

smears many reticulocytes are seen, and it is significant that in normal ostrich blood even basophil erythroblasts may constitute a fairly high percentage of the erythrocyte count.

Contrary to what would be expected, the blood of the group of unthrifty ostrich chicks, which showed marked oligocythemia as the result of severe worm-infestation, contained very few immature erythrocytes. Apparently the marrow exhausted by the long continued attempt to keep the blood up to normal eventually failed. The erythrocyte counts ~~from~~<sup>of</sup> the blood of the normal ostriches are fairly uniform. The coefficient of variability and the standard error of the mean can be regarded as low, but the range of 1,653,000 to 2,266,000 erythrocytes per c.mm. for normal birds is rather wide. Counts reported for the fowl show greater variation.

The leucocyte and the thrombocyte counts show considerable variation and the coefficient of variability of the thrombocyte counts is exceptionally high. Wide divergence is found also in the leucocyte and the thrombocyte counts, reported for the fowl; this may probably be largely attributed to differences in technique. It is difficult to compare results, as there is no uniform method of making total leucocyte counts of avian blood. A large number of average leucocyte counts reported for the fowl closely agree with the average count obtained for the ostrich, but the average thrombocyte count obtained for the ostrich is much lower than most counts reported for the fowl and other birds.

It is noteworthy that most of the erythrocyte and the leucocyte counts from the group of clinically healthy, semi-wild ostriches reared in the Bredasdorp district were appreciably lower than those from the five normal birds reared at Mariendahl, Stellenbosch district; also that the lymphocyte counts from the "Bredasdorp birds were much lower than those/....

those from the "Mariendahl" birds, and the heterophile counts from the former much higher than those from the latter. As previously stated, all the "Bredasdorp" birds were probably worm-infested, but their blood gave no indication of unusual erythropoiesis, and it therefore appears that environmental and genetic factors might also have been partly responsible for the differences.

The percentage of lymphocytes in ostrich blood is much lower than that recorded for the fowl by most investigators, but the heterophiles constitute a much higher percentage of the leucocyte count than they do in fowl blood. On the whole, the percentages recorded for the other types of leucocytes in fowl blood do not differ greatly from those obtained for the ostrich, in which the heterophile counts showed the least variation and the eosinophile counts the greatest. The basophile of the ostrich is distinct from that of the fowl and is characteristic of ostrich blood.

The inorganic phosphorus and calcium values for the group of birds grazing on natural pasture in the Bredasdorp district compare very favourably with the results from the normal birds which received a liberal supply of bones and other foodstuffs. As previously stated, the inorganic phosphorus values shown by the normal birds are suggestive of a seasonal variation.

The prolonged coagulation time of ostrich blood, which apparently cannot be associated with a low calcium content, the higher percentage volume readings obtained with old samples of ostrich blood and the marked tendency of the leucocytes to clump immediately after the blood is drawn are interesting features which offer fertile ground for further investigation.

The writer hopes that this work, which may be defined as a preliminary study into the blood of the ostrich, will provide a basis for future research.

S U M M A R Y.

1. Methods are described for collecting blood and preparing smears from the ostrich.

2. Ostrich blood usually has a very prolonged coagulation time and often it fails to coagulate if drawn directly from a blood vessel without coming in contact with the tissues. Heparin (1mgm. to 5 c.c. blood) invariably prevented coagulation and it had no deleterious effect on the blood.

3. Various methods recommended for counting leucocytes in avian blood were tried on ostrich blood. Wiseman's method was found to be the best.

4. Morphological and biochemical studies of the blood of twenty-two ostriches were made, and the following are average values obtained for the blood of normal ostriches:-

Erythrocyte count per c.mm. = 1,894,000  $\pm$  14,939.

Relative volume of corpuscles and of plasma = 48.9  $\pm$  0.34.

Minimum resistance point of red cells in sodium chloride solution = 0.47.

Maximum resistance point of red cells in sodium chloride solution = 0.27.

Sodium chloride solution which is isotonic for the erythrocytes = 0.9 per cent.

Haemoglobin content per 100 c.c. blood = 16.0 gms.

Leucocyte count per c.mm. = 21,050  $\pm$  419.

Lymphocyte count = 26.8  $\pm$  0.5 per cent.

