

Short Communication

Hematological Profile of Wild Boars (*Sus scrofa*) From Timor Island: A First Report

Filphin Adolfin Amalo^{1,2}, Eka Pramytha Hestianah^{3*}, Suwarno Suwarno⁴, Boedi Setiawan⁵, Ingrid Trinidad Maha², Heny Nitbani², Yulia Nelymalik Selan², Stefania Tekla Dungan Tagu⁶

1) Doctoral Program of Veterinary Science, Faculty of Veterinary Medicine, Universitas Airlangga. Jl. Mulyorejo, Mulyorejo, Surabaya 60115, East Java, Indonesia

2) Department of Veterinary Anatomy, Physiology, Pharmacology and Biochemistry, Faculty of Medicine and Veterinary Medicine, Universitas Nusa Cendana, Jl. Adisucipto, Penfui, Kupang 85001, East Nusa Tenggara, Indonesia

3) Division of Veterinary Anatomy, Faculty of Veterinary Medicine, Universitas Airlangga. Jl. Mulyorejo, Mulyorejo, Surabaya 60115, East Java, Indonesia

4) Division of Veterinary Microbiology, Faculty of Veterinary Medicine, Universitas Airlangga. Jl. Mulyorejo, Mulyorejo, Surabaya 60115, East Java, Indonesia

5) Division of Clinic Veterinary, Faculty of Veterinary Medicine, Universitas Airlangga. Jl. Mulyorejo, Mulyorejo, Surabaya 60115, East Java, Indonesia

6) Undergraduate Student, Veterinary Medicine Program, Faculty of Medicine and Veterinary Medicine, Universitas Nusa Cendana, Kupang, Indonesia

* Corresponding author, email: eka-p-h@fkh.unair.ac.id

Keywords:

Blood
Hematology
Sus scrofa
Timor Island
Wild Boars

Submitted:

22 August 2025

Accepted:

12 November 2025

Published:

11 May 2026

Editors:

Ardaning Nuriliani
Annisa Widyasari

ABSTRACT

This study analysed the hematological profile of wild boars on Timor Island as a physiological reference. Blood from 10 healthy adult wild boars (5 males and 5 females, 3–5 years, 15–30 kg) was collected via the jugular vein and analysed. Leukocyte counts were lower than reference values, with elevated neutrophils and reduced lymphocytes and eosinophils. Monocyte and basophil levels remained within normal range. The neutrophil-to-lymphocyte ratio (4.15) indicated physiological stress. Erythrocyte count, hemoglobin, and PCV exceeded reference values, while MCV, MCH, and MCHC were normal. Variations may reflect genetic, environmental, nutritional, seasonal, geographic, and handling stress factors.

Copyright: © 2026, J. Tropical Biodiversity Biotechnology (CC BY-SA 4.0)

How to cite:

Amalo, F.A. et al., 2026. Hematological Profile of Wild Boars (*Sus scrofa*) From Timor Island: A First Report. *Journal of Tropical Biodiversity and Biotechnology*, 11(2), jtbb24031. doi: 10.22146/jtbb.24031

Wild boars (*Sus scrofa*) are wild mammals widely distributed across various regions worldwide, including Southeast Asia and Indonesia. These animals are well known for their adaptability to various environmental conditions, ranging from tropical rainforests and grasslands to mountainous areas. These animals are well known for their adaptability to diverse environmental conditions, ranging from tropical rainforests and grasslands to mountainous regions. In Indonesia, the wild boar population is spread across several large and small islands, one of which is Timor Island, playing an important role in the ecosystem but has the potential to act as an intermediary for diseases (Rekiel et al. 2024). The diverse lifestyle of wild boars, along with suboptimal biosecurity measures, positions this species as a significant reservoir for the transmission of diseases, particularly those that can spread to domestic animals and humans.

Timor Island has unique ecosystem characteristics, featuring a dominance of tropical dry forests, savannas, and coastal areas (BPS NTT 2023). These environmental conditions indirectly influence the physiological and biological adaptations of various fauna inhabiting the island, including wild boars. To date, there is no scientific data on the health conditions and hematological profile of wild boars on Timor Island. Hematological information is important as a fundamental parameter in assessing the health status of wildlife populations, both for conservation purposes and as a basis for anticipating potential zoonoses that may arise from interactions between humans, domestic animals, and wildlife.

