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Hematological Profile in Dairy Cattle with Foot and Mouth Diseases in Lembang, West Bandung

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Abstract

Foot and mouth disease (FMD) is a widespread infectious disease that significantly affects the dairy farming sector in Indonesia. In reducing the impact caused by FMD, proper treatment performed by veterinarians is necessary. Hematological profile can be used as a data reference to prioritize dairy cattle infected with FMD. This study aimed to describe the hematological profile in dairy cattle with FMD infection. This study was collected data from 15 dairy cattle with FMD infection at Koperasi Peternak Sapi Bandung Utara (KPSBU), Lembang, West Bandung, West Java, Indonesia. Parameters observed in the hematology analyzer were the numbers of erythrocytes, leukocytes, lymphocytes, neutrophils, platelets, hemoglobin, hematocrit, MCV, MCH, MCHC, RDW, and MPV. The results of the examination of hematological profile showed various numbers. It found lymphopenia, neutrophilia, and high MPV values. It was suggested for veterinarians to refer to this study's results to determine an effective and efficient treatment.

Keywords: dairy cattle, foot and mouth disease, hematological profile, infectious disease

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INTRODUCTION

In Indonesia, the dairy industry in fulfilling milk needs continues to grow annually with a total of 962,676.66 tons of milk in 2021 (Statistics Indonesia, 2021). The health status of farm animals affects milk productivity (Aisyah, 2011; Yuniarti, 2017). The low condition of animal health due to infectious diseases is one of the factors that can reduce the production of fresh milk in Indonesia (Agustina *et al*., 2020; Pisestyani *et al*., 2023). Infectious diseases are diseases caused by infectious agents such as viruses, bacteria, protozoa, and others, causing the health status of the infected animals to decrease and their productivity to be disrupted (Rahman *et al*., 2020).

One of the infectious viral diseases that is currently hitting Indonesia is foot and mouth disease (FMD). FMD is an infectious disease caused by the Aphthovirus virus in splits hoofed animals such as cattle, buffalo, sheep, goats, camels, and wild animals such as elephants, bison, and giraffes (World Organisation of Animal Health, 2022; Dinana *et al*., 2023). According to the Ministry of Agriculture, Republic of Indonesia (2022), FMD nowadays has hit 21 provinces in Indonesia with a total of 336,892 animal cases.

According to Rushton and Knight-Jones (2015) and Tawaf (2017), weight loss, decreased milk production, decreased fertility, increased costs of culling animals affected by FMD, vaccination costs, increased calving interval, or even death can occur in an area as a result of the FMD. Naipospos and Suseno (2017) conducted a simulation of financial losses due to FMD in Indonesia. The result showed the impact of the FMD outbreak that the government had sustained costs of around IDR 9.9 trillion (Oktanella *et al*., 2023).

These losses can be minimized by conducting effective and efficient treatment for cattle infected with FMD. Hematological examination and peripheral blood smear can be a reference to determine the health status of animals

to help monitor the incidence of a disease (Mayulu *et al*., 2012). There are still few studies that explain the hematological profile in cattle affected by FMD, especially in Indonesia. A dairy cooperative called Koperasi Peternak Sapi Bandung Utara (KPSBU), Lembang, is also affected by FMD infection. This study aimed to determine the hematological profile in dairy cattle with FMD in the Lembang, West Bandung. This study can be a reference for further treatment of dairy cattle affected by FMD or to improve productive and economic losses due to FMD.

MATERIALS AND METHODS

Ethical Approval

This study has been approved on research ethics under the number 835/UN6.KEP/EC/2022, which was submitted to the Ethics Committee of the Faculty of Medicine, Padjadjaran University.

Study Period and Location

The study was conducted at the Koperasi Peternak Sapi Bandung Utara (KPSBU), Lembang, and the examination was done at Medika Satwa Petshop and Petclinic on July 7–20, 2022.

