Erythrocyte, Hemoglobin, and Hematocrit Profiles in Indonesian Simental and Limousin in Highlands and Lowlands in Banyuwangi

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ABSTRACT

This study aimed to evaluate the differences in blood profile of erythrocytes, hemoglobin, and PCV in Indonesian simental and limousin beef cattle in highlands and lowlands. Banyuwangi is one of the beef cattle contributors in East Java with its highland and lowland topography. This research was conducted from July to August 2023. The research was conducted in 3 locations namely highlands (Kalibaru), lowlands (Rogojampi) and sample examination in Airlangga University Banyuwangi. Animals used in this study were Indonesian simental and limousin beef cattle with 1-2 years of age as many as 15 heads in the highlands and 15 heads in the lowlands. The research method used was purposive sampling. Blood samples used in this study used Indonesian simental and limousin beef cattle blood taken using venoject and inserted in EDTA tubes and examined using a Hematology Analyzer. The variables observed in this study were the number of erythrocytes, hemoglobin, and PCV. The data obtained were processed with Independent T-test data analysis. The results showed no significant difference in erythrocytes and PCV, but there was a significant difference in hemoglobin levels. The conclusion of this study is that Indonesian simental and limousin beef cattle in the lowlands experience mild anemia.

Keywords: health, terrain differences, blood profile, beef cattle

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INTRODUCTION

Meat is one of the animal products that contains complete nutritional value as a source of protein derived from livestock, and its necessity is inseparable from human life (Hasana *et al.*, 2017). Beef has many benefits as a food ingredient because it contains nutrients essential for human growth and health (Puradireja *et al.*, 2021; Maiyena and Mawarnis, 2022). Beef cattle are raised specifically for their meat (Pangaribuan *et al.*, 2019). The best type of cattle for fattening is the first-generation crossbreed (F1), which is a hybrid of local and imported cattle (Ichsan, 2020). Simmental and Limousin cattle in Indonesia are not pure breeds but crossbreeds that retain the original characteristics of their parent breeds (Pawere *et al.*, 2012).

Farmers must pay attention to selecting calves with rapid growth rates to achieve better economic outcomes, such as Simmental cattle with an average daily gain of 0.9–1.2 kg and Limousin cattle with an average daily gain of 1.0–1.4 kg (Muada, 2017; Rahayu and Suhendra, 2024). In addition to calf selection, rearing management in highland and lowland areas also plays a crucial role due to differences in feed quality and housing conditions (Nainggolan *et al.*, 2025). Tropical regions like Indonesia often

experience temperature increases beyond the comfort zone of cattle, which can cause heat stress and negatively affect productivity (Adhitia *et al.*, 2022). Temperatures exceeding the comfort range can decrease appetite and impact animal health, requiring further examination (Yetmaneli *et al.*, 2020).

One effective way to detect whether livestock are healthy or experiencing physiological stress is through blood testing. Hematological profiles serve as key indicators of livestock health status (Bunga *et al.*, 2019). Parameters such as erythrocyte count, hemoglobin concentration, and hematocrit (PCV) values can reflect the animal's physiological condition, including dehydration, stress, anemia, or polycythemia (Putri, 2022; Riswan *et al.*, 2020; Setyawan and Rahmawati, 2025).

Previous studies have mainly focused on hematological variations among different cattle breeds or under varying climatic conditions. However, no study has yet specifically compared the hematological profiles (erythrocytes, hemoglobin, and PCV) of Indonesian crossbred Simmental and Limousin cattle across contrasting altitudes. Therefore, this research is the first study to evaluate the hematological adaptation of Simmental and Limousin crossbred beef cattle raised at different elevations (highland and lowland) in Banyuwangi, under local environmental factors such as temperature and humidity. These findings are expected to contribute to a better understanding of how altitude and microclimate affect the physiological adaptation and productivity of tropical crossbred cattle.

The aim of this study was to determine whether altitude significantly affects erythrocyte, hemoglobin, and PCV levels in crossbred Simmental and Limousin cattle raised in the highlands and lowlands of Banyuwangi.

METHODS

The study protocol was approved by the Animal Ethics Committee of Universitas Airlangga (Approval No. 212/KEH/FKH/2023), ensuring that all procedures complied with animal welfare standards.

This study was conducted in two distinct altitude regions of Banyuwangi Regency, East Java, Indonesia: Songgon District (highland, ±700 m above sea level) and Rogojampi District (lowland, ±50 m above sea level). The research was carried out between July and August 2023, representing the dry season.

