UNIVERSITI PUTRA MALAYSIA

QUANTITATIVE OBSERVATIONS ON THE PULMONARY ANATOMY OF THE DOMESTIC FOWL AND OTHER GROUND-DWELLING BIRDS

M. K. VIDYADARAN

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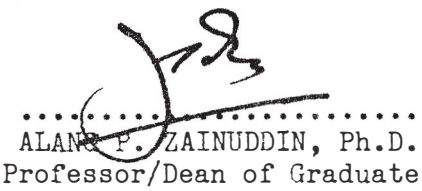

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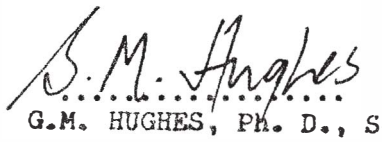

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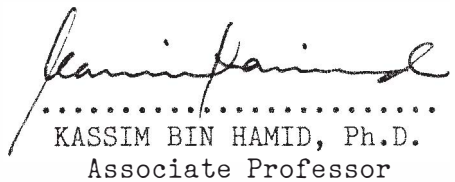

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QUANTITATIVE OBSERVATIONS ON THE PULMONARY ANATOMY OF THE DOMESTIC FOWL AND OTHER GROUND-DWELLING BIRDS

by

M. K. Vidyadaran

A thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy in the Faculty of Veterinary Medicine and Animal Science, University Pertanian Malaysia.

February 1987

This thesis is dedicated to my parents

Mr. M. P. K. Menon

and

Mrs. Lakshmi Menon

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"I often say that when you can measure what you are speaking about and express it in numbers you know something about it; but when you cannot express it in numbers your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of science".

Lord Kelvin, 1883 (cited by Dunnill, 1968)

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LIST OF ABBREVIATIONS

D_{eo_2}	oxygen diffusing capacity (conductance) of erythrocytes
DL_{o_2}	total anatomical pulmonary diffusing capacity for oxygen
D_{mo_2}	oxygen diffusing capacity of the membrane for oxygen
D_{po_2}	oxygen diffusing capacity of the plasma for oxygen
D_{to_2}	oxygen diffusing capacity of the blood-gas (tissue) barrier for oxygen
Hc	pulmonary capillary haematocrit
He	venous haematocrit
r	correlation coefficient
Sa	surface area of the air capillary epithelium
Sc	surface area of the blood capillary epithelium
s.d.	standard deviation
Se	surface area of the capillary erythrocytes
Sp	surface area of the plasma layer
St	surface area of the blood-gas (tissue) barrier
Va	volume of the lumen of the air capillaries
Vb	volume of the wall and lumen of the blood vessels larger than capillaries
Vc	volume of the lumen of the blood capillaries
Ve	volume of the pulmonary capillary erythrocytes
Vec	volume of the cytoplasm of the pulmonary capillary erythrocytes
Ven	volume of the nucleus of the pulmonary capillary erythrocytes

V_L	volume of the fixed lung (left lung x 2)
V_{lb}	volume of the lumina of parabronchi and secondary bronchi (including atria)
V_p	volume of the wall and lumen of the primary bronchus
V_t	volume of the blood-gas (tissue) barrier
V_{tn}	volume of the tissue not involved in gaseous exchange
V_x	volume of the exchange tissue of the lung
W	body weight
$\bar{t}_{hp}$	harmonic mean thickness of the plasma
$\bar{t}_{ht}$	harmonic mean thickness of the blood-gas (tissue) barrier
$\bar{t}_t$	arithmetic mean thickness of the blood-gas (tissue) barrier

Specific values are those standardized against body weight; for example, S_t/W means the specific surface area of the tissue barrier.

In the text and Tables, all lung values are totals for the left and right lungs together.

The anatomical terminology adopted in this thesis is that used by the International Committee on Avian Anatomical Nomenclature (I.C.A.A.N.) and published in the Nomina Anatomica Avium (King, 1979).

The taxonomic nomenclature follows Gruson, (1976).

An abstract of the thesis presented to the Senate of Universiti Pertanian Malaysia in partial fulfilment of the requirements for the Degree of Doctor of Philosophy

QUANTITATIVE OBSERVATIONS ON THE PULMONARY ANATOMY OF THE DOMESTIC FOWL AND OTHER GROUND-DWELLING BIRDS

by

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June, 1986

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The pulmonary stereology of the adult domestic fowl (Gallus gallus variant domesticus), the Red Jungle Fowl (Gallus gallus), the Muscovy Duck (Cairina moschata), the White-breasted Water-Hen (Amaurornis phoenicurus), and the juveniles of the domestic fowl and Red Jungle Fowl were investigated. The lung of the domestic fowl was compared with that of the Red Jungle Fowl at day 1, day 7, and day 30.