The hematological profile is one of the important indicators in animal health studies as it reflects the physiological and pathological conditions of individuals or populations (Ježek et al. 2018). Parameters such as the number of white blood cells (WBC), red blood cells (RBC), hemoglobin concentration (Hb), packed cell volume (PCV), and differential white blood cell counts are often used to detect infections, anaemia, physiological stress, and other health diseases (Thorn et al. 2022). In wild animals, the hematological profile can also provide an overview of adaptation to the environment, including responses to food availability, habitat quality, and the presence of other environmental stress factors (Sumarto et al. 2016; Kophamel et al. 2022).

Various studies have been conducted to describe the hematological profile of several wild mammal species, including wild boars from different regions of the world (Harapin et al. 2003; De et al. 2013; Kobeza 2014; Casas-Diaz et al. 2015). Variations in hematological values between populations are often observed and influenced by various factors, such as genetic factors, sex, age, nutritional quality, health status, activity levels, and stress levels of animals, as well as environmental, seasonal, and geographical conditions (Siegel et al. 2020; Eljarah & Ismail 2023; Lazăr et al. 2025). Therefore, it is important to have specific data from each local population as a basic reference for assessing the health and management of wildlife populations in a given area.

Timor Island, with its unique geographical and ecological conditions, has the potential to influence the hematological profile of wild boars living in this area. Additionally, the high level of human activity in this area, including hunting and land conversion, can be an additional stress factor that indirectly affects the physiological condition of wildlife. Therefore, examining the hematological profile of wild boars on Timor Island is important not only from an academic and scientific perspective but also in supporting wildlife conservation and management efforts in the area (Becker et al. 2019; Vilela et al. 2020; BPS NTT 2023).

Based on the above description, this study aims to provide an initial overview of the hematological profile of wild boars (*Sus scrofa*) on Timor Island. As the first report, these results are expected to serve as an important

reference for the development of wildlife health studies in Indonesia, particularly in the East Nusa Tenggara region. Additionally, the data obtained is anticipated to form the basis for supporting conservation programs, managing populations, and acting as an initial step in mitigating the risk of disease transmission from wildlife to domestic livestock on Timor Island.

This study is expected to enhance the awareness of communities and stakeholders in the fields of environment, forestry, and animal health regarding the importance of monitoring wildlife health, particularly that of wild boars, which play crucial role in the local ecosystem. Additionally, this study aims to inspire a comprehensive follow-up investigation to support biodiversity conservation in eastern Indonesia.

In this study, all procedures were approved by the Animal Care and Use Committee, Universitas Airlangga, Indonesia (approval No. 1.KEH.087.06.2024). Blood samples were obtained from 10 apparently healthy wild boars (5 males and 5 females) in Tuakau Village, West Fatuleu District, Kupang Regency, East Nusa Tenggara, during the rainy season (November–December 2024). Tuakau Village was selected because it represents a typical natural habitat where wild boars are commonly found and provides feasible access for field sampling. The animals were estimated to be 3–5 years old based on tooth eruption and wear patterns, following standard morphological criteria (Mayer 2002), and the assessment was performed by a trained veterinarian. The animals weighed approximately 15–30 kg. Given the small sample size ($n = 10$), the findings of this study should be interpreted with caution as they may not fully represent the broader wild boar population.

The wild boars were captured in forested areas using snares made from polyester rope. After capture, restraint was achieved by looping the rope around the hind legs, forelegs, or across the chest. The rope was gradually tightened to secure the animal and minimize injury. One handler guided the boar toward a holding pen while another used a restraint board or similar tool to limit movement during clinical examination and sample collection.

Health status was assessed by observing for signs of stress or aggression, checking body temperature, palpating for wounds or abnormalities, and examining the skin, fur, and presence of ectoparasites. Only animals with no apparent clinical signs were included in the study.

