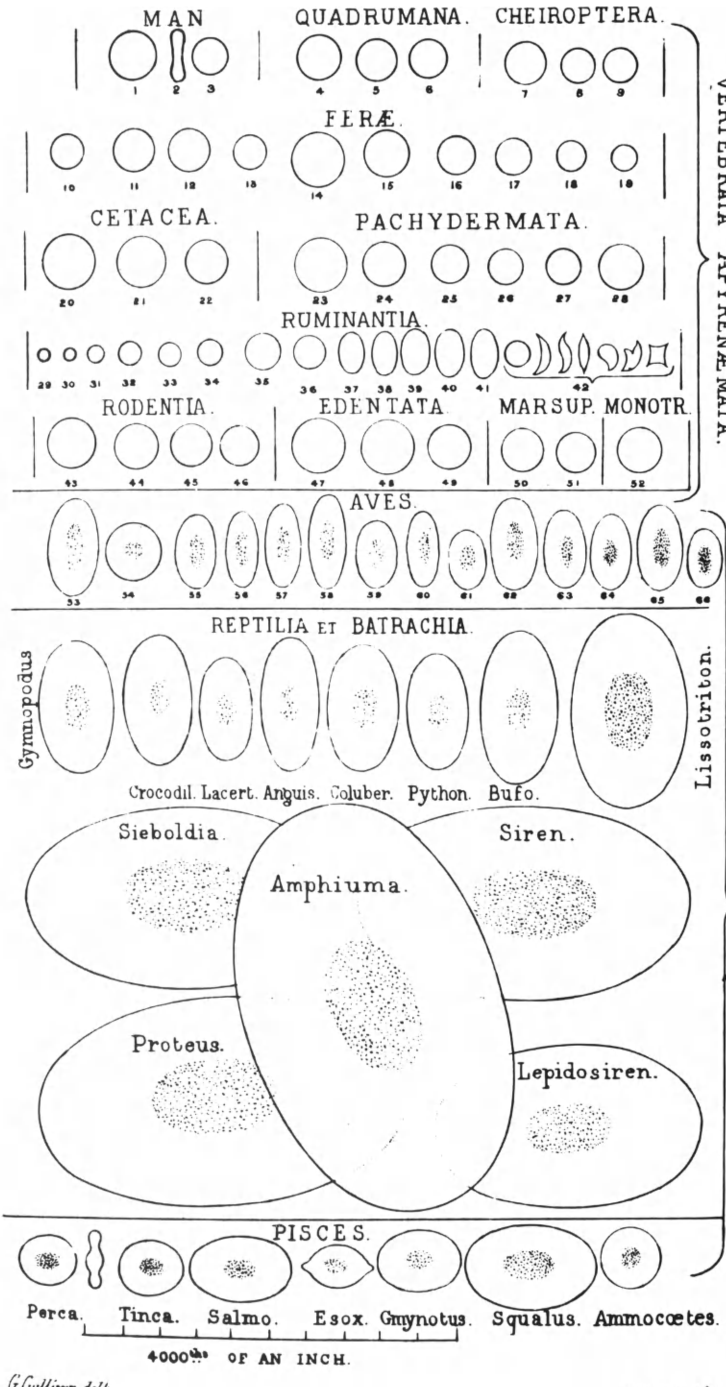

RED BLOOD-CORPUSCLES.

Frontispiece

Reprinted from the Proceedings of the Zoological Society of London for 1875.

EXPLANATIONS OF THE FIGURES ON PLATE LV. *(Frontispiece)*

All the objects are red blood-corpuscles done to one and the same scale, which is at the foot of the drawing. The whole length of the scale represents $\frac{1}{400}$ of an English inch, and each one of its ten divisions $\frac{1}{4000}$ of an inch, as described at page 475. Only corpuscles of the average sizes and quite regular shapes are given; and they are all magnified to the same, or nearly the same, degree—to wit, about 800 diameters.

VERTEBRATA APYRENÆMATA.

Homo.

1. Corpuscle lying flat.
2. The same on edge.
3. Membranous base of the same, after removal by water of the colouring-matter.

Quadrumana.

4. Simia troglodytes.
5. Ateles ater.
6. Lemur anguanensis.

Cheiroptera.

7. Cynonycteris collaris.
8. Vespertilio noctula.
9. Vespertilio pipistrellus.

Feræ.

10. Sorex tetragonurus.
11. Ursus labiatus.
12. Bassaris astuta.
13. Cercoleptes caudivolvulus.
14. Trichechus rosmarus.
15. Canis dingo.
16. Mustela zorilla.
17. Felis tigris.
18. Paradoxurus pallasii.
19. Paradoxurus bondar.

Cetacea.

20. Balæna boops.
21. Delphinus globiceps.
22. Delphinus phocæna.

Pachydermata.

23. Elephas indicus.
24. Rhinoceros indicus.
25. Tapirus indicus.
26. Equus caballus.
27. Dicotyles torquatus.
28. Hyrax capensis.

Ruminantia.

29