BULETIN VETERINER UDAYANA

pISSN 2085-2495
eISSN 2477-2712

Received: 18 July 2026; Accepted: 28 August 2026; Published: 31 August 2026

HISTOMORPHOMETRY OF ERYTHROCYTES AND LEUKOCYTES ALSO DIFFERENTIAL LEUKOCYTE COUNT IN BROWN HAWK OWL (*NINOX SCUTULATA*)

Histomorfometri Eritrosit dan Leukosit serta Peritungan Diferensial Leukosit pada Burung Punggok Cokelat (*Ninox scutulata*)

Kadek Ferdy Agastia Dwi Pratama

Owl Tower Bali, Pengosekan Street, Ubud, Gianyar Regency, Bali, 80571, Indonesia

Corresponding author email: fagastia@gmail.com

How to cite: Pratama KFAD. 2026. Histomorphometry of erythrocytes and leukocytes also differential leukocyte count in brown hawk owl (*Ninox scutulata*). *Bul. Vet. Udayana.* 18(4): 967-977. DOI: https://doi.org/10.24843/bulvet.2026.v18.i04.p21

Abstract

*Ninox scutulata*or Brown Hawk Owl is one of the owl species spread across Indonesia and plays a role as a predator of rodents in agricultural areas. Until now, information regarding blood cell histomorphometry and differential leukocyte count of *Ninox scutulata*is still very limited. This study aims to describe the morphology, histomorphometry of blood cells, and differential leukocyte count as basic hematological data of Ninox scutulata. The study used 10 *Ninox scutulata* kept at the Owl Tower Bali conservation center. Blood smear preparations stained with the Romanowsky method were observed microscopically for histomorphometric measurements of erythrocytes, lymphocytes, monocytes, heterophils, basophils, and eosinophils. Histomorphometry includes parameters of area, perimeter, and diameter. Data were analyzed descriptively using the mean, standard deviation, median, minimum value, and maximum value. The results of the study showed that erythrocytes were oval with a central nucleus, lymphocytes were round with a large nucleus, monocytes had a reniform nucleus, heterophils had a bilobed nucleus with rod-shaped to oval granules, basophils had dense dark blue to dark purple granules, while eosinophils had a bilobed nucleus with round, bright red granules. Histomorphometry showed that erythrocytes had the largest size, followed by heterophils, eosinophils, basophils, monocytes, and lymphocytes. Differential leukocyte count examination showed that heterophils were the leukocytes with the highest percentage, followed by lymphocytes, monocytes, basophils, and eosinophils. This study provides a basic data overview of morphology, histomorphometry, and differential leukocyte count in *Ninox scutulata*which can be used as a reference in evaluating the health of the *Ninox scutulata*species of owl.

Keywords: Differential leukocyte count, erythrocytes, histomorphometry, leukocytes, Ninox scutulata.

Terakreditasi Nasional Sinta 4, berdasarkan Keputusan Direktur Jenderal Pendidikan Tinggi, Riset, dan Teknologi No. 158/E/KPT/2021

Volume 18 No. 4: 967-977
August 2026
https://doi.org/10.24843/bulvet.2026.v18.i04.p21

Abstrak

*Ninox scutulata*atau *Brown Hawk Owl* merupakan salah satu spesies burung hantu yang tersebar di Indonesia dan berperan sebagai predator hewan pengerat di kawasan pertanian. Hingga saat ini informasi mengenai histomorfometri sel darah dan *differential leukocyte count Ninox scutulata*masih sangat terbatas. Penelitian ini bertujuan untuk mendeskripsikan morfologi, histomorfometri sel darah, dan *differential leukocyte count* sebagai data dasar hematologi *Ninox scutulata*. Penelitian menggunakan 10 ekor *Ninox scutulata*yang dipelihara di pusat konservasi Owl Tower Bali. Preparat apus darah yang diwarnai dengan metode Romanowsky diamati secara mikroskopis untuk pengukuran histomorfometri eritrosit, limfosit, monosit, heterofil, basofil, dan eosinofil. Histomorfometri yang meliputi parameter luas area, perimeter, dan diameter. Data dianalisis secara deskriptif menggunakan nilai rerata, standar deviasi, median, nilai minimum, dan nilai maksimum. Hasil penelitian menunjukkan bahwa eritrosit berbentuk oval dengan satu nukleus sentral, limfosit berbentuk bulat dengan nukleus besar, monosit memiliki nukleus *reniform*, heterofil memiliki nukleus berlobus dua dengan granula berbentuk batang hingga lonjong, basofil memiliki granula padat berwarna biru tua hingga ungu tua, sedangkan eosinofil memiliki nukleus berlobus dua dengan granula bulat berwarna merah terang. Histomorfometri menunjukkan eritrosit memiliki ukuran terbesar, diikuti heterofil, eosinofil, basofil, monosit, dan limfosit. Pemeriksaan *differential leukocyte count* menunjukkan heterofil merupakan leukosit dengan persentase tertinggi, diikuti limfosit, monosit, basofil, dan eosinofil. Penelitian ini memberikan gambaran data dasar mengenai morfologi, histomorfometri, dan *differential leukocyte count* pada *Ninox scutulata*yang dapat dimanfaatkan sebagai referensi dalam evaluasi kesehatan burung hantu spesies *Ninox scutulata.*

Kata kunci: *Differential leukocyte count*, eritrosit, histomorfometri, leukosit, *Ninox scutulata*.