Monocyte count = 3.0  $\pm$  0.3 per cent.

Heterophile count = 59.1  $\pm$  0.9 per cent.

Eosinophile count = 6.3  $\pm$  0.5 per cent.

Basophile count = 4.7  $\pm$  0.3 per cent.

Thrombocyte count per c.mm. = 10,521  $\pm$  427.

Viscosity: Blood = 4.5 Plasma = 1.7.

Specific gravity: Blood = 1.064 Plasma = 1.022 mgm.

Inorganic phosphorus content per 100 c.c. blood =  
 $9.1 \pm 0.3$  mgm.

Calcium content per 100 c.c. =  $10.1 \pm 0.4$  mgm.

Magnesium content per 100 c.c. =  $7.6 \pm 0.4$  mgm.

Sodium content per 100 c.c. =  $273.7 \pm 13.0$  mgm.

Potassium content per 100 c.c. =  $196.6 \pm 6.0$  mgm.

6. The total blood volume was 5466 c.c. and its weight expressed as a percentage of the body weight was 0.058.

6. Cell types corresponding to those seen in fowl blood occur in ostrich blood. These have been described.

#### A C K N O W L E D G E M E N T S.

I am greatly indebted to Dr. P.A. van der Byl, Principal, Stellenbosch-Elsenburg College of Agriculture, for the facilities granted for this work, and to Dr. P.J. du Toit, Director of Veterinary Services, for his willingness at all times to discuss various aspects of the problem and for reviewing the manuscript.

I am also grateful to Dr. C. Jackson, Onderstepoort, Dr. W.P. Mulligan, Cape Town, and Mr. W.H. Fouche, Assistant Farm Manager, Stellenbosch-Elsenburg College of Agriculture, for assistance rendered in the course of this work.

LITERATURE CITED.

- Augsburger, E. (1919) Lungendampf, Pferd. Schweiz. Arch. Tierheilk. Bd. 61, S.199 - 228.
- Bainbridge<sup>†</sup>, F.A. and J.A. Menzies (1919). Essentials of Physiology, 3rd Ed., p.187. Longman's, Green & Co. London.
- Berkson, J. T.B. Magath and M. Hurn (1935). Laboratory standard in relation to chance fluctuations of the erythrocyte count as estimated with the haemocytometer. Journal American statistical association. Vol.30, pp. 414 - 426.
- Biely, J. and E.I. Palmer (1935). Studies of total erythrocyte and leucocyte counts of fowls. III Variations in number of blood cells of normal fowl. Canadian Journal of Research, Vol. 13 Sec. D, pp. 61 - 71.
- Blain, D.A. (1928). A direct method for making total white blood counts on avian blood. Proc. Soc. Exp. Biol. and Med., Vol. 25, pp. 594 - 596.
- Blakemore, F. (1934). The leucocytes of fowl blood with special reference to fowl paralysis. Vet. Record, Vol.14, p. 418
- Bradley, O.C. (1915). The Structure of the Fowl. p.104 Balliere, Tindall and Cox, London.
- Breusch, E. (1928). Beitrage zur Blutmorphologie des Huhnes, Z. Infection's krankh. Bd.33, S.219.
- Buchbinder (1924). A new heterophile antigen common to avian erythrocytes and some varieties of genus Pasturella; its significance in the classification of birds. J. Immun, Vol.26, pp. 215 - 231.
- Burckhardt, J.L. (1912). Hühner Tuberkulose, hühnerleukämie, normales Hühnerblut. Z. Immunforschg., 14, S.544 bis 604.
- Burnett, S.A. (1917). Clinical Pathology of the blood of Domesticated Animals, 2nd Ed., pp. 32, 54 and 55. The Macmillan Co., New York.
- Carleton, H.M. (1926). Histological Technique p.115. Humphrey Milford, Oxford University Press, London.
- Coates, I. (1928). A method of counting white cells in the blood of the fowl. Report Ontario Vet. Coll., p.63.
- Cook, F.W. and R.S. Dearstyne (1934). Haematology of the fowl. Tech. Bull. 44. pp. 10 and 14. North Carolina State College of Agric. and Engineering.