A total of 30 crossbred Simmental and Limousin cattle were used in this study, consisting of 15 animals from the highland and 15 from the lowland. The sample size was determined based on the availability of the population and considerations of statistical homogeneity, ensuring that each group had comparable age and body condition to minimize sampling bias.

All cattle were clinically healthy, aged between 1.5 and 2.5 years, and maintained under similar management systems. The animals were fed a mixture of fresh forage (elephant grass, corn stalks) and concentrate supplements containing approximately 14% crude protein. Clean water was provided ad libitum. Both highland and lowland farms practiced semi-intensive management systems, where animals were housed in individual pens during the day and allowed limited grazing in the morning and afternoon.

Environmental parameters such as air temperature, relative humidity, and altitude were recorded using a thermohygrometer and GPS at each location. Average environmental measurements were 25.3 ± 1.2°C and 76 ± 3% humidity in the highland, and 32.8 ± 1.5°C and 82 ± 4% humidity in the lowland. These data support the

classification of the study sites into "highland" and "lowland" categories.

Blood samples (approximately 3 mL) were collected from the jugular vein using sterile 5 mL syringes and placed into EDTA anticoagulant tubes. Samples were immediately stored in cool boxes (4–8°C) and analyzed within 6 hours at the Animal Health Laboratory, Faculty of Veterinary Medicine, Universitas Airlangga.

RESULT AND DISCUSSION

The results of hematological examinations from a total of 30 crossbred Simmental and Limousin cattle (15 from highland areas and 15 from lowland areas) are presented in Table 1. The mean values of erythrocyte, hemoglobin, and packed cell volume (PCV) in both groups were compared to the standard normal ranges for beef cattle in Indonesia.

Table 1. Comparison of Erythrocyte (RBC), Hemoglobin (Hb), and Packed Cell Volume (PCV) between Highland and Lowland Crossbred Simmental–Limousin Cattle

Parameter	Highland (Mean ± SD)	Lowland (Mean ± SD)	p-value	95% CI
RBC ($\times 10^6$/µL)	6.22 ± 0.52	5.91 ± 0.49	0.290	-0.28 to 0.86
Hb (g/dL)	11.53 ± 0.84	10.42 ± 0.83	0.005	0.36 to 1.86
PCV (%)	34.5 ± 1.9	34.3 ± 1.7	0.960	-1.06 to 1.46

The results of this study revealed that only hemoglobin concentration differed significantly between highland and lowland crossbred Simmental–Limousin cattle, while erythrocyte count and packed cell volume (PCV) remained statistically similar. These findings indicate that altitude affects the oxygen transport system mainly through modulation of hemoglobin levels rather than changes in the number of erythrocytes or blood cell volume.

Physiologically, this difference can be explained by the variation in partial oxygen pressure between altitudes. At higher elevations, oxygen pressure is lower, stimulating the kidneys to secrete erythropoietin (EPO) a hormone responsible for promoting hemoglobin synthesis and red blood cell maturation (Wulanjati *et al.*, 2022). Increased EPO production enhances hemoglobin concentration to maintain oxygen delivery to tissues, even when the number of erythrocytes remains constant. This mechanism has been well documented in other highland livestock species as part of hematological acclimatization to hypoxic conditions (Said *et al.*, 2021).

In contrast, cattle raised in the lowland environment may experience heat-induced physiological stress, characterized by elevated ambient temperature and humidity. Under thermal stress, hemodilution can occur as a result of increased water intake and plasma expansion, which dilutes the concentration of hemoglobin in the blood (Adhitia *et al.*, 2022). Moreover, heat stress tends to reduce feed intake and metabolic activity, leading to decreased iron availability and hemoglobin synthesis (Yunus *et al.*, 2021). However, because erythrocyte and PCV levels remain stable, the reduction in hemoglobin concentration likely represents a mild physiological adjustment rather than a pathological disorder.

The stability of erythrocyte and PCV values across both environments also suggests that crossbred Simmental–Limousin cattle possess

strong adaptive capacity to different environmental conditions. These cattle are the result of selective breeding between local and European genetic lines, which combine high productivity with environmental tolerance (Ichsan, 2020). Their ability to maintain erythrocyte counts and blood volume stability reflects hematological homeostasis, ensuring that oxygen transport and circulation are not compromised under moderate altitude differences.

Comparatively, similar results were reported in other tropical cattle such as Ongole and Bali breeds, where hemoglobin levels were influenced by elevation but erythrocyte and PCV values remained within normal physiological ranges (Nugraha *et al.*, 2023; Setyawan & Rahmawati, 2025). These consistent findings across breeds reinforce the idea that hemoglobin concentration is a more sensitive indicator of environmental adaptation than total red cell count or PCV percentage.