INTRODUCTION

Ninox scutulata, commonly known as the Brown Hawk-Owl, is an owl species belonging to the family Strigidae, widely distributed across Asia, including Indonesia. In Indonesia, *Ninox scutulata*can be found in Sumatra, Kalimantan, Java, and Bali, as well as several regions in Nusa Tenggara. The primary habitats of *Ninox scutulata*consist of both primary and secondary forests, and they are occasionally observed in agricultural plantations retaining large trees suitable for roosting and nesting. *Ninox scutulata*is a nocturnal predator that preys upon various insects, rodents, reptiles, amphibians, and small birds. Morphologically, *Ninox scutulata*is medium-sized, featuring a rounded head devoid of ear tufts, bright yellow irises, and brown plumage with a white ventral region adorned with dark brown vertical streaks (Abhinav *et al.*, 2023). In addition to its role as a natural predator contributing to rodent population control in agricultural ecosystems, *Ninox scutulata*is also managed in conservation centers as part of species preservation efforts (Saputri *et al.*, 2022).

Hematological examination serves as a vital approach to evaluate the physiological status of wild animals. A routinely utilized hematological parameter is the differential leukocyte count, which determines the relative proportions of circulating heterophils, lymphocytes, monocytes, eosinophils, and basophils (Badaruddin *et al.*, 2022). Although the differential leukocyte count offers valuable insight into leukocyte composition, it does not provide detailed information regarding the morphological and morphometric characteristics of individual cells. Histomorphometric analysis acts as an essential complement by enabling the evaluation of cellular characteristics through precise measurements of diameter, perimeter, and surface area of blood cells (Pratama *et al.*, 2025). Alterations in leukocyte morphometric properties may reflect immune cell activation, inflammatory responses, infections, or other physiological

Volume 18 No. 4: 967-977
August 2026
https://doi.org/10.24843/bulvet.2026.v18.i04.p21

changes, thereby rendering the interpretation of hematological results more comprehensive. Information regarding the histomorphometric traits of *Ninox scutulata* blood cells remains extremely limited to date; hence, establishing baseline data is imperative to serve as a reference for health evaluations of this species (Kim *et al.*, 2025).

To address the limited availability of hematological data, this study aimed to establish baseline histomorphometric profiles of erythrocytes and leukocytes, along with the differential leukocyte counts, in Ninox scutulata. The findings of this research are expected to provide a valuable scientific reference for interpreting hematological assessments, supporting physiological health evaluations, and advancing the conservation, rehabilitation, and research of owls in Indonesia.

RESEARCH METHODS

Ethical Approval

This study was approved by the institutional animal ethics committee prior to implementation. Ethical approval was granted under certificate number B/163/UN14.2.9/PT.01.04/2026, confirming that all procedures complied with ethical standards governing the use of animals in research.

Animals and Sampling

The study utilized ten healthy *Ninox scutulata* individuals maintained at the Owl Tower Bali conservation center, Ubud, Gianyar Regency, Bali. Blood samples were collected from the cutaneous ulnar vein (*vena cutanea ulnaris*) of each bird to prepare thin blood smears. Blood collection was performed in strict accordance with animal welfare principles to minimize stress during handling.

Study Design

This study employed an observational, cross-sectional design aimed at evaluating the histomorphometric characteristics of erythrocytes and leukocytes, as well as the differential leukocyte counts, in *Ninox scutulata*. A single blood collection was conducted on ten healthy *Ninox scutulata* kept at the Owl Tower Bali conservation center. A total of ten blood smear preparations were analyzed for blood cell histomorphometry and differential leukocyte proportions.

Study Variables

The variables of this study comprised independent, dependent, and controlled variables. The independent variable was the owl species, *Ninox scutulata*. The dependent variables included erythrocyte and leukocyte histomorphometry—evaluated based on diameter, perimeter, and surface area parameters—along with differential leukocyte counts, consisting of the relative percentages of heterophils, lymphocytes, monocytes, eosinophils, and basophils. Controlled variables included animal health status, restricted to individuals meeting clinical inclusion criteria: active roosting behavior, clean cloaca, bright eyes without discharge, non-drooping wings, negative fecal parasite screening, and normal body temperature (39.5-42.0°C).