Blood was collected aseptically from the jugular vein using a 3 mL syringe after occlusion and disinfection with alcohol-soaked cotton. Sampling was performed without sedation, and blood collection was completed within approximately 5–10 minutes following capture. The samples were transferred into EDTA tubes and immediately stored in a cool box at approximately 4 °C, then transported to the laboratory for analysis.

Hematological examinations were carried out using an automated hematology analyser (Mindray BC-2800Vet). Parameters measured included red blood cell count (RBC), hemoglobin concentration (Hb), packed cell volume (PCV), and erythrocyte indices—mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC). These indices represent the average size of red blood cells and the hemoglobin content or concentration within them. Total white blood cell (WBC) count and differential leukocyte counts (lymphocytes, neutrophils, eosinophils, monocytes, and basophils) were also determined. The neutrophil-to-lymphocyte (N/L) ratio was calculated by dividing the number of neutrophils by lymphocytes.

All hematological measurements were tabulated and presented as means with standard deviation (SD) and range (minimum-maximum) using Microsoft Excel (version 12.0, Microsoft® Excel® 2007), then compared with the physiological values of domestic pigs and data from studies on other wild boar populations across various regions.

The hematological profile of wild boars from the Timor Islands is presented in Table 1. The results obtained from this study were compared with the recommended normal hematological values of domestic pigs and data from studies on other wild boar populations across various regions. Based on the examination results, wild boars were generally in good health, although they had ectoparasites and minor injuries observed on the legs. The body temperature was within the normal range of 39.2 to 39.7 °C, showing no signs of serious infection or metabolic disease, with minor injuries attributed to mechanical stress. The results showed variations in several hematological parameters, including the number of leukocytes, the percentage of neutrophils, lymphocytes, and eosinophils, as well as the values of erythrocytes, hemoglobin, and PCV.

White blood cells are the primary indicator of the body's immune re-

Table 1. Hematological Profile of Wild Boars from the Timor Islands Compared with Other Wild Boars and Reference Values.

Parameters	Wild Boar (Timor Islands) (n = 10) Mean ± SD (Min - Max)	Wild Boar (Sisak-Moslavina County)* (n = 23) Mean ± SD (Min - Max)	Wild Boar (Andaman and Nicobar Islands)** (n = 3) Mean ± SD	Wild Boar (Northeastern Spain)*** (n = 89) Mean ± SD (Min - Max)	Wild Boar (Ukraine)**** (n = 10) Mean ± SD (Min - Max)	Reference Values***** Mean (Min - Max)
Leukocytes/WBC (×10 ³ μL ⁻¹)	5.43 ± 6.21 (1 - 14.5)	9.79 ± 4.27 (6.0 - 20.35)	35.12 ± 2.05	-	4.99 ± 0.39 (4.60 - 6.00)	16 (11 - 22)
Neutrophils (%)	74.75 ± 11.18 (60 - 86)	-	4.80 ± 0.72	7.81 ± 3.40 (1.94 - 15.43)	-	37 (28 - 47)
Lymphocytes (%)	18.00 ± 10.13 (11 - 33)	0.441 ± 0.099 (0.25 - 0.58)	62.80 ± 0.36	3.46 ± 1.47 (1.28 - 7.27)	54.15 ± 4.67 (48.70 - 63.00)	53 (39 - 62)
Monocytes (%)	4.75 ± 2.63 (1 - 7)	-	8.37 ± 0.15	0.37 ± 0.19 (0.12 - 1.08)	27.5 ± 1.33 (25.00 - 29.80)	5 (2 - 10)
Eosinophils (%)	1.75 ± 2.06 (0 - 4)	0.034 ± 0.036 (0.00 - 0.11)	21.37 ± 1.07	0.17 ± 0.29 (0.00 - 1.71)	-	3.5 (0.5 - 11)
Basophils (%)	0.50 ± 0.58 (0 - 1)	-	0.70 ± 0.10	0.05 ± 0.07 (0.00 - 0.38)	-	0.5 (0 - 2)
Erythrocytes /RBC (×10 ⁶ μL ⁻¹)	9.70 ± 0.54 (8.9 - 10)	8.00 ± 0.68 (6.87 - 9.03)	9.72 ± 0.17	6.50 ± 0.55 (5.36 - 7.64)	4.5 ± 0.11 (4.32 - 4.72)	6.5 (5 - 8)
Haemoglobin/Hb (g dL ⁻¹)	16.75 ± 1.25 (15 - 17.7)	15.66 ± 1.73 (12.3 - 18.3)	17.27 ± 0.35	14.02 ± 1.32 (10.9 - 15.7)	-	13 (10 - 16)
PCV (%)	52.55 ± 1.50 (50.3 - 53.4)	60.98 ± 4.20 (55.4 - 69.4)	61.3 ± 0.56	36 ± 4 (30 - 51)	-	42 (32 - 50)
MCV (fL)	53.30 ± 0.08 (53.2 - 53.4)	77.5 ± 5.13 (70 - 86)	63.1 ± 0.8	57.82 ± 3.58 (51.30 - 66.60)	54 ± 2.26 (49.00 - 58.00)	60 (50 - 68)
MCH (pg)	17.15 ± 0.39 (17 - 17.6)	-	17.77 ± 0.17	21.13 ± 1.32 (18.10 - 22.90)	17.34 ± 1.46 (14.00 - 19.00)	19 (17 - 21)
MCHC (g dL ⁻¹)	31.6 ± 1.92 (29 - 33)	-	28.17 ± 0.33	34.71 ± 1.18 (32.20 - 37.00)	31.36 ± 2.28 (27.00 - 33.4)	32 (30 - 34)
N/L Ratio	4.15 ± 2.45	-	0.07	2.26	-	-