Study Design

The sample in this study was dairy cattle with FMD in the Lembang KPSBU area, which were selected by purposive sampling technique. The number of specimens used was 15 dairy cattle with FMD. The criteria for inclusion are ≥ 2-year-old female adult cattle, cattle with mild and moderate clinical symptoms of FMD, and untreated cattle with FMD (systemically administered drugs such as antibiotics, vitamins, anti-inflammatories, analgesics, and anesthetics). The exclusion criteria were clinically healthy cattle that did not show symptoms of FMD, vaccinated cattle against FMD, and cattle with a history of parasitic infection based on the history of worm medication.

Hematology Examination

A total of 3 mL Blood samples were taken from the jugular vein in the neck area or the coccygeal vein at the base of the tail by injecting a sterile needle at an angle of 30° to the cranial direction with the needle hole facing up and aspiration. The collected blood sample was put into the EDTA tube and stored in a chiller box with a temperature of 2–10℃. Then, the examination was done using the MS-H630 Auto Hematology Analyzer (Ningbo Medicalsystem Biotechnology Co., Ltd., China).

Data Analysis

The data obtained from the results of laboratory examinations were tabulated using Microsoft Excel software and analyzed descriptively.

RESULTS AND DISCUSSION

Erythrocyte Profile

Erythrocyte profile were observed include red blood cells (RBC), hemoglobin, and hematocrit, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), and red blood cell distribution width (RDW). The result of erythrocyte profile of dairy cattle with FMD in Koperasi Peternak Sapi Bandung Utara (KPSBU) Lembang was reported in Table 1.

The standard erythrocyte count in adult cattle is 4.8–7.6 × 10^6/µL (Brooks *et al*., 2022). Based on this reference, two samples were below standard erythrocyte counts (samples 383 and 389), while the remaining 13 were in the normal range. According to Bunga *et al*. (2019), an increase in the number of bovine erythrocytes can occur, one of which is due to the high accumulation of heavy metals such as lead. The presence of lead will disrupt the binding of hemoglobin and oxygen in the blood (Vijay, 2009). The body then responds by increasing the release of erythropoietin to stimulate erythropoiesis due to the lack of oxygen supply to the tissues (Brooks *et al*., 2022).

However, the relationship between heavy metal accumulation and FMD conditions at KPSBU Lembang did not have a significant effect. The distance of the farm that is quite far from the traffic crowds or the environment with

Table 1. Erythrocyte profile in dairy cattle with FMD infection

Sample	Age (Year)	RBC (10^6/µL)	HGB (g/dL)	HCT (%)	MCV (fL)	MCH (pg)	MCHC (g/dL)	RDW (%)
376	3	6.46	10.4	29.4	45.5	16.2	35.6	21.6
377	3	5.84	8.7	29.6	50.7	14.9	29.5	20.6
378	3	5.14	7.6	23.3	45.4	14.8	32.6	22.4
379	3	5.87	9.6	24.2	41.2	16.3	39.6	19.4
380	3	6.50	9.6	26.3	40.4	13.3	33.0	20.8
381	3	6.07	9.9	28.7	47.3	16.4	34.6	19.5
382	2	6.65	9.7	29.1	43.7	14.6	33.4	19.9
383	8	4.62	8.3	23.9	51.7	18.0	34.8	17.3
384	2	6.41	9.7	30.2	47.1	15.1	32.0	20.0
385	3	5.58	8.7	26.0	46.5	15.5	33.3	18.1
386	5	5.60	8.9	26.6	47.5	16.0	33.6	20.7
388	5	5.95	8.5	25.9	43.5	14.3	32.9	20.2
389	8	3.17	5.7	20.1	63.5	18.1	28.5	26.7
391	5	5.61	9.2	26.7	47.5	16.4	34.6	17.8
394	8	7.49	10.1	32.0	42.7	13.6	31.7	20.4
Mean	4.26	5.80	8.97	26.80	46.95	15.57	33.31	20.36
SD	2.15	0.99	1.18	3.12	5.56	1.41	2.58	2.23
Highest	8	7.49	10.4	32	63.5	18.1	39.6	26.7
Lowest	2	3.17	5.7	20.1	40.4	13.3	28.5	17.3