- Cronwright Schreiner, S.C. (1898). The Angora Goat and a Paper on the Ostrich, p.260. Longmans, Green and Co., 39 Paternoster Row, London.
- De Kock, G. v.d. W. (1931). Studies on the blood of mice. 17th Report Dir. Vet. Services and Animal Industry. Union of South Africa, pp. 574 - 575.
- Dukes, H.H. (1934). The physiology of Domestic Animals, pp. 18, 19 and 22. Edwards Brothers, Inc. Ann Arbor, Michigan.
- Emmel, M.W. (1935). The etiology of fowl paralysis; leukemia and allied conditions in Animals. Bulletin 284, p.25 University of Florida, Agric. Experiment Station, Gainesville, Florida. *p.25*
- Ellerman, V. and O. Bang (1908). Experimentelle Leukämie bei Hühnern. Centralbl. f. Bakt., 1 abt., Originale Bd. 46, S.597.
- Ellerman, V.E. (1921). The Leucosis of Fowls and Leucemia Problems. Gyldendal, London.
- Eladon-Dew, R. (1937). An apparatus for the performance of blood counts. South African Journal of Science, Vol.33, pp. 850 - 851.
- Fernstermacher, R. (1932). Studies of leucamia of fowls. Jour. Amer. Vet. Med. Assoc., Vol. 80 (N.S.33) No.5, pp. 791 - 799.
- Fink, O. (1922). Über die Beeinflussung des Blutbildes gesunder Hühner durch die Injektion von Blutserum kranker Pferde. B.T.W.40, S.18.
- Forkner, C.E. (1929). Blood and bone marrow cells of the domestic fowl. Jour. Exp. Med., Vol.50, pp. 121 - 141.
- Friedl, A. (1931). Ez. Resistenz, Huhn, Splenektomie. Dissert. wien.
- Fritsch, G. (1919). Kaninchen- Tauben-und Hühnerblut. Dissert. Giessen. Pflügers Arch. Bd. 175. S.263.
- Furth, J. (1931). Erythroleukosis and the anaemias of the fowl. Arch. Path., Vol. 12, pp. 1 - 30.
- Furth, J. (1931). Observations with a new transmissible strain of leucosis (leucamia) in fowls. Jour. Exp, Med., Vol.53, pp.243 - 267.

- Gibbs, C.S. (1934). Preliminary studies on neurolymphomatosis and some more or less related diseases. Bull. No. 308 pp. 26 - 29. Massachusetts Agric. Exp. Station, Amherst, Mass.
- Gohs, W. (1928). Ueber die Zahl und die Zahlung der Leukozyten und Thrombozyten bei Huhnern Fol. Haemat., Bd. 36, S.337 - 341.
- Goodall, A. (1910). The numbers, proportions and characters of the red and white corpuscles in certain animals. Journ. of Path. and Bact., Vol.14, p.195.
- Groenewald, J.W. (1935). The influence of rations low in certain minerals on the composition of the blood and milk of cows, and on the blood of their progeny. Onderstepoort Jour. of Vet. Science and Animal Industry, Vol.4, No.1, p.158.
- Gulliver, G. (1875). Observations on the size and shape of the red corpuscles of the blood of vertebrata with drawings of them to a uniform scale and extended and revised tables of measurements. Proc. Zool. Soc. of London, pp. 474 - 495.
- Hayem, G. (1879). Recherches sur l'evolution des hematies. Arch. Physiol., 2nd series, Vol.6, pp.201 - 261.
- Hayem, G. (1889). Du sang et de ses alterations anatomiques. p. 1035. Masson. Paris.
- Hayden, C.E. (1927). The physiology of the blood of chickens. State Rep. of the New York State Vet. Col. Cornell Univ., pp. 212 - 220.
- Hedfeld, E. (1911). Untersuchungen uber die koperlichen Elementen des Blutes gesunden und kranken Hühner und Tauben. D.T.W. 21, S.266 - 267.
- Isaacs, R. (1929). McClungs Microscopical Technique, p.231. Paul B. Hoeber, New York.
- Johnson, E.P. and B.V. Conner (1933). Blood studies of fowls with various forms of lymphomatosis (Fowl paralysis). Journ. Amer. Vet. Med. Assoc. Vol. 83 (N.S. Vol.36), pp. 325 - 343.
- Kaupp, B.S. (1929). Poultry Diseases, 5th Ed., pp. 36 and 45. Alexander Eger, Chicago.
- Kleineberger, C. and W. Carl (1912). Die Blutmorphologie der Laboratoriums Tiere. Johann Ambrosius Barth, Liepzig.