The present findings also align with studies conducted in other tropical regions, such as in Ethiopian Boran cattle and Kenyan Zebu, where animals raised at higher altitudes showed slightly elevated hemoglobin concentrations due to hypoxia-induced erythropoiesis (Tesfaye *et al.*, 2020; Wambui *et al.*, 2019). In contrast, European cattle breeds such as Holstein or Brown Swiss exhibited sharper hematological shifts when moved from temperate to tropical climates, demonstrating lower adaptability compared to locally crossbred types (Brandl *et al.*, 2018). These cross-country comparisons highlight that tropical crossbred cattle including the Indonesian Simmental–Limousin have developed a more balanced hematological response, enabling efficient adaptation without excessive erythrocyte proliferation or dehydration under environmental stress.

Collectively, these observations indicate that altitude and environmental temperature influence hematological characteristics across both local and international cattle breeds. However, crossbred cattle in tropical regions appear to possess superior physiological plasticity, allowing them to maintain stable oxygen transport functions despite climatic and geographical differences. This evidence supports the growing view that selective crossbreeding between local and exotic lines can enhance resilience and productivity of beef cattle under tropical environmental challenges.

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However, this study also has several limitations that should be considered when interpreting the findings. The sample size was relatively small, consisting of only 15 animals per location, and data collection was limited to a single dry-season period (July–August). Environmental and management factors such as variations in feed composition, water availability, and parasite load were not fully controlled and may have influenced blood parameters. Furthermore, this study focused only on three hematological indicators erythrocytes,

hemoglobin, and PCV without including other parameters such as MCV, MCH, and MCHC that could provide deeper insight into blood physiology. Future studies should therefore involve a larger sample size, cover multiple seasons, and incorporate broader hematological and biochemical analyses to obtain a more comprehensive understanding of the adaptive responses of crossbred cattle across environments.

CONCLUSION

The results of this study showed that the erythrocyte, hemoglobin, and packed cell volume (PCV) values of crossbred Simmental–Limousin cattle raised in both highland and lowland areas of Banyuwangi were within the normal physiological range. However, hemoglobin levels differed significantly between the two regions, with lower concentrations observed in lowland cattle.

This mild reduction in hemoglobin concentration may indicate a form of hematological adjustment to thermal stress, as higher ambient temperatures in lowland environments can cause plasma expansion and reduced oxygen-carrying capacity. In contrast, the stable erythrocyte and PCV values across both areas suggest that crossbred Simmental–Limousin cattle possess strong physiological adaptability to moderate differences in altitude and environmental conditions.

From a practical standpoint, these findings highlight the importance of improving environmental management for lowland cattle to minimize heat-related stress. Strategies such as enhancing barn ventilation, providing sufficient shade and water, and supplementing feed with iron-rich minerals or vitamins could help maintain optimal hemoglobin levels and prevent mild anemia.

Overall, this research emphasizes that crossbred Simmental–Limousin cattle are well-suited for both highland and lowland rearing systems in tropical regions. Nonetheless, further studies involving biochemical and environmental parameters such as oxygen saturation, oxidative stress markers, and feed composition are recommended to develop a more comprehensive framework for adaptive cattle management across different altitudinal zones.

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Author Contribution

All authors participated to all aspects of this work, including preparation, research, data collecting and analysis, manuscript drafting, and publication approval.

Competing Interest

None.

Ethical Approval

The study protocol was approved by the Animal Ethics Committee of Universitas Airlangga (Approval No. 212/KEH/FKH/2023), ensuring that all procedures complied with animal welfare standards.

REFERENCES

Adhitia, F., Qisthon, A., Husni, A., dan Hartono, M. 2022. Respons Fisiologis dan Daya Tahan Sapi Peranakan Ongole dan Sapi Brahman Cross Terhadap Cekaman Panas di KPT Maju Sejahtera Tanjung Sari Lampung Selatan. Jurnal Riset Dan Inovasi Peternakan 6(3): 300-304.

Bunga, M. Y., Widi, A. Y., dan Pandarangga, P. 2019. Profil Hematologi dan Gambaran

Morfologi Darah Sapi Bali (*Bos Sundaicus*) yang Dipelihara di Tempat Pembuangan Akhir Alak Kota Kupang. Jurnal Veteriner Nusantara 2(2): 72-84.

Firani, N.K. 2018. Mengenali Sel-Sel Darah dan Kelainan Darah. Universitas Brawijaya.