Data Collection Methods

Blood samples from healthy *Ninox scutulata* were collected from the cutaneous ulnar vein (*vena cutanea ulnaris*) following physical restraint to minimize stress, ensure the safety of both the animal and handler, and facilitate the venipuncture procedure. The bird was placed in dorsal recumbency with one wing extended, and a 0.5 mL blood sample was drawn into an EDTA

Terakreditasi Nasional Sinta 4, berdasarkan Keputusan Direktur Jenderal
Pendidikan Tinggi, Riset, dan Teknologi No. 158/E/KPT/2021

Volume 18 No. 4: 967-977
August 2026
https://doi.org/10.24843/bulvet.2026.v18.i04.p21

tube. The tube was gently inverted in an eight-figure motion 8 to 10 times to ensure proper homogenization with the anticoagulant.

Blood smears were prepared immediately by placing a drop of blood onto a clean glass slide, spreading it using a sterile spreader slide held at a 35° angle, and pushing it smoothly across the slide. Upon air-drying, the smears were stained using the modified Diff-Quik Romanowsky staining technique. The staining procedure comprised fixation in absolute methanol for 2–3 seconds, eosin staining for 20–30 seconds, and azure-methylene blue staining for 15–30 seconds, followed by rinsing under gentle running tap water and air-drying. The prepared blood smears were subsequently examined under a light microscope at $1000 \times$ magnification with oil immersion.

Microscopic Examination and Histomorphometry

The blood smear preparations of *Ninox scutulata* were examined using an Olympus CX33 microscope integrated with EPView software to measure the histomorphometric parameters of erythrocytes and leukocytes, as well as to perform the differential leukocyte count. Histomorphometric evaluations were conducted on each sample by measuring 10 cells each for erythrocytes, lymphocytes, monocytes, and heterophils, and 5 cells each for basophils and eosinophils. The observed data were analyzed descriptively by presenting the minimum, maximum, and mean values for each parameter evaluated.

Data Analysis

The histomorphometric data of erythrocytes and leukocytes, along with the differential leukocyte counts of *Ninox scutulata*, were descriptively analyzed using IBM SPSS Statistics (Version 29). Descriptive statistical analysis was performed to determine the mean, standard deviation (SD), minimum, and maximum values for each observed parameter. The results were presented in tables accompanied by blood smear photomicrographs to illustrate the morphological characteristics of each blood cell type.

RESULTS AND DISCUSSION

Results

Erythrocytes of *Ninox scutulata* were identified across all samples as oval-shaped cells containing a single, centrally located oval or occasionally irregular nucleus. The nucleus exhibited a dark purple to bluish coloration with dense, distinct chromatin. The cytoplasm was smooth, pinkish, and possessed well-defined borders without granules. Morphometrically, erythrocytes had a mean surface area of $33.84 \pm 6.23\ \mu m^2$, a perimeter of $20.53 \pm 1.92\ \mu m$, and a diameter of $6.55 \pm 0.66\ \mu m$.

Lymphocytes displayed a uniform morphology across all samples. These cells were perfectly spherical with a large nucleus occupying most of the cellular volume, leaving a very thin rim of cytoplasm. The lymphocyte nucleus was deep purple with dense, coarse chromatin. The agranular cytoplasm is stained light blue, appearing as a narrow halo around the nucleus. Morphometric evaluation revealed that lymphocytes had a mean surface area of $8.78 \pm 1.56\ \mu m^2$, a perimeter of $10.46 \pm 0.94\ \mu m$, and a diameter of $3.33 \pm 0.30\ \mu m$.

Monocytes showed consistent morphological features in all samples. Monocytes were round to irregular in shape with clear cell boundaries. Each cell possessed a single, kidney-shaped (reniform) nucleus with a bluish-purple hue and loosely arranged chromatin. The pale blue cytoplasm was moderately abundant. Morphometrically, monocytes demonstrated a mean

Terakreditasi Nasional Sinta 4, berdasarkan Keputusan Direktur Jenderal
Pendidikan Tinggi, Riset, dan Teknologi No. 158/E/KPT/2021

Volume 18 No. 4: 967-977
August 2026
https://doi.org/10.24843/bulvet.2026.v18.i04.p21

surface area of 9.04 ± 2.39 μm^2, a perimeter of 10.56 ± 1.43 μm, and a diameter of 3.36 ± 0.46 μm.