Notes: * Harapin et al. 2003; ** De et al. 2013; *** Casas-Diaz et al. 2015; **** Kobeza 2014; ***** Thorn et al. 2022.

sponse to infection or physiological stress. The leukocyte levels of wild boars from Timor Island were $5.43 \pm 6.21 \times 10^3 \mu\text{L}^{-1}$, which is lower than the normal reference value of $16 \times 10^3 \mu\text{L}^{-1}$. The large standard deviation in WBC values indicates substantial inter-individual variation, which may reflect physiological differences, subclinical infections, or varying stress responses among individuals (Ježek et al. 2018). These findings could hypothetically indicate reduced immune activity or stress-related responses; however, such an interpretation should be made with caution, as hematological variations may also arise from subclinical infection, hydration status, or the timing of blood sampling. Similar findings were reported by Harapin et al. (2003) and Kobeza (2014), who observed low leukocyte levels in wild boar species in Croatia and Ukraine. In contrast, De et al. (2013) reported higher leukocyte levels in Indian wild boars. This suggests that variations in hematological values are likely influenced by environmental conditions, specific stressors, local adaptation, and the physiological and health status of the animal (Ježek et al. 2018). Additionally, exposure to heat stress in pigs can trigger significant changes in leukocyte counts (Rudolph et al. 2024).

White blood cells are essential components of blood, playing a crucial role in the body's defence system at both the cellular and humoral levels. Leukocytes circulate to the site of infection and trigger an inflammatory response as a defence mechanism against foreign agents entering the body (Sun et al. 2021). However, low leukocyte counts can show pathological conditions such as viral infections, circulatory shock, acute inflammation, cytotoxic substances, bone marrow diseases, nutritional deficiencies, or even chronic stress (Roland et al. 2014; Pascutti et al. 2016).

Differential leukocyte counts in wild boars from Timor Island showed that the percentage of neutrophils was $74.75 \pm 11.18 \%$, significantly higher than normal values. In contrast, the percentages of lymphocytes and eosinophils were lower than normal, recorded at $18.00 \pm 10.13 \%$ and $1.75 \pm 2.06 \%$, respectively. This imbalance in leukocyte components is an important indicator of physiological stress in animals. According to Roland et al. (2014), a stress leukogram is characterised by neutrophilia, lymphocytopenia, eosinopenia, and sometimes monocytosis, and this condition is triggered by exposure to endogenous or exogenous corticosteroids.

