fatal outcomes may occur. The number of animals with a score of 4–5 in the goat herd is 96. So, a serious

Table 1. Descriptive statistics of hematological blood analysis for goats.

| Values		FAMACHA© scores			p value
		3 (n:6)	4 (n:55)	5(n:41)	
WBC	μ/mm³	16.44 ± 4.19	16.81 ± 4.10	17.43 ± 4.41	p > 0.05
Lym	%	40.35 ± 2.43	35.40 ± 8.42	36.78 ± 9.41	p > 0.05
Mon	%	6.33 ± 0.99	6.09 ± 1.06	5.88 ± 0.76	p > 0.05
Gra	%	53.31 ± 3.38	58.49 ± 8.44	57.32 ± 9.42	p > 0.05
Lym	μ/mm³	6.63 ± 1.70	6.07 ± 2.41	6.60 ± 2.75	p > 0.05
Mon	μ/mm³	1.04 ± 0.32	1.20 ± 1.13	1.01 ± 0.27	p > 0.05
Gra	μ/mm³	8.76 ± 2.25	9.72 ± 2.41	9.79 ± 2.38	p > 0.05
RBC	μ/mm³	16.51^A ± 2.33	14.69^A ± 1.81	13.68^B ± 1.57	p<0.01
MCV	fL	14.25 ± 0.38	14.35 ± 1.29	13.91 ± 1.40	p > 0.05
Hct	%	23.48^A ± 3.75	21.15^A ± 3.13	19.07^B ± 3.42	p<0.01
MCH	pg	5.50 ± 0.57	5.20 ± 0.35	5.24 ± 0.37	p > 0.05
MCHC	g/dL	38.91 ± 4.10	36.89 ± 4.07	38.54 ± 5.27	p > 0.05
RDW		15.23 ± 0.78	15.08 ± 1.63	14.70 ± 1.52	p > 0.05
Hb	g/dL	9.10^A ± 1.34	7.73^B ± 0.88	7.21^C ± 0.78	p<0.01
THR	μ/mm³	521.7 ± 91.2	598.3 ± 345.2	673.9 ± 418.6	p > 0.05
MPV	fL	4.88 ± 0.11	4.93 ± 0.21	4.91 ± 0.20	p > 0.05
Pct	%	0.25 ± 0.03	0.36 ± 0.57	0.32 ± 0.18	p > 0.05
PDW		4.78 ± 0.47	4.63 ± 0.60	4.68 ± 0.55	p > 0.05

A-C: p < 0.01
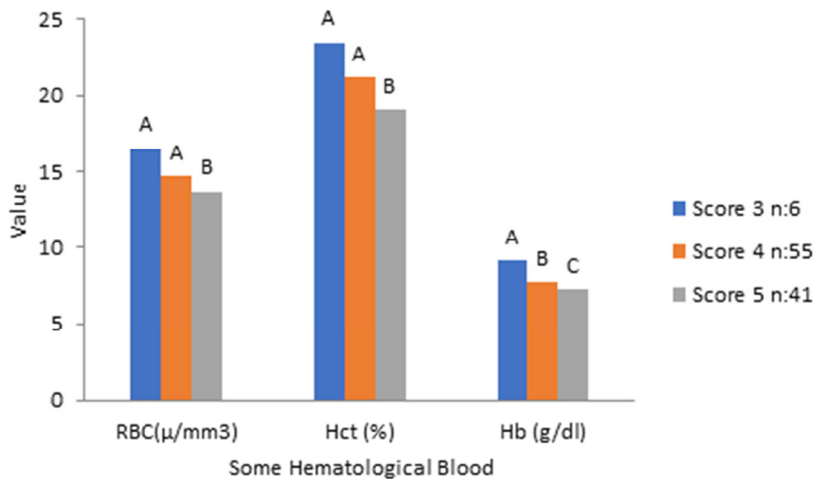
Figure 2. Bar charts of some hematological blood in goats according to FAMACHA scores.