Table 2. Anemia classification based on MCV and MCHC values

Anemia Classification	MCV Value	MCHC Value	Causes
Normocytic normochromic	Normal	Normal	-
Hypochromic macrocytic	↑	↓	Bleeding or hemolysis
Normochromic macrocytic	↑	Normal	Bleeding or hemolysis; erythropoiesis disorders
Hypochromic microcytic	↓	↓	Iron and vitamin B6 (pyridoxine) deficiency
Normochromic microcytic	↓	Normal	Iron deficiency; liver dysfunction
Hypochromic normocytic	Normal	↓	Rare, technical error

Source: Stockham and Scott, 2008.

high lead accumulation like final disposal area proves this case. The decrease in erythrocytes in dairy cattle with FMD at KPSBU Lembang is due to erythropoiesis disorders by the lack of nutritional intake. This is supported by study by Retnawati and Budiyanto (2020) which states that low erythrocyte counts in dairy cattle can occur due to erythropoiesis disorders due to lack of nutrients or mineral deficiencies in provision. A decrease in the number of erythrocytes in cattle affected by FMD was reported by Barkakati *et al*. (2015), which is thought to be caused by anemia due to a decrease in the erythropoiesis process. This is supported by Ghanem and Abdel-Hamid (2010), where there was a significant difference in the form of a decrease in the number of erythrocytes in Holstein cattle infected with FMD. The occurrence of anemia is associated with endocrinopathy that occurs as a secondary effect of viral infection, in this case, the FMD virus (Gökçe *et al*., 2004). A decrease in the number of erythrocytes due to endocrinopathy was also reported by Radostits *et al*. (2007).

Normal hemoglobin in adult cattle is 8.2–13 g/dL (Brooks *et al*., 2022). Based on the reference, there were two samples with below-normal hemoglobin (samples 378 and 389), and the remaining 13 were in the normal range. Hemoglobin levels are directly proportional to the number of erythrocytes because hemoglobin is the main component of erythrocytes (Aspinall and Cappello, 2015). Factors that affect hemoglobin

Table 3. Leukocytes and platelets profiles in dairy cattle with FMD infection

Sample	Age (Year)	WBC (10^3/µL)	Lym		Neu		PLT (10^3/µL)	MPV (fL)
			(%)	(10^3/µL)	(%)	(10^3/µL)		
376	3	7.08	29.7	2.10	62.9	4.46	349	7.1
377	3	7.37	26.0	1.92	66.2	4.88	369	8.5
378	3	1.40	20.9	0.29	62.9	0.89	165	9.0
379	3	6.07	18.2	1.10	72.5	4.41	124	10.2
380	3	8.38	22.1	1.85	70.3	5.90	533	7.0
381	3	12.75	18.7	2.38	71.1	9.07	249	9.4
382	2	12.15	28.7	3.48	60.6	7.37	500	7.6
383	8	6.58	19.3	1.27	75.6	4.98	418	7.6
384	2	7.80	30.3	2.36	60.2	4.70	377	7.4
385	3	7.71	34.4	2.65	54.5	4.21	644	7.5
386	5	10.53	24.3	2.55	66.1	6.97	645	7.5
388	5	8.87	43.0	3.82	40.2	3.56	233	9.0
389	8	6.40	23.0	1.48	63.9	4.09	408	7.3
391	5	5.17	31.1	1.61	57.9	3.00	403	7.9
394	8	11.64	27.5	3.20	65.9	7.68	280	8.3
Mean	4.26	7.99	26.48	2.14	63.39	5.08	379.80	8.09
SD	2.15	2.95	6.74	0.94	8.56	2.06	156.32	0.95
Highest	8	12.75	43	3.82	75.6	9.07	645	10.2
Lowest	2	1.4	18.2	0.29	40.2	0.89	124	7

levels in the blood are nutrition, race, age, activity, reproductive cycle, sampling time, and the anticoagulant used (Bunga *et al*., 2019; Retnawati and Budiyanto, 2020). If it is associated with FMD conditions, the decrease in hemoglobin occurs due to anorexia in cattle affected by FMD. Anorexia causes nutritional intake to decrease and then hemoglobin levels to decrease.