The most common causes of neutrophilia are stress and inflammation, and inflammatory neutrophilia is observed in viral, bacterial, protozoal, parasitic, and fungal infections (Thrall et al. 2022). Additionally, neutrophilia occurs in non-infectious inflammations such as traumatic injury, necrosis, infarction, burns, thrombosis, neoplasia, poisoning, endocrine diseases, bleeding, and hemolysis (Carter 2018; Thrall et al. 2022). Subsequently, the causes of lymphocytopenia include acute stress, viral or bacterial infections, immune suppression, chronic renal failure, and corticosteroid use (Roland et al. 2014). Eosinopenia can occur during the early stages of infectious diseases, uremia, or acute hemolysis (Santos et al. 2025). In contrast, eosinophilia is more typically associated with parasitic infections or allergic responses (Huang & Appleton 2016; Barinberg et al. 2025).

An increase in the neutrophil-to-lymphocyte ratio (N/L) is a hematological indicator commonly used to assess stress responses in animals. The neutrophil-to-lymphocyte ratio (4.15) observed in this study may suggest physiological stress, although no species-specific threshold has been established for pigs. Previous studies in other species, such as goats and cattle, have proposed that an N/L ratio exceeding 1.5 can indicate stress-related responses (Kannan et al. 2000; Carrasco-Garcia et al. 2020). This elevation in the N/L ratio is associated with cortisol release during stress. When animals undergo physiological stress, whether caused by human manipulation, environmental changes, or transportation, the endocrine system responds by acti-

vating the hypothalamic-pituitary-adrenal (HPA) axis, leading to an increased secretion of glucocorticoid hormones, specifically cortisol. Subsequently, cortisol plays a crucial role in modifying the immune system, one of which is by stimulating the release of neutrophils from the bone marrow into the bloodstream and prolonging the lifespan of neutrophils by inhibiting apoptosis (Wessely-Szponder et al. 2018). Meanwhile, cortisol also causes the redistribution of lymphocytes from the bloodstream to peripheral tissues and lymphoid organs. This phenomenon involves increased lymphocyte adhesion to blood vessel endothelium, migration to tissues, and retention in lymphoid organs, typically resulting in decreased lymphocyte counts in peripheral blood (Otani et al. 2022). Consequently, there is an increase in the N/L ratio, reflecting physiological stress in animals.

This phenomenon has been shown in various animal species, including domestic pigs, which are often used as reference models for interpreting hematological responses due to their close physiological similarity to wild boars. Reference ranges in domestic pigs are well established from large standardized populations, whereas data for wild boars remain limited and variable among regions, making domestic pigs a useful comparative reference species in this study. Sutherland et al. (2016) showed that transportation treatment in pigs can cause an increase in cortisol levels and the N/L ratio in a short time. A high N/L ratio not only reflects acute stress but can also be an indicator of chronic stress because glucocorticoids work systemically and can suppress the adaptive immune system in the long term. Other studies also support that stress due to environmental factors or handling procedures can trigger significant changes in the N/L ratio, making this parameter very useful for monitoring animal welfare and detecting acute and chronic stress conditions (Carvalho et al. 2020).

Assessing the N/L ratio is also very important in wild or semi-wild animals such as wild boars, which tend to be more sensitive to external stressors. In the context of conservation and wildlife physiology studies, an increase in this ratio can indicate short-term effects of capture, translocation, or habitat change. Therefore, the N/L ratio is relevant not only for livestock but also for evaluating the health and welfare status of wildlife, which is difficult to monitor continuously in nature. Meanwhile, monocyte and basophil levels remained within the normal range and showed no significant deviations, indicating the absence of ongoing systemic parasitic infection or active allergic disease (Thrall et al. 2022).

The concentration of erythrocytes from wild boars on Timor Island was $9.70 \pm 0.54 \times 10^6 \mu\text{L}^{-1}$, which is higher than the normal value of $6.5 \times 10^6 \mu\text{L}^{-1}$. Hemoglobin and PCV levels also increased, while MCV, MCH, and MCHC values were within the normal range. These results are similar to the results of studies by Harapin et al. (2003) and De et al. (2013), which also reported high erythrocyte, hemoglobin, and PCV values in wild boars. However, Kozbeza (2014) reported the opposite, where erythrocyte values in wild boar species in Ukraine were lower.