anemic condition should be suspected. The differences in terms of RBC, Hct, and Hb amounts according to these score groups were statistically significant, confirming anemia (p < 0.01). According to Duncan test performed in terms of RBC values, the differences of score 5 from both score 4 and score 3 were significant, while the difference of 1.82 μ / mm3 between scores 3 and 4 was not significant. The same situation was observed between hematocrit values. However, in terms of hemoglobin values, the value which was 9.10 g / dL in score 3 decreased to 7.73 in score

4 and 7.21 in score 5. While the differences of score 3 from 4 and 5 were statistically significant, the difference of 0.52 g / dL between scores 4 and 5 was also found significant.

The fact that these three parameters, which are one of the important indicators of anemia, coincide with the FAMACHA card scores in goats can be considered as evidence that the use of the FAMACHA card is a useful and practical tool in the identification of anemia.

Egbe-Nwiyi et al. [22] investigated the effects of age and sex on some blood parameters in goats. WBC values were 8.41, 7.57, 5.79, and 7.36 (x 10^3 / μL) in males at the age of 0–3 months, 9–12 months, 1–2 years, and 3–5 years, respectively, while the values in females were 6.82, 6.81, 6.30, and 6.73 (x 10^3 / μL), respectively. High WBC values in the current study indicate the presence of an infection in the herd. In the present study, hemoglobin amounts were slightly lower than those of [22]. Egbe-Nwiyi et al. [22] determined the amount of hemoglobin in males as 11.88, 14.22, 13.34, and 14.16 g %, respectively according to the above age groups and 12.16, 12.75, 13.98, and 13.75, respectively according to the same age groups in females. Hemoglobin amounts of animals with scores of 4 and 5 according to FAMACHA were within the reference range of 8–12 g / dL reported by [23] and [24]. The score values 4 and 5 reflect anemia. The same is true for Hct values for scores 4 and 5. Hct values for scores 4 and 5 are below 22%, the lower limit reported by [24].

Egbe-Nwiyi et al. [23] determined some hematological blood parameters of infected and noninfected goats as follows. Hb, WBC, RBC, MCV, MCH, and MCHC values were 9.53, 9.88, 12.94, 21.83, 7.58, and 35.41, respectively in goats that were not infected with blood parasitic. The values were determined as 8.81, 8.97, 11.91, 23.59, 7.52, and 33.99 respectively, in blood parasitic infected patients (tick-borne haemoparasitic). The same researchers reported the ranges of normal (reference) Hb, WBC, RBC, MCV, MCH, and MCHC values as 8–12, 4–13, 8–18, 16–25, 5.2–8.0, and 30–36, respectively.

Al-Bulushi et al. [24] found the mean values of WBC, Neu, Lym, Mono, Eos, Baso, RBC, Hb, Hct, Mcv, Mch, Mchc, RDW values as 14.6–8.05, 60.87–39.90, 32.32–47.15, 3.34–5.61, 2.78–6.04, 0.67–1.36, 12.8–10.44, 10.4–6.97, 38.29–12.70, 30.08–12.15, 8.09–6.70, 27.05–55.25 and 35.86–31.35 respectively in Omani–Damascus goats. Researcher declared that reference value ranges for WBC, Neu, Lym, Mono, Eos, Baso, RBC, Hb, Hct, Mcv, Mch, Mchc were as 3–13, 30–48, 50–70, 0–4, 1–8, 0–1, 8–18, 8–12, 22–38, 16–25, 2.20–8 and 30–36, respectively. But they did not report any values for RDW.

Khan et al. [25] determined the mean of some hematological values for Hb (g / dL), Lymphocyte (%), Monocyte (%), Neutrophils (%), Eosinophils (%) and Basophils (%) in goats 8.9, 35.2, 2.4, 51.5, 10.2 and 0.7,

respectively and the minimum and maximum values as 8.12–10.58, 17.42–51.7, 1–4.8, 31.78–67.9, 6.65–19.34 and 0–1.93, respectively. Values for Lymphocyte in the current study are similar to those reported by [25]. Monocyte values around 6 % are much higher than the study above.