Heterophils were bilobed, with nuclear lobes connected by thin chromatin strands. The lobes stained purple to blue, and the cytoplasm contained pink granules ranging in shape from fine sand-like particles to short rod-like or needle-like structures. These cytoplasmic granules were coarse, relatively large, and densely packed. Morphometric analysis showed that heterophils had a mean surface area of 25.54 ± 2.93 μm^2, a perimeter of 17.89 ± 1.04 μm, and a diameter of 5.69 ± 0.33 μm.

Basophils were small and spherical with a single, centrally located nucleus. A key diagnostic feature was the presence of dense, coarse granules staining deep blue to dark purple within the cytoplasm. Morphometrically, basophils possessed a mean surface area of 17.18 ± 4.53 μm^2, a perimeter of 14.56 ± 1.96 μm, and a diameter of 4.64 ± 0.62 μm.

Eosinophils were relatively large cells containing a bilobed nucleus. The nucleus is stained dark purple to blue, accompanied by bright red, spherical cytoplasmic granules. Unlike heterophils, which possess rod-shaped or elongated granules, the granules of eosinophils tend to be spherical, imparting a more uniform and homogeneous appearance to the cytoplasm. Eosinophil granules are also generally rounder and more uniform than those of heterophils. Morphometrically, eosinophils exhibited a mean surface area of 21.77 ± 0.82 μm^2, a perimeter of 16.54 ± 0.31 μm, and a diameter of 5.26 ± 0.10 μm.

The results of the differential leukocyte count in *Ninox scutulata* revealed that lymphocytes had a maximum value of 35%, a minimum value of 29%, a median of 32%, a mean of 31.7%, and a standard deviation of 2.00. Monocytes displayed a maximum value of 25%, a minimum value of 14%, a median of 23%, a mean of 21.4%, and a standard deviation of 3.66. Heterophils recorded a maximum value of 44%, a minimum value of 35%, a median of 38%, a mean of 38.5%, and a standard deviation of 2.46. Basophils showed a maximum value of 7%, a minimum value of 2%, a median of 5%, a mean of 4.91%, and a standard deviation of 1.66. Meanwhile, eosinophils had a maximum value of 5%, a minimum value of 2%, a median of 3.5%, a mean of 3.5%, and a standard deviation of 1.08.

Discussion

Similar to the majority of avian erythrocytes, those of *Ninox scutulata* exhibited typical morphological characteristics. The erythrocytes were oval-shaped, containing a single centrally positioned nucleus. The nucleus appeared oval to slightly irregular with dense chromatin, whereas the cytoplasm was uniformly pink and agranular (Clark *et al.*, 2009). The presence of nucleated erythrocytes is a defining feature of birds that distinguishes them from mammals. Nucleated erythrocytes in avian species result from erythropoiesis, during which the cell nucleus does not undergo enucleation and is retained throughout maturation into peripheral blood circulation. In contrast, mature mammalian erythrocytes lack a nucleus due to nuclear extrusion during the final stage of erythropoiesis. This loss of the nucleus provides additional space for hemoglobin, facilitating cellular flexibility when traversing small-caliber capillaries and indirectly enhancing the efficiency of oxygen transport to tissues (Brooks *et al.*, 2022). Histomorphometric parameters presented in Table 1 reveal size variations among erythrocytes within the same individual of *Ninox scutulata*. Such variation represents a normal physiological trait in birds, as erythrocyte size is known to vary between species and is influenced by genetic factors, age, physiological status, and individual health (Bosagna *et al.*, 2018). Differences in erythrocyte size may also be affected by developmental stages, wherein younger erythrocytes are generally slightly larger than fully mature ones (Samour, 2016).

Terakreditasi Nasional Sinta 4, berdasarkan Keputusan Direktur Jenderal
Pendidikan Tinggi, Riset, dan Teknologi No. 158/E/KPT/2021

Volume 18 No. 4: 967-977
August 2026
https://doi.org/10.24843/bulvet.2026.v18.i04.p21

Morphological similarities were also observed in lymphocytes, which closely resembled those of birds in general. Lymphocytes were spherical with a large single nucleus dominating nearly the entire cellular volume. The nucleus was deep purple with dense, coarse chromatin, while the cytoplasm appeared as a thin, ring-like basophilic halo without granules (Bråthen *et al.*, 2025). High nucleocytoplasmic ratio with a prominent nucleus and a narrow basophilic cytoplasmic rim is a hallmark characteristic of lymphocytes (Clark *et al.*, 2009). Physiological status, genetics, and age further influence lymphocyte size in *Ninox scutulata*, accounting for the observed size variations across study samples (Cheng *et al.*, 2023). Analogous to general avian hematology, the presence of both small and large lymphocytes was observed in *Ninox scutulata*, contributing to the broad range of histomorphometric values recorded (Kolesnik *et al.*, 2020).