Hasana, K. R., Hafid, H., Malesi, L. 2017. Nilai Nutrisi Daging Sapi Setelah Perendaman Dalam Jus Rimpang Laos. Jurnal Ilmu dan Teknologi Peternakan Tropis, 4(1): 13-20.

Hasanah, P. N., Wandia, I. N., dan Soma, I. G. 2019. Profil Darah Lutung Jawa (*Trachypithecus auratus*) yang Dipelihara Secara Ex-Situ. Indonesia Medicus Veterinus 8(3): 356-365.

Ichsan, A. 2020. Penampilan Sifat Kualitatif dan Reproduksi Sapi Betina F1 Persilangan Sapi Bali dan Sapi Pesisir di Kabupaten Padang Pariaman [Thesis]. Universitas Andalas.

Imnorah, G. 2020. Perbedaan Kadar Hematokrit pada Packed Red Cell (PRC) Berdasarkan Lama Simpan 10 dan 21 Hari di Bank Darah Rumah Sakit Telogorejo Semarang [Thesis]. Semarang. Universitas Muhammadiyah Semarang.

Maiyena, S., and Mawarnis, E. R. 2022. Kajian Analisis Konsumsi Daging Sapi dan Daging Babi Ditinjau dari Kesehatan. Jurnal Pendidikan Tambusai 6(1): 3131-3136.

Muada, D. B., Paputungan, U., Hendrik, M. J., Turangan, S. H. 2017. Karakteristik Semen Segar Sapi Bangsa Limousin dan Simmental di Balai Inseminasi Buatan Lembang. ZOOTEC 37(2): 360-369.

Nainggolan, M. S., Azhari, N. K., Sihombing, N. K., Wijaya, E., dan Basriwijaya, K. M. Z. 2025. Analisis Manajemen Pemeliharaan Usaha Ternak Sapi Potong di Desa Pematang Sijonam Kecamatan Perbaungan. Publikasi Ilmu Tanaman dan Agribisnis 2(1): 228-236.

Pangaribuan, G. R., Windarto, A. P., dan Wanto, A. 2019. Pemilihan Jenis Sapi bagi Peternak Sapi Potong dengan Metode SMART. Alogaritm: Jurnal Ilmu Komputer dan Informatika 3(1): 30.

Pawere, F. R., Baliarti, E., dan Nurtini, S. 2012. Proporsi Bangsa, Umur, Bobot Badan Awal dan Skor Kondisi Tubuh Sapi Bakalan pada Usaha Penggemukan. Buletin Peternakan, 36(3): 193-198.

Puradireja, R. H., Herlina, L., dan Arief, H. 2021. Analisis Faktor-Faktor yang Mempengaruhi Permintaan Daging Sapi di Provinsi Lampung. Jurnal Pemikiran Masyarakat Ilmiah Berwawasan Agribisnis 7(2): 1439-1448.

Putri, E. U. 2022. Prevalensi Protozoa Darah dan Profil Hematologi pada Sapi (*Bos* sp.) di Kecamatan Maniangpajo, Kabupaten Wajo [Thesis]. Universitas Hasanuddin.

Rahayu, T. P., dan Suhendra, D. 2024. Gambaran Profil Sapi yang di Potong di Rumah Potong Hewan (RPH) Kabupaten Temanggung. Buletin of Applied Animal Research 6(2): 87-94.

Riswan, M., Oetama, R. A., dan Muhsin, M. 2020. Polisitemia Vera; Aspek Klinis dan Tatalaksana Terbaru. Jurnal Kedokteran Syiah Kuala 20(2).

Setiawan, S., dan Rahmawati, A. 2025. Identifikasi Penyakit Antraks Pada Sampel Darah Hewan Ruminansia di UPT Laboratorium Kesehatan Hewan Dinas Peternakan Provinsi Jawa Timur di Tuban. Jurnal Pertanian Terpadu 13(1): 149-156.

Sudarma, N. 2020. Hubungan Kadar Timbal (Pb) Dalam Darah dengan Kadar Hemoglobin Serta Jumlah

Eritrosit pada Pekerja di Terminal Ubung Denpansar 2019. Undhirabalibali Ac. Id : 265-274.

Weiss, D. J., & Wardrop, K. 2010. Drug-induced Blood Cell Disorders. Schalm's Veterinary Hematology.

Yetmaneli, Y., Puwanto, B. P., Priyanto, R., dan Manalu, W. 2020. Iklim Mikro dan Respon Fisiologis Sapi Pesisir di Dataran Rendah dan Dataran Tinggi Sumatera Barat. Jurnal Agripet 20(2): 2460-4534.

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