Kaplan et al. [17] found significant positive correlations between PCV (packed cell volume) and FAMACHA eye scores, FEC (number of eggs in feces), and FAMACHA eye scores in goats and sheep. It has also been determined that the FAMACHA method is less sensitive in goats than sheep [17]. Considering that anemia is the main pathological effect of *Haemonchus contortus*, the parasite burden causes erythrocyte loss for the animal [26]. The number of *Trichostrongylid* eggs in feces and PCV (packed cell volume) is associated with the number of *Haemonchus spp.* worms. The correlation between *Haemonchus spp* [26] and FEC, PCV, Hb, and FAMACHA in sheep abomasum has been observed in many studies [17, 27, 28].

Hematological blood analysis results for 110 sheep are presented in Table 2.

Figure 3 was created in order to better understand the distribution of some hematological blood analyses in sheep in Table 2.

Unlike goats, definition of score 5 could not be made according to FAMACHA scores in Table 2. According to the scoring, (2) scored 9 animals, (3) scored 46 animals and (4) scored 55 animals were determined. As mentioned earlier, as the FAMACHA© scores increase, the severity of anemia also increases. In the sheep herd in which the study was conducted, the number of animals with a score of 3–4 is 101. In other words, a serious anemic condition should not be suspected as much as in goats. However, differences in Hct and Hb amounts according to these score groups were found statistically significant, confirming anemia (p < 0.05). In terms of hematocrit values, the differences between score 2 and 3 and score between 3 and 4 were statistically insignificant. Yet, the differences between score 2 and score 3 from score 4 were found significant. The fact that the hemoglobin and erythrocyte amounts in the blood are below normal plays a role in the formation of anemia. Hematocrit values are associated with anemia, since they show both parameters, namely the status of both hemoglobin and erythrocyte levels. Similar results were observed in the amount of hemoglobin in sheep. In terms of hemoglobin values, the value which was 10.48 g / dL in score 2 decreased to 10.05 in score 3, and the score decreased to 9.56 in score 4. Hb values obtained in the current study were higher than the average values reported by [29] for sheep. While the differences of score 2 and 3 from score 4 were statistically significant as in Hct, the difference of 0.43 g / dL between scores 2 and 3 was found insignificant. Likewise, Berton et al. [29] reported a value lower than the Hct values obtained in the current

Table 2. Descriptive statistics of hematological blood analysis for sheep.

Values		FAMACHA© Scores			p value
		2 (n:9)	3 (n:46)	4 (n:55)	
WBC	μ/mm³	9.71 ± 4.85	8.49 ± 5.02	7.05 ± 5.37	p > 0.05
Lym	%	62.48[AB] ± 12.28	65.44[A] ± 9.02	57.38[B] ± 11.11	p<0.01
Mon	%	5.33 ± 1.93	5.27 ± 2.05	6.04 ± 2.11	p > 0.05
Gra	%	32.18[A] ± 11.24	29.29[AB] ± 7.59	36.57[B] ± 10.14	p<0.01
Lym	μ/mm³	6.38 ± 4.34	5.87 ± 4.30	4.37 ± 4.76	p > 0.05
Mon	μ/mm³	0.44 ± 0.11	0.36 ± 0.11	0.35 ± 0.12	p > 0.05
Gra	μ/mm³	2.88 ± 1.25	2.25 ± 1.00	2.32 ± 1.10	p > 0.05
RBC	μ/mm³	11.43 ± 1.23	10.68 ± 1.70	10.15 ± 1.62	p > 0.05
MCV	fL	32.26 ± 2.19	34.11 ± 5.27	33.40 ± 4.79	p > 0.05
Hct	%	36.73[a] ± 3.52	35.42[a] ± 4.96	32.97[b] ± 5.22	p<0.01
MCH	fL	9.15 ± 0.62	9.62 ± 2.12	9.81 ± 4.12	p > 0.05
MCHC	g/dL	28.55 ± 2.32	28.95 ± 5.27	29.62 ± 8.58	p > 0.05
RDW		11.84 ± 0.99	11.89 ± 0.87	11.74 ± 0.88	p > 0.05
Hb	g/dL	10.48[a] ± 1.18	10.05[a] ± 0.96	9.56[b] ± 1.13	p<0.01
THR	μ/mm³	381.6 ± 163.5	356.6 ± 169.2	337.5 ± 142.1	p > 0.05
MPV	fL	8.16 ± 0.21	8.11 ± 0.22	8.12 ± 0.28	p > 0.05
Pct	%	0.31 ± 0.13	0.28 ± 0.13	0.27 ± 0.11	p > 0.05
PDW		7.31 ± 2.85	7.30 ± 2.65	6.97 ± 3.02	p > 0.05