A hallmark feature of monocytes is a kidney-shaped (reniform) nucleus staining bluish-purple with loosely arranged chromatin. Monocyte cytoplasm is expansive, light blue, and devoid of visible granules. The morphology of *Ninox scutulata* monocytes closely resembles that observed in birds in general (Salakij *et al.*, 2018). Compared to lymphocytes, histomorphometric findings presented in Table 1 demonstrate that *Ninox scutulata* monocytes are slightly larger in size. This pattern occurs because monocytes are inherently larger and tend to be more uniform in size, whereas lymphocytes display greater size variation due to the distinct presence of both small and large lymphocytes (Bhattacherjee, 2023). Healthy *Ninox scutulata* individuals maintained normal monocyte morphology, as monocyte dimensions are influenced by cellular maturation stages and physiological status in birds (Heitbrock, 2015).

Granulocytic leukocytes of the heterophil lineage in *Ninox scutulata* exhibited morphological characteristics consistent with general avian hematology (Woo *et al.*, 2026). Heterophil nuclei were bi- to tri-lobed, connected by thin chromatin strands, with the cytoplasm densely packed with eosinophilic granules ranging from short rods to oval structures that partially obscured the cytoplasm. Heterophil granules appeared pinkish, while the nuclei stained bluish-purple (Onyango *et al.*, 2025). As shown in Table 1, heterophils in *Ninox scutulata* were identified as relatively large cells compared to lymphocytes and monocytes.

The characteristic blue appearance of basophils in *Ninox scutulata* is similar to that of other avian species, presenting as spherical cells with a single, centrally located nucleus (Doley *et al.*, 2023). The cytoplasm was packed with coarse, dark blue to deep purple granules densely distributed throughout the cell, often overlaying the nucleus. Basophil granules in *Ninox scutulata* appeared denser than those of heterophils and eosinophils, thereby imparting a darker cytoplasmic background (Vaasjo *et al.*, 2026). Histomorphometric measurements in Table 1 indicate that basophil dimensions in *Ninox scutulata* remain within the standard physiological range reported for birds (Wiyabot, 2022).

Eosinophils were identified as the largest cells among all leukocyte populations, as presented in Table 1. Morphologically, *Ninox scutulata* eosinophils possessed a bilobed nucleus staining dark purple to bluish. The cytoplasm was filled with bright red, uniformly distributed spherical granules. While differentiating heterophils from eosinophils can occasionally present diagnostic challenges, granule morphology serves as a key distinguishing criterion: heterophil granules are rod-shaped or elongated, whereas eosinophil granules are characteristically spherical, conferring a more homogeneous cytoplasmic appearance (Garcia *et al.*, 2022).

The differential leukocyte count of *Ninox scutulata* shown in Table 2 demonstrated the highest relative percentage in heterophils, followed sequentially by lymphocytes, monocytes, basophils, and eosinophils. This leukocytic composition aligns with the normal hematological profile of healthy raptors and owls (Brooks *et al.*, 2022). The predominant presence of

Volume 18 No. 4: 967-977
August 2026
https://doi.org/10.24843/bulvet.2026.v18.i04.p21

heterophils in this study indicates that all evaluated individuals maintained leukocyte distributions within physiological ranges. Lymphocytes constituted the second most abundant leukocyte type. In avian medicine, shifts in lymphocyte counts serve as important indicators of physiological state and health status. Lymphopenia is commonly associated with physiological stress mediated by elevated glucocorticoid levels, whereas lymphocytosis may occur during chronic infections, immune-mediated disorders, and lymphoproliferation (Campbell & Grant, 2022). The lymphocyte proportions observed in this study reflect a relatively normal physiological condition, as monocyte levels remained lower than those of heterophils and lymphocytes. Physiologically, monocytes participate in phagocytosis, tissue debris clearance, and differentiation into tissue macrophages. Clinically, monocytosis is often linked to chronic inflammation, granulomatous diseases, or tissue healing, whereas low monocyte counts are typically considered a physiological finding in healthy birds (Samour, 2016). Basophils and eosinophils represented the two granulocyte types found in the lowest proportions. In owls, eosinophils are associated with responses to parasitic infestations and certain hypersensitivity reactions, while basophils mediate the release of inflammatory compounds, such as histamine and heparin, during inflammatory processes and allergic reactions (Clark *et al.*, 2009). The low percentages of both cell types observed in this study indicate no physiological activation of these specific immune responses in the examined *Ninox scutulata*. Overall, the differential leukocyte distribution in *Ninox scutulata* exhibits a pattern typical of healthy avian hematology, dominated by heterophils and lymphocytes, with lower proportions of monocytes, eosinophils, and basophils.