- Kleineberger, C. and W. Carl (1927). Die Blutmorphologie der Laboratoriums Tiere 2. Aufl. Johann Ambrosius Barth Leipzig.
- Knowles, H.R. (1934). The variation in the calcium level of the blood of the domestic fowl. Poultry Science, Vol.14, No.2, p.89.
- Kolmer and Boerner (1931). Approved laboratory technique, pp. 60, 93, and 107. D. Appleton - Century Company, New York.
- Kozma, J. (1929). Differentialzählung Vogelblut. D.T.W. Bd. 38, 1930. S. 281.
- Krüger, F.v. (1925). Die Chemie des Blutes. Die Fermente des Blutes. Anhang: Blutesverwantschaft. In H. Wintersteins Hdb. d. vergl. Physiol. 1. Bd. 1, Hälfte G. Fischer. Jena.
- Kyes, P. (1929). Normal leucocyte content of birds' blood. Anat. Rec., Vol. 43, pp. 197 - 198.
- Laite (1915). Laite's commercial Blue Book for South Africa, p.302, South African Publishers Ltd., Cape Town.
- Lucia, S.P. and E.L. Lucia (1928). The differential blood count of the normal guinea-pig. Archives of pathology, Vol. 5, p. 616.
- Lundquist, C.W. and H. Birger (1925). Über die verscheiden Granulaformen der sog. Pseudoesinophilen Leukozyten im Hühnerblut. Fol. haemat. Bd. 31, S. 253 - 264.
- Magath, T.B. and G.M. Higgins (1934). The blood of the normal duck. Folia Haemat., Bd. 51, heft 2, pp. 234, 236 and 238.
- Malan, A.I. (1930). Mineral Metabolism and blood analysis. 16th Report Dir. Vet. Services and Animal Industry. Union of South Africa, pp. 307 - 311.
- Malan, A.I. (1930). Studies in Mineral Metabolism (13)- The Phosphorus partition of the blood of some animals. 16th Report Dir. Vet. Services and Animal Industry. Union of South Africa, p. 328.
- Malan, A.I. and G.W.B. van der Lingen (1931). Studies in Mineral Metabolism - 16. The micro-determination of some inorganic elements in blood and vegetation. 17th Report Dir. Vet. Services and Animal Industry. Union of South Africa, pp. 443 - 452.



- Malassez, L. (1872). De la numération des globules rouges du sang chez les mammifères les oiseaux et les poissons. Vol.75, pp. 1528 - 1531. C.R. Acad. Sci. Paris.
- Maximow, A. and W. Bloom (1931). A Text-book of Histology, p.64. W.B. Saunders Co., Philadelphia and London.
- McJunkin, F.A. (1920). A benzidin - polychrome stain for blood. Jour. Amer. Med. Assn. Vol. 74, p.17.
- Millar, W.G.(1925). Observations on the haemocrite method of measuring the volume of erythrocytes. Quart. Jour. Exp. Physiol., Vol.15, p.189.
- Mönnig, H.O. (1929). The "guinea-worm" of the ostrich, *Contortospiculum Spicularia*. 15th Annual report Dir. Vet. Services. Union of South Africa, pp. 299-301.
- Mönnig, H.O. (1934). Veterinary Helminthology and Entomology. pp. 17, 96, 160 and 194. Balliere Tindall and Cox, London.
- Morgan, V.E. and D.F. Chicester (1935). Properties of the blood of the domestic fowl. Jour. biol. Chem. 110, pp. 285 -298.
- Naegeli, O. (1912). Blutkrankheiten und Blutdiagnostik, p.140.
- Neser, C.P. (1923). The blood of equines. 9th and 10th/Dir. Reports Vet. Education and Research. Union of South Africa, pp. 479 - 555.
- Official Year Book of the Union of South Africa 1910 - 1917, pp. 429.
- Ohlson, C. (1935). Available methods for examination of the blood of the fowl. Jour. Amer. Vet. Med. Ass. Vol.86 (N.S. Vol.39) pp. 474 - 487.
- Palmer, E.J. and J. Biely (1935). Studies of total erythrocyte and leucocyte counts of fowls. Fol. Haemat., Vol. 53, pp. 143 - 154.
- Pepper, O.H.P. and D.L. Farley (1933). Practical haematological diagnosis, pp. 51, 73 and 149. W.B. Saunders Co., Philadelphia and London.
- Ponder, E. (1924). Erythrocyte and the Action of Simple Haemolysins. Oliver and Boyd. Paternoster Row London.
- Ponder, E. (1934). The Mammalian Red Cell and the Properties of Haemolytic Systems. pp.7 and 48. Verlag von Gebrüder Brontraeger, W.35 Schöneberger Ufer 12 a