Erythrocytes are one of the cellular components of blood that bind hemoglobin and serve as oxygen carriers (Aspinall & Cappello 2015). The high concentration of erythrocytes in wild boars from Timor Island suggests the possibility of hemoconcentration due to mild dehydration or increased oxygen demand. High hemoglobin values show a greater oxygen-binding capacity, while increased PCV reflects a high relative volume of red blood cells in the blood. This is in line with Randolph et al. (2022), stating that increased levels of erythrocytes, hemoglobin, and PCV can result from dehydration caused by insufficient fluid intake or stress, leading to relative polycythemia. Relative polycythemia is triggered by a decrease in plasma volume in dehydrated individuals or by splenic contraction. Previous studies by Casas-Díaz et al. (2015) and Gldenpfennig et al. (2021) showed that stress due to handling and re-

straint can lead to hemoconcentration, which is reflected in increased erythrocytes, hemoglobin, and PCV. In addition, Esposito et al. (2020) stated that splenic contraction that occurs during handling can increase PCV by more than 10 %.

In general, the hematological profile of wild animals, such as wild boars, is significantly influenced by various intrinsic and extrinsic factors. One important factor is the possibility of long-term geographical isolation in wild boar populations on Timor Island, which can lead to genetic variation compared to other wild boar populations. This genetic variation can affect physiological parameters, including blood profiles (Bovo et al. 2019; Ajmone-Marsan et al. 2023). Additionally, age and sex are factors that can affect metabolism and hormone levels, which in turn affect blood composition (Karaşahin et al. 2022). However, in this study, the influence of age and sex was not analysed in detail and should be further explored in future studies.

Nutritional status plays an important role in hematopoiesis. According to Grimes and Fry (2015), protein and iron deficiencies can reduce erythrocyte production. On the other hand, the relatively dry geographical conditions of Timor Island and its long dry season may cause environmental stress that affects the metabolism and blood profile of animals. Arnold (2020) stated that seasonal changes can affect blood volume and leukocyte distribution in wild mammals. The stress factor of handling has also been shown to significantly affect hematological parameters. Cortisol released during stressful conditions can lead to leukocyte mobilization and spleen contraction, ultimately increasing PCV values and the number of erythrocytes in circulation (Otani et al. 2022). In the present study, capture and handling procedures were standardized and performed as quickly and carefully as possible to minimise stress-related physiological alterations.

Comparisons with other wild boar populations revealed variability potentially attributable to genetics, environment, nutrition, seasonal factors, and handling stress. Considering these complex influences, future studies with larger and stratified samples are needed to clarify the specific drivers of hematological variation and the role of environmental adaptation in shaping wild boar physiology, particularly on Timor Island.

AUTHORS CONTRIBUTION

F.A.A. designed the research, supervised the project, and finalised the manuscript. E.P.H., S., and B.S. prepared and critically revised the manuscript. I.T.M., H.N., and Y.N.S. analysed data and edited the manuscript. S.T.D.T. conducted field sampling. All authors approved the final manuscript.

ACKNOWLEDGMENTS

The Indonesian Education Scholarship (BPI), Centre for Higher Education Funding and Assessment (PPAPT), and Indonesian Endowment Fund for Education (LPDP) the Ministry of Higher Education, Science, and Technology of the Republic of Indonesia. Grant number: 00206/BPPT/BPI.06/9/2023.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

REFERENCES

- Ajmone-Marsan, P. et al., 2023. *Genomic characterization of animal genetic resources – Practical guide*. FAO Animal Production and Health Guidelines No. 32, Rome. doi: 10.4060/cc3079en.
- Arnold, W., 2020. Review: Seasonal differences in the physiology of wild northern ruminants. *Animal*, 14 (Supplement 1), pp.s124-s132. doi: 10.1017/S1751731119003240.