CONCLUSION AND SUGGESTIONS

Conclusion

Ninox scutulata exhibits oval-shaped erythrocytes containing a single, centrally located oval to slightly irregular nucleus. Lymphocytes are spherical with a large nucleus dominating nearly the entire cellular volume, monocytes are round to irregular with a reniform nucleus, heterophils possess a bilobed nucleus with rod- to oval-shaped granules, basophils are spherical with dense dark blue to deep purple granules, and eosinophils feature a bilobed nucleus with bright red spherical granules. The morphological characteristics of all blood cell types are consistent with general avian hematology. Histomorphometric evaluations demonstrated distinct cell sizes based on surface area, perimeter, and diameter parameters. Erythrocytes were the largest cell type, followed sequentially by heterophils, eosinophils, basophils, monocytes, and lymphocytes. The differential leukocyte count revealed that heterophils were present in the highest relative proportion, followed by lymphocytes, monocytes, basophils, and eosinophils. This distribution pattern is characteristic of normal owl hematology and can serve as valuable baseline reference data for evaluating the physiological status of *Ninox scutulata*.

Suggestions

Future studies are recommended to utilize a larger sample size incorporating age and sex variations to establish more representative hematological reference values. Subsequent research should also integrate histomorphometric analysis with complete routine hematological profiles—including total erythrocyte count, hemoglobin concentration, hematocrit, erythrocyte indices, total leukocyte count, and differential leukocyte count—to obtain a comprehensive evaluation of avian hematological health.

ACKNOWLEDGMENTS

The authors express their gratitude to Owl Tower Bali for their support during the execution of this research. Beyond its role in owl preservation, Owl Tower Bali serves as an educational and

Volume 18 No. 4: 967-977
August 2026
https://doi.org/10.24843/bulvet.2026.v18.i04.p21

scientific platform for wildlife conservation research.

REFERENCES

Abhinav, C., Guleria, V., Dogra, P., Kumar, P. (2023). The range of the Brown Hawk Owl *Ninox scutulata*in northern India—An update. *Indian Birds*, *19*(1), 13–17.

Badaruddin, R., Hafid, H., Nafiu, L. O., Syamsuddin, S., Indi, A., & Auza, F. A. (2022). Hemoglobin Level and Total Differential Blood Leucocytes of Broiler Chicken Given Different Probiotics. International Journal of Scientific Research in Science, *9*(2), 224–230. https://doi.org/10.32628/IJSRSET229230

Bhattacherjee, A. (2023). Avian Erythrocytes and Agranulocytes—A Review. *Science Reviews. Biology*, *2*(2), 21–29. https://doi.org/10.57098/SciRevs.Biology.2.2.2

Bråthen, V. S., Skomsø, D. B., & Bech, C. (2025). The Heterophil-to-Lymphocyte (H/L) Ratio Indicates Varying Physiological Characteristics in Nestlings Compared to Adults in a Long-Lived Seabird. *Birds*, *6*(1), 4. https://doi.org/10.3390/birds6010004

Brooks, M. B., Harr, K. E., Seelig, D. M., Wardrop, K. J., Weiss, D. J. (2022). Veterinary Hematology. *Wiley - Blackwell*.

Campbell, T. W., & Grant, K. R. (2022). *Exotic animal hematology and cytology*. Wiley Blackwell.

Cheng, J., Lei, H., Xie, C., Chen, J., Yi, X., Zhao, F., Yuan, Y., Chen, P., He, J., Luo, C., Shu, D., Qu, H., & Ji, J. (2023). B Lymphocyte Development in the Bursa of Fabricius of Young Broilers is Influenced by the Gut Microbiota. *Microbiology Spectrum*, *11*(2), e04799-22. https://doi.org/10.1128/spectrum.04799-22

Clark, P., Boardman, W. S. J., Raidal, S. R. (2009). *Atlas of clinical avian hematology*. Wiley-Blackwell.

Doley, P. J., Sarma, K., Kalita, P. C., Goswami, R., Kalita, A., Sarkar, R., Gollahalli Eregowda, C., Roychoudhary, P., & Choudhary, O. P. (2023). Ultrastructural characteristics of the blood cells of chickens commonly reared under backyard poultry farming in Mizoram, India. *Anatomia, Histologia, Embryologia*, *52*(2), 223–233. https://doi.org/10.1111/ahe.12874

Garcia, V. M. P., Huerta, I. A. C., Ashram, S. E., Estrada, M. A. J., Martinez, B. F., Graham, D. B., Isaias, G. T. (2022). *Histological Identification and Quantification of Eosinophils and Ascites in Leghorn Chickens Treated with High Oral Concentrations of NaCl–Pilot Study*. Toxics 10(7), 381. https://doi.org/10.3390/toxics10070381