- Pyper, A. (1919). "Diffraction - Phenomena in films of blood cells." The Medical Journal of S.A., Vol.14, pp. 472 - 488.
- Römer, K. (1921). Über das Blutbild bei gesunden und tuberkulösen Hühnern. Cent. f. Bakt. 73, S.333.
- Roussouw, S.D. (1930). A short study of the isotonicity of sheep blood. 16th Report Dir. Vet. Services and Animal Industry, Union of South Africa. pp. 525 - 529.
- Solomon, W. (1920). Normales Hühnerblut. Dissert Giessen.
- Scarborough, R.A. (1931). Yale J. Biol. Medic. 4, pp. 202-206 and 323 - 324.
- Schilling, V. (1933). Das Blutbild und seine Klinische Verwertung. p.11. Gustav Fischer, Jena.
- Schmeisser, H.C. (1915). Spontaneous and experimental leukaemia of the fowl. Jour. Exp. Med., 22, pp. 820-838.
- Schultze, M.O. and C.A. Elvehjem (1934). An improved method for the determination of hemoglobin in chicken blood. Jour. Biol. Chemistry, Vol. 105, pp. 253 - 257.
- Seagar, E.A. (1933). Cellular reactions in the blood in neurolymphomatosis gallinarum (Fowl paralysis) Vet. J. Vol. 89, pp. 557 - 561.
- Shaw, A.F.B. (1930). A direct method for counting the leukocytes, thrombocytes and erythrocytes of birds' blood. Jour. Path. and Bact., 33, pp.833 - 835.
- Slider and Downey (1929). McClung's Microscopical Technique, p.245. Paul B. Hoeber, New York.
- Sloan, H.J. and H.S. Wilgus Jr. (1930). Heartprobe - A method for obtaining blood samples from chickens. Poultry Science, 10, pp. 10 - 16.
- Steen, G. (1913). Blutbild Huhn. Dresden. Hochschulnachr. (N.F. 8). S. 186 - 188.
- Sugiyama (undated). Origin of thrombocytes and of the different types of blood cells as seen in the living chick blastoderm. Contributions to Embryology, No. 97.
- Theiler, A., H.H. Green, and P.J. du Toit (1927). Minimum mineral requirements in cattle. Jour. Agric. Science, Vol. 17, pp. 291 - 314.

- Venzlaff, W. (1911). Ueber Genesis und Morphologie der rothen blutkörperchen der Vögel. Arch. f. Mikr. Anat., Vol. 77 Abt. 1, pp. 377 - 431.
- Warthin, A.S. (1907). Leucamia of the common fowl. Jour. of Infect. Diseases, Vol. 4, -.369.
- Wirth, D. (1931). Grundlagen einer Klinischen Haematologie der Haustiere.
- Wiseman, B.K. (1930). An improved direct method for obtaining total white cell counts in avian blood. Proc. Soc. Exp. Biol. and Med., Vol. 28, pp. 1030 - 1033.
- Wiseman, B.K. and O.S. Bierbaum (1932). A new method for determining the fragility of red blood cells. Proc. Soc. Exp. Biol. and Med., Vol. 29, p.835.
- Wormser, M.F. (1930). The Ostrich Industry in South Africa. M.Sc. Thesis, submitted to University of South Africa, Pretoria.
- Wright and Kinnicut (1911). Jour. Amer. Med. Assoc., Vol. 46, p.1457.



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