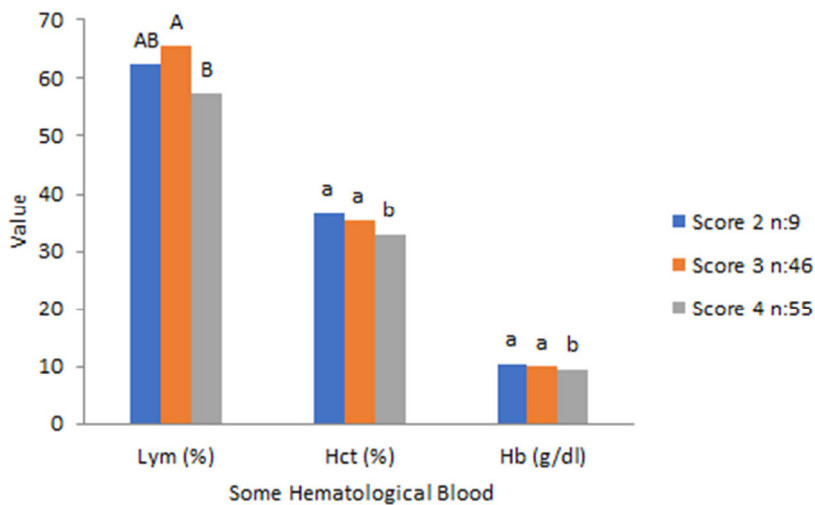a, b: p < 0.05, A, B: p < 0.01

Figure 3. Bar charts of some hematological blood in sheep according to FAMACHA scores.

study. Berton et al. [29] determined WBC, RBC, Hct, and Hb values as 10.96 103 / μL, 9.97 106 / μL, 29.05 % and 8.43 g / dL, respectively, in their study on sheep.

Rodriguez et al. [28] determined RBC, WBC and Hb values as 8.8 x 106 erythrocytes / mm³, 5919 leukocytes / mm³ and 7.8 g / dL, respectively, at the beginning of the experiment in sheep they experimentally infected with *Haemonchus contortus*. Significant decreases in these values occurred on the 25th day of the trial and on the 25th day, RBC, WBC and Hgb values were 5 x 106

erythrocytes / mm³, 5107 leukocytes / mm³ and 4.5 g / dL, respectively.

Macedo et al. [30] determined the Hct (%) values for FAMACHA scores 1,2,3,4, and 5 in sheep as ≥ 28, 23 ≤ x ≤ 27, 18 ≤ x ≤ 22, 13 ≤ x ≤ 17 and ≤ 12, respectively. These findings are in consistency with this study's results. Egbe-Nwiyi et al. [22] investigated the effects of age and sex on some blood parameters in sheep. They found WBC values as 7.69, 7.49, 7.53, and 6.95 (x 10³ / µL) in males at the age of 0–3 months, 9–12 months, 1–2 years, and 3–5 years, respectively, while, in females, the values were 8.29, 7.74, 7.65, and 6.99 (x 10³ / µL), respectively. In the same study, hemoglobin amounts were determined as 11.55, 13.03, 11.56, and 10.98 g % in males, respectively according to the above age groups and in females as 11.79, 12.41, 11.33, and 10.32, respectively.