Guerrero-Bosagna, C., Morisson, M., Liaubet, L., Rodenburg, T. B., De Haas, E. N., Košťál, Ľ., & Pitel, F. (2018). Transgenerational epigenetic inheritance in birds. *Environmental Epigenetics*, *4*(2), 1–8. https://doi.org/10.1093/eep/dvy008

Heitbrock, L. Z. (2015). Blood monocytes and their subsets: established features and open questions. Frontiers in Immunology, *6*(423), 1–5. https://doi.org/10.3389/fimmu.2015.00423

Kim, M., Hmohn, Z. Z. W., Jang, W., Baek, G., Han, J. I. (2025). Hematologic and clinical chemistry reference intervals for six species of wild birds frequently rescued in the Republic of Korea. *Frontiers In Veterinary Science*, (January), 1–11. https://doi.org/10.3389/fvets.2024.1484082

Kolesnik, E., Derkho, M., Strizhikov, V., Strizhikova, S., Sereda, T., Gizatullina, F., Rebezov, M. (2020). Functional Morphology Of Birds' Blood Leukocytes. *Journal of Experimental*

Volume 18 No. 4: 967-977
August 2026
https://doi.org/10.24843/bulvet.2026.v18.i04.p21

Biology and Agricultural Sciences, *8*(2320), 374–380. https://doi.org/10.18006/2020.8(Spl-2-AABAS).S374.S380

Onyango, V. O., Ginko, M., Ndiritu, G. G., Cousseau, L., Heiskanen, J., Kung′u, G. N., Njoroge, P., Githiru, M., Pellikka, P., Apfelbeck, L. L. B. (2025). Heterophil-to-lymphocyte ratio varies with habitat fragmentation and canopy cover in a tropical understory insectivore. *Journal of Ornithology*, *167*(2), 501–512. https://doi.org/10.1007/s10336-025-02321-0

Pratama, K. F. A. D., Suwiti, N. K., Ardana, I. B. K., Setiasih, N. L. E., Dharmawan, N. S., Sulabda, I. N., Besung, I. N. K. (2025). Association of Sex and Age with Histomorphometric Features of Agranulocytic Leukocytes and Erythrocyte Indices in Sumbawa Horses. *World's Veterinary Journal*, *15*(4), 1007–1014. https://doi.org/10.54203/scil.2025.wvj102

Salakij, C., Pornpanom, P., Lertwatcharasarakul, P., Kasorndorkbua, C., Salakij, J. (2018). Haemoproteus in barn and collared scops owls from Thailand. *Journal of Veterinary Science*, *19*(2), 280–289. https://doi.org/10.4142/jvs.2018.19.2.280

Samour, J. (2016). *Avian Medecine* (3rd editio). Mosby.

Saputri, A. I., Iswandaru, D., Wulandari, C., Bakri, S. (2022). Studi Korelasi Keanekaragaman Burung Dan Pohon pada Lahan Agroforestri Blok Pemanfaatan KPHL Batutegi. *Jurnal Belantara*, 232–245. https://doi.org/10.1093/conphys/coag013

Vaasjo, E., Claudin, A. N., Castano, P. A., Alcivar, G. M., Fessl, B., Garcia, V. H., Apakupakul, K., Deem, S. L. (2026). Haematology and biochemistry reference intervals of Galapagos short-eared owls (Asio flammeus galapagoensis) from Floreana Island. *Conservation Physiology*, *14*, 1–9. https://doi.org/10.1093/conphys/coag013

Wiyabot, T. (2022). Complete Blood Count and Blood Chemistry of Samae Dam Chickens (*Gallus gallus*) in Small-Holder Farmers, Thailand. *OnLine Journal of Biological Sciences*, *22*(2), 223–229. https://doi.org/10.3844/ojbsci.2022.223.229

Woo, S. J., Songodan, T., Seo, M., & Han, J. Y. (2026). Chicken heterophils as evolutionary models: Insights into myeloperoxidase-independent antimicrobial strategies. *Frontiers in Immunology*, *17*, 1931366. https://doi.org/10.3389/fimmu.2026.1931366

Volume 18 No. 4: 967-977
August 2026
https://doi.org/10.24843/bulvet.2026.v18.i04.p21