Normal hematocrit in adult cattle is 24–39% (Brooks *et al*., 2022). Based on this reference, there were two samples with below-normal hematocrit (samples 378 and 389), and the remaining 13 were in the normal range. An increase in hematocrit can occur due to dehydration due to a disturbed ratio of erythrocytes to blood plasma, while a decrease in hematocrit can occur due to a lack of amino acids in the feed (Bunga *et al*., 2019).

A low erythrocyte count, hemoglobin, and hematocrit levels may indicate an anemic animal. Particularly in sample 389, where the three parameters are under normal conditions. This is supported by Putera *et al*. (2014), where cattle with low erythrocyte counts and low hematocrit levels indicate that cattle are anemic and dehydrated which affects the energy in the body. According to Brooks *et al*. (2022), bleeding, hemolytic disease, or decreased erythropoiesis in the bone marrow can cause anemia.

There are two types of anemia. One is regenerative anemia due to hemorrhage or hemolysis and the other is non-regenerative anemia due to chronic inflammation when cytokines signal macrophages to absorb iron, resulting in decreased erythropoiesis. Based on this description, the most likely type of anemia in sample 389 was non-regenerative anemia. Other causes of non-regenerative anemia are chronic kidney disease, endocrine disease, and nutritional imbalances such as vitamin B12 or folic acid deficiency and iron deficiency (Brooks *et al*., 2022). In addition, samples 378 and 383 have the possibility of experiencing non-regenerative anemia. Sample 378 has below-normal hemoglobin and hematocrit levels, while sample 383 has below-standard erythrocyte and hematocrit totals (Table 1).

Standard MCV values in adult cattle are 41.2–58.7 fL (Brooks *et al*., 2022). Based on this reference, there is one sample with an MCV value below normal (sample 380) and one sample with

an MCV value above normal (sample 389), while the remaining 13 are within the normal range. MCV represents the average volume of an erythrocyte. Macrocytosis is a condition when macrocytes (large volume of erythrocytes) increase in peripheral blood vessels. MCV value above normal indicates this condition. Microcytosis is a condition when microcytes (small-volume erythrocytes) increase in the peripheral blood vessels. MCV value below normal indicates this condition (Bunga *et al*., 2019). Usually, macrocytosis dwells in an increase in the erythropoiesis process. This effect is due to immature erythrocytes being more substantial in volume. Vitamin B12 and folic acid deficiencies are also causes of macrocytosis with decreased MCV values indications (Bunga *et al*., 2019). While iron deficiency, copper deficiency, or liver dysfunction can cause microcytosis.

MCH value or mean normal corpuscular hemoglobin in adult cattle is 14.3–19.6 pg (Brooks *et al*., 2022). Based on this reference, there are two samples with MCH values below normal (samples 380 and 394), while the remaining 13 are within the normal range. MCH represents how much hemoglobin is contained per erythrocyte average. While an increase in MCH will occur in a macrocytosis state, a decrease in MCH will develop in a microcytosis state (Bunga *et al*., 2019).

The standard MCHC value in adult cattle is 32.4–35.8 g/dL (Brooks *et al*., 2022). Based on this reference, there were four samples with MCHC values below normal (samples 377, 384, 389, and 394) and one sample with MCHC values above normal (sample 379), while the remaining 10 were within the normal range. MCHC values represent hyperchromasia conditions. A low MCHC value indicates a quantity growth of hypochromic erythrocytes (decreased color = pale). Hyperchromasia is an increase in the number of hyperchromic erythrocytes (increased color = concentrated) which is characterized by high MCHC values.