A multistage sampling technique was used for pulmonary stereology. Standard stereological procedures of point counting, intersection counting, and measurement of intercept

length, were employed for estimating volume density, surface area, and harmonic mean thickness respectively. The anatomical diffusing capacity was estimated from Weibel's model.

The pulmonary stereological characteristics of the Red Jungle Fowl are broadly similar to those of the domestic fowl, but the Red Jungle Fowl has a higher specific volume of the lung and a thinner blood-gas (tissue) barrier, with a higher specific diffusing capacity of the barrier for oxygen than the domestic fowl.

The lung of the White-breasted Water-Hen, a ground-dwelling bird, has stereological characteristics similar to some flying birds (non-passerine), thus showing that not all ground-dwelling birds have inferior pulmonary stereological characteristics.

The domestic Muscovy Duck has pulmonary characteristics which are broadly similar to those reported for other Anseriformes, except for a greater thickness of the blood-gas (tissue) barrier. The specific oxygen diffusing capacity of the blood-gas (tissue) barrier was well below that of other anseriforms and birds in general.

The juvenile of both the domestic fowl and the Red Jungle Fowl has a thicker blood-gas (tissue) barrier than the adult. In each age group examined, the blood-gas (tissue) barrier was thicker in the domestic fowl than in the Red Jungle Fowl.

At day 7 the pulmonary stereology of the domestic fowl is vastly inferior to that of the Red Jungle Fowl. It is suggested that lung development has not been adequate to meet the rapid increase in body weight.

The pathophysiological effects of the stereological values of some of the parameters are discussed. Surface to volume and volume to volume relationships suggest a possible greater total length of blood capillaries in the exchange tissue of the domestic fowl than in the Red Jungle Fowl, with the possibility of greater resistance to pulmonary blood flow.

Scanning electron microscopy showed that both the blood and air capillaries were tortuous. The air capillaries resembled irregular chambers connected by small tubes, while the blood capillaries formed a network of tubes of uniform diameter.

Carcass evaluation indicated that although muscle, bone, etc. were highly correlated with volume of lung, body weight is still the best comparator.

Abstrak tesis yang dikemukakan kepada Senat
Universiti Pertanian Malaysia sebagai sebahagian
daripada keperluan untuk Ijazah Doktor Falsafah

QUANTITATIVE OBSERVATIONS ON THE PULMONARY ANATOMY OF THE DOMESTIC FOWL AND OTHER GROUND-DWELLING BIRDS

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Stereologi pulmonari ayam peliharaan (Gallus gallus variant domesticus), ayam hutan merah (Gallus gallus), itik Muskovi (Cairina moschata) burung Uak-uak (Amaurornis phoenicurus) dewasa, dan anak-anak ayam peliharaan dan ayam hutan merah telah diselidiki. Perbandingan antara paru-paru ayam peliharaan dengan ayam hutan merah pada umur 1, 7 dan 30 hari dilakukan.

Teknik persampelan pelbagai lapisan telah digunakan untuk stereologi pulmonari. Prosedur stereologi yang biasa untuk pengiraan-pengiraan titik, antara bahagian, dan ukuran bagi jarak intersep, telah digunakan untuk anggaran

ketumpatan volum, luas permukaan dan min harmonik ketebalan. Keupayaan difusi anatomi adalah dianggarkan mengikut contoh Weibel.

Sifat-sifat stereologi pulmonari ayam hutan merah pada keseluruhannya adalah sama dengan ayam peliharaan, tetapi ayam hutan merah mempunyai volum paru-paru spesifik yang lebih tinggi dan rintangan darah gas yang lebih nipis, dengan keupayaan difusi spesifik oleh rintangan yang lebih tinggi untuk oksigen daripada ayam peliharaan.

Paru-paru burung Uak-uak, yang amnya menetap di atas tanah, mempunyai sifat stereologi yang sama dengan setengah burung yang terbang (bukan paserine), menunjukkan bukan semua burung jenis di atas tanah mempunyai sifat stereologi pulmonari yang bermutu rendah (inferior).

Itik Muskovi peliharaan mempunyai sifat-sifat pulmonari yang banyak persamaan dengan yang dilaporkan bagi Anseriformes yang lain, kecuali ketebalan rintangan darah-gas (tisu). Keupayaan difusi oksigen spesifik bagi rintangan darah-gas (tisu) adalah rendah daripada jenis anseriformes yang lain dan burung-burung amnya.

Kedua-dua anak ayam peliharaan dan ayam hutan merah mempunyai rintangan darah-gas (tisu) lebih tebal daripada yang dewasa. Di dalam sekumpulan umur yang diperiksa, rintangan darah-gas (tisu) adalah lebih tebal bagi ayam peliharaan daripada ayam hutan merah.