Tables

Table 1. Histomorphometry eritrocyte and lymphocyte of *Ninox scutulata*

Indicator	Mean±SD	Maximum	Minimum
Erytrocyte surface area (µm²)	33.84±6.23	52.08	17.14
Erytrocyte perimeter (µm)	20.53±1.92	25.58	14.67
Erytrocyte diameter (µm)	6.55±0.66	8.94	4.67
Lymphocyte surface area (µm²)	8.78±1.56	11.38	6.04
Lymphocyte perimeter (µm)	10.46±0.94	11.96	8.71
Lymphocyte diameter (µm)	3.33±0.30	3.81	2.77
Monocyte surface area (µm²)	9.04±2.39	13.61	4.95
Monocyte perimeter (µm)	10.56±1.43	13.08	7.98
Monocyte diameter (µm)	3.36±0.46	4.16	2.51
Heterophil surface area (µm²)	25.54±2.93	33.19	16.49
Heterophil perimeter (µm)	17.89±1.04	20.42	14.39
Heterophil diameter (µm)	5.69±0.33	6.5	4.58
Basophil surface area (µm²)	17.18±4.53	25.36	9.01
Basophil perimeter (µm)	14.56±1.96	17.85	10.64
Basophil diameter (µm)	4.64±0.62	5.68	3.39
Eosinophil surface area (µm²)	21.77±0.82	23.51	20.19
Eosinophil perimeter (µm)	16.54±0.31	17.19	15.93
Eosinophil diameter (µm)	5.26±0.10	5.47	5.07

Table 2. Differential leukocyte count of *Ninox scutulata*

Indicator	Mean±SD	Maximum	Minimum	Median
Lymphocyte	31.7±2.00	35	29	32
Monocyte	21.4±3.66	25	14	23
Heterophil	38.5±2.46	44	35	38
Basophil	4.9±1.66	7	2	5
Eosinophil	3.5±1.08	5	2	3,5

Terakreditasi Nasional Sinta 4, berdasarkan Keputusan Direktur Jenderal
Pendidikan Tinggi, Riset, dan Teknologi No. 158/E/KPT/2021

Volume 18 No. 4: 967-977
August 2026
https://doi.org/10.24843/bulvet.2026.v18.i04.p21

Figure 1. *Ninox scutulata*, also known as Brown Howk-Owl, a medium-sized nocturnal owl featuring a rounded, ear-tuftless head, bright yellow irises, dark brown upperparts, and dark-streaked white underparts (Source: Institutional Commercial Documentation of Owl Tower Bali)

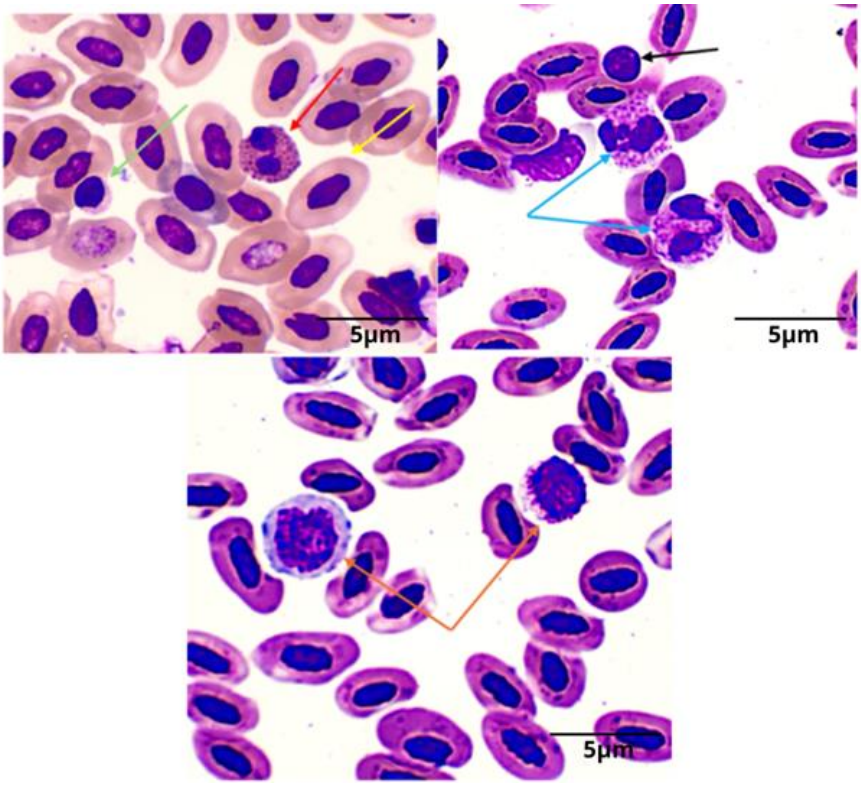

Figure 2. Micrograph of a peripheral blood smear from *Ninox scutulata* (MDT Diff-Quick, 1000× magnification). Erythrocyte (yellow arrow), monocyte (green arrow), eosinophil (red arrow), lymphocyte (black arrow), heterophil (blue arrow), and basophil (orange arrow). Note the characteristic oval, nucleated morphology of the avian erythrocytes, and the diverse granules distinguishing the granulocytic leukocytes.

Terakreditasi Nasional Sinta 4, berdasarkan Keputusan Direktur Jenderal
Pendidikan Tinggi, Riset, dan Teknologi No. 158/E/KPT/2021