Based on Table 2, sample 380 presumably has a normochromic microcytic anemia condition because the MCV value is below normal and the MCHC value is normal. It is possibly due to a lack of nutritional intake, specifically iron and vitamin B6 (pyridoxine) deficiency because of anorexia. Sample 389 was also suspected of having hypochromic macrocytic anemia because the MCV value was above normal and the MCHC value was below normal. It is possibly due to bleeding or hemolysis because of the lesion condition. Samples 377, 384, and 394 were suspected of having hypochromic normocytic anemia because the MCV value was normal, while the MCHC value was below normal. It is possibly due to a technical error during sampling (hemolysis) or during sample storage (cooler box temperature was not maintained) (Siswanto and Soma, 2014).

The normal RDW or red cell distribution width in adult cattle is 17-26%. Based on this reference, there is one sample with an RDW value above normal, while the remaining 14 are within the normal range. Sample 389 has an RDW value of 26.7%. An increase in the RDW value indicates an anisocytosis condition, which is a variation in erythrocyte volume (Stockham and Scott, 2008). This is supported by the MCV value which is above normal.

Leukocyte Profile

The normal leukocyte count in adult cattle is 4.4–10.8 × 10^3/µL (Brooks *et al*., 2022). Based on this reference, there was one sample with a leukocyte count below normal (sample 378), three samples with an above-normal leukocyte count (sample 381, 382, and 394), and the remaining 11 were within the normal range (Table 3). The increase and decrease in the number of leukocytes can be caused by several factors such as physiological conditions or pathological conditions (Adinugroho *et al*., 2019). The number of leukocytes can indicate the condition of the body in responding to protect it against microorganisms or infectious agents. According to Bunga *et al*. (2019), the presence of microorganisms or infectious agents that enter the body can stimulate the immune system as a protective response by increasing immune cells, namely leukocytes, resulting in a condition of leukocytosis or an increase in the number of leukocytes in samples 381, 382, and 394.

Meanwhile, the decrease in the number of leukocytes or Leukopenia in sample 378 indicates the presence of infectious agents (bacteria, viruses, fungi, and parasites), in this case, the FMD virus. This is in line with study conducted by (Saravanan *et al*., 2020), where there is a possible positive relationship between FMD virus infection and leukopenia in cattle and pigs.

Normal lymphocyte levels in adult cattle are 41–77% or 1.8–8.1 × 10^3/µL (Brooks *et al*., 2022). Based on the percentage comparison of lymphocytes with all components in the blood, there were 14 samples with a leukocyte count below normal, while only one sample had a lymphocyte percentage in the normal range, namely, sample 388. Based on the number of lymphocytes per unit microliter (µL), there were five samples with lymphocytes below normal (samples 378, 379, 383, 389, and 391), and the remaining 10 had lymphocytes in the normal range. Lymphopenia or a decrease in lymphocytes is one of the most visible and characteristic conditions in this study. Where this condition was found in almost all samples except sample 388 (Table 3). This is supported by study conducted by El-Mandrawy and Farag (2017), which stated that there were significant differences in the form of neutrophilia, eosinopenia, and lymphopenia in cattle infected with FMD. This condition of lymphopenia can occur due to the interaction between T and B cells with the FMD virus when the infection lasts for a short time, where it occurs when it reaches the peak of the viremia stage and causes temporary immunosuppression (El-Deen *et al*., 2017; El-Deen *et al*., 2017; El-Deen *et al*., 2017). Mandrawy and Farag, 2017). According to Brooks *et al*. (2022), lymphopenia can occur due to diseases caused by viral and bacterial infectious agents as an indication of the stress response, where the decrease in lymphocyte concentration occurs due to congenital immunodeficiency.

Normal neutrophil levels in adult cattle are 20–65% or 0.8–5 × 10^3/µL (Brooks *et al*., 2022). Based on the percentage ratio of neutrophils to all components in the blood, there were seven samples with neutrophil percentages above normal (samples 377, 379, 380, 381, 383, 386, and 394), while the remaining eight samples had neutrophil percentages in the normal range. Based on the number of neutrophils per unit microliter (µL), there were five samples with neutrophils above normal (samples 380, 381, 382, 386, and 394), and the remaining 10 had neutrophils in the normal range (Table 3). Neutrophilia, an increase in neutrophils in the seven samples was another indication that was the most visible and distinctive in this study. This is in line with study by Hashem *et al*. (2018), which found significant differences in the presence of leukocytosis, neutrophilia, and monocytosis in cattle infected with FMD. The increase in phagocytic cells (neutrophils and monocytes) can be caused by tissue damage due to viral infection because neutrophils and other phagocytic cells are the first line of defense against bacterial and viral infections (Hashem *et al*., 2018; Kristanto and Septiyani, 2023). According to Brooks *et al*. (2022), neutrophilia can occur due to chronic inflammatory stimulation when granulocytic hyperplasia in the bone marrow occurs. If associated with FMD, inflammation may result from the lesion as a secondary infection, thereby increasing the number of neutrophils in the blood (Wilujeng *et al*., 2020).

The normal platelet count in adult cattle is 160–650 × 10^3/µL (Brooks *et al*., 2022). Based on these references, all samples had platelet counts in the normal range. The mean platelet volume (MPV) value in adult cattle is 4–7 fL (Brooks *et al*., 2022). Based on this reference, there were 14 samples with a leukocyte count above normal, while only one sample had an MPV value in the normal range, namely, sample 380. An increase in MPV is generally associated with an increase in thrombopoiesis (platelet production process), usually associated with a congenital disease or bone marrow disease such as aplastic anemia (Purnama *et al*., 2019). However, this study did not find this type of condition in FMD dairy cattle at KPSBU Lembang. A technical error through sample storage may cause an increase in MPV in this study. MPV value will increase over time in samples stored at 4℃. Based on this reference, the increase in MPV can be caused by several factors

like anticoagulants, storage time, and storage temperature.

CONCLUSION

Based on the data obtained from 15 dairy cattle with FMD at Koperasi Peternak Sapi Bandung Utara (KPSBU), Lembang, the mean and standard deviation of the hematological value with the erythrocyte count parameter was 5.80 ± 0.99 × 10^6/µL; hemoglobin level of 8.97 ± 1.18 g/dL; hematocrit level of 26.8 ± 3.12%; MCV value of 46.95 ± 5.56 fL; MCH value of 15.57 ± 1.41 pg; MCHC value of 33.31 ± 2.58 g/dL; RDW value of 20.36 ± 2.23%; leukocyte count of 7.99 ± 2.95 × 10^3/µL; lymphocyte levels of 26.48 ± 6.74% or 2.14 ± 0.94 × 10^3/µL; neutrophil content of 63.39 ± 8.56% or 5.08 ± 2.06 × 10^3/µL; platelet count of 379.8 ± 156.32 × 10^3/µL; and the MPV value of 8.09 ± 0.95 fL. The abnormalities found in the hematological value of FMD dairy cattle at KPSBU Lembang were lymphopenia, neutrophilia, and a high MPV value. Hematological parameters can be utilized to prioritize FMD-infected dairy cattle. This can assist veterinarians in more successfully identifying and treating affected cattle, thus reducing the burden of FMD on Indonesia's dairy-producing sector. The results of this study can also be useful as a reference for further studies in the development of diagnostic and prognostic tools involving hematological changes.

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AUTHORS' CONTRIBUTIONS

RAM: Conceptualization and drafted the manuscript. S, RG, and AMR: Performed laboratory analysis. NH: Validation, supervision, and formal analysis. RAM: Performed the statistical analysis and the preparation of tables. All authors have read, reviewed, and approved the final manuscript.

COMPETING INTERESTS

The authors declare that they have no competing interests.

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