- Aspinall, V. & Cappello, M., 2015. *Introduction to Veterinary Anatomy and Physiology Textbook, 3rd ed*, London: Elsevier.
- Barinberg, D. et al., 2025. The metabolic program of inflammatory eosinophils accounts for chronic parasite induced skin disease. *bioRxiv* [Preprint], 2025.02.28.640104. doi: 10.1101/2025.02.28.640104.
- Becker, D.J. et al., 2019. Leukocyte Profiles Reflect Geographic Range Limits in a Widespread Neotropical Bat. *Integrative and Comparative Biology*, 59 (5), pp.1176-1189. doi: 10.1093/icb/icz007.
- Bovo, S. et al., 2019. Genome-wide association studies for 30 haematological and blood clinical-biochemical traits in Large White pigs reveal genomic regions affecting intermediate phenotypes. *Scientific Reports*, 9, 7003. doi: 10.1038/s41598-019-43297-1.
- BPS NTT., 2023. *Provinsi Nusa Tenggara Timur Dalam Angka 2023*. BPS Provinsi Nusa Tenggara Timur, Jakarta.
- Carrasco-Garcia A.A. et al., 2020. Effect of stress during slaughter on carcass characteristics and meat quality in tropical beef cattle. *Asian-Australasian Journal of Animal Science*, 33(10), pp.1656-665. doi: 10.5713/ajas.19.0804.
- Carter, C.M., 2018. Alterations in Blood Components. *Comprehensive Toxicology*, 2018, pp.249-93. doi: 10.1016/B978-0-12-801238-3.64251-4.
- Carvalho, D.F. et al., 2020. Hematological changes induced by handling stress in pigs and implications for animal welfare. *Livestock Science*, 239, 104096. doi: 10.1016/j.livsci.2020.104096.
- Casas-Diaz, E. et al., 2015. Hematologic and biochemical reference intervals for Wild Boar (*Sus scrofa*) captured by cage trap. *Veterinary Clinical Pathology*, 44(2), pp.215-222. doi: 10.1111/vcp.12250.
- De, A.K. et al., 2013. Comparative study on haematological traits of endangered Andaman wild pig and other indigenous pig breeds available at Andaman and Nicobar Islands, India. *Veterinary World*, 6(10), pp.794-798. doi: 10.14202/vetworld.2013.794-798.
- Eljarah, A. & Ismail, Z.B., 2023. Hematology and serum biochemistry variables in apparently normal Arabian Oryx (*Oryx leucoryx*). *Veterinary World*, 16(6), pp.1369-1372. doi: 10.14202/vetworld.2023.1369-1372.
- Esposito, L. et al., 2020. Assessment of living conditions in wild boars by analysis of oxidative stress markers. *Journal of Applied Animal Welfare Science*, 24(1), pp.64-71. doi: 10.1080/10888705.2020.1790365.
- Grimes, C.N. & Fry, M.M., 2015. Nonregenerative anemia: mechanisms of decreased or ineffective erythropoiesis. *Veterinary Pathology*, 52(2), pp.298-311. doi: 10.1177/0300985814529315.
- Güldenpfennig, J. et al., 2021. An approach to assess stress in response to drive hunts using cortisol levels of wild boar (*Sus scrofa*). *Scientific Reports*, 11, 16381. doi: 10.1038/s41598-021-95927-2.
- Harapin, I. et al., 2003. Haematological and biochemical values in blood of wild boar (*Sus scrofa ferut*). *Veterinarni Medicina*, 73(6), pp.333-343.
- Huang, L. & Appleton, J.A., 2016. Eosinophils in Helminth Infection: Defenders and Dupes. *Trends Parasitology*, 32(10), pp.798-807. doi: 10.1016/j.pt.2016.05.004.
- Ježek, J. et al., 2018. The influence of age, farm, and physiological status on pig hematologic profiles. *Journal of Swine Health and Production*, 26(2), pp.72-78. doi: 10.54846/jshap/1049.
- Kannan, G. et al., 2000. Transportation of goats: effects on physiological stress responses and live weight loss. *Journal of Animal Science*, 78, pp.1450-1457. doi: 10.2527/2000.7861450x.
- Karaşahin, T. et al., 2022. Effects of age and sex on some hematological and biochemical parameters in Hair goats. *Veterinary Research Forum*, 13(1), pp.15-19. doi: 10.30466/vrf.2020.120090.2841.