Egbe-Nwiyi et al. [23] determined some hematological blood parameters in infected and noninfected sheep as follows. Hb, WBC, RBC, MCV, MCH, and MCHC values were 10.69, 10.17, 12.62, 24.64, 8.48, and 35.06, respectively in sheep that were not infected with blood parasitic and 8.72, 10.45, 9.39, 24.25, 8.16, and 32.95 respectively in sheep infected with blood parasitic. The same investigator reported the reference ranges of Hb, WBC, RBC, MCV, MCH, and MCHC values as 9–15, 4–12, 9–15, 28–40, 8–12, and 31–34, respectively. Yılmaz et al. [31] determined 2 animals had a score of 1, 12 had a score of 2, 26 had a score of 3, 20 had a score of 4, and 7 animals had a score of 5 according to the FAMACHA scoring they performed in their study in Aydın province, Turkey on Saanen goats. RBC values were 15.77, 12.77, 11.68, 11.38, and 7.28, respectively for scores 1, 2, 3, 4 and 5; Hb values were 10.60, 7.47, 7.11, 6.28, and 3.95; Hct values were 27.31, 19.10, 17.80, 16.57, and 10.81, respectively. They determined the MCV values as 17.00, 14.92, 15.42, 14.65, and 15.29, MCH values as 6.70, 5.90, 6.18, 5.54, and 5.58, and MCHC values as 38.75, 39.52, 41.28, 38.12, and 36.64. Among these values, they reported that the differences between scores for RBC, Hb, and Hct were statistically significant. Mean values of score 1 in terms of RBC, Hb, and Hct were found different from the other score averages. Likewise, the average values of score 5 were found significantly different from the other averages, as well.

4. Conclusion

As a result, the differences or similarities of the current study results from these hematological values, which are affected by factors such as age, sex, race, in both sheep and goats do not have much importance. Despite all these, the fact that Hb and Hct, which are important indicators of anemia, overlap with the FAMACHA card scores in sheep, that is, it can be said that the use of the FAMACHA card is a useful and practical tool in identifying anemia in sheep as well as in goats. In other words, it was concluded from the research findings that the relationship between scoring using the FAMACHA card and hematological blood analysis in the detection of anemia is more effective in goats, whereas it is possible to use it in sheep. In scoring with the FAMACHA card, evaluations are made for anemia caused by the parasite named *Haemonchus contortus*. However, in the present study, an evaluation was made about anemia by considering the FAMACHA scores and blood hematological features.

According to Katsogiannou et al. [18], toxins produced from hemoparasites such as Clostridium perfringens type D, Clostridium hemolyticum, and leptospirosis are some of the causes of hemolytic anemia. Moreover, some herbs, medicines or heavy metals and a lack of some trace elements can cause hemolysis. Immune-related hemolytic anemia has also been reported in ruminants. This can be caused by reduced red blood cell production, vitamin B12, or iron deficiency, as well as chronic diseases. Pathological conditions of the bone marrow, such as inflammatory or neoplastic cell filtration, and hypoplasia or aplasia of the bone marrow are associated with reduced erythrocyte production. Accordingly, anemia may have different causes.

It can be stated that scoring using the FAMACHA card in parasite control, which is a part of herd management, can also be used to determine anemia that occurs due to other reasons. In other words, based on the literature and the data in the current study, it can be said that the FAMACHA score card can be used practically by the breeders in the diagnosis of anemia without the need for blood analysis of the animals in the herd.

Conflict of interest

The author has no conflict of interest.

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