- Kobeza, P., 2014. Blood parameters of wild boar (*Sus scrofa*) on the territory of the Steppe Zone of Ukraine. *Natural Sciences*, 1, pp.45-53.
- Kophamel, S. et al., 2022. Importance of health assessments for conservation in noncaptive wildlife. *Conservation Biology*, 36, e13724. doi: 10.1111/cobi.13724.
- Lazăr, R. et al., 2025. Hematological and Biochemical Profiles of Nutria (*Myocastor coypus*): Implications for Biodiversity Management and Household Rearing Practices. *Journal of Zoological and Botanical Gardens*, 6(1), 3. doi: 10.3390/jzbg6010003.
- Mayer, J.J., 2002. *A simple field technique for age determination of adult wild pigs: Environmental information document*. WSRC-RP-2002-00635. Westinghouse Savannah River Company, Aiken, South Carolina.
- Otani, H. et al., 2022. Effects of glucocorticoids on lymphocyte migration and apoptosis in stressed animals. *Animals*, 12(3), 326. doi: 10.3390/ani12030326.
- Pascutti, M.F. et al., 2016. Impact of Viral Infections on Hematopoiesis: From Beneficial to Detrimental Effects on Bone Marrow Output. *Frontiers in Immunology*, 7, 364. doi: 10.3389/fimmu.2016.00364.
- Randolph, J.F. et al., 2022. Erythrocytosis. In *Schalm's Veterinary Hematology, 7th ed.* Wiley, pp.209-214. doi: 10.1002/9781119500537.
- Rekiel, A. et al., 2024. Wild boar (*Sus scrofa* L. 1758), a problematic but also a useful species—review. *Journal of Elementology*, 29(3), pp.575-590. doi: 10.5601/jelem.2023.28.4.3248.
- Roland, L. et al., 2014. Hematology as a diagnostic tool in bovine medicine. *Journal of Veterinary Diagnostic Investigation*, 26(5), pp.592-598. doi: 10.1177/1040638714546490.
- Rudolph, T.E. et al., 2024. Heat stress alters hematological parameters in barrows and gilts. *Journal of Animal Science*, 102, skae123. doi: 10.1093/jas/skae123.
- Santos, S.A. et al., 2025. Eosinophils: old cells, new directions. *Frontiers in Medicine*, 16(11), 1470381. doi: 10.3389/fmed.2024.1470381.
- Siegel, A.M. & Walton, R., 2020. *Hematology and Biochemistry of Small Mammals: Ferrets, Rabbits, and Rodents, 4th ed.* Philadelphia: Saunders Elsevier.
- Sumarto, S. et al., 2016. *Ekologi hewan*. Bandung: Patra Media Grafindo.
- Sun, H. et al., 2021. Editorial: Imaging and Mechanism of Leukocyte Recruitment and Function in Inflammation and Infections. *Frontiers in Cell and Developmental Biology*, 9, 690003. doi: 10.3389/fcell.2021.690003.
- Sutherland, M.A. et al., 2016. Impacts of chronic stress and social status on various physiological and performance measures in pigs. *Journal of Animal Science*, 94(4), pp.1561-1572. doi: 10.2527/jas.2015-9661.
- Thorn, C.E. et al., 2022. *Hematology of pigs*, Hoboken, NJ: John Wiley & Sons.
- Thrall, M.A. et al., 2022. *Veterinary Hematology, Clinical Chemistry, and Cytology, 3rd ed.* Hoboken, NJ: John Wiley & Sons, Inc.
- Vilela, S. et al., 2020. Physiological Stress Reactions in Red Deer Induced by Hunting Activities. *Animals*, 10(6), 1003. doi: 10.3390/ani10061003.
- Wessely-Szponder, J. et al., 2018. Neutrophils lifespan and death in animals: current knowledge and future perspectives. *Veterinary Research Communications*, 42(4), pp.255-265. doi: 10.1007/s11259-018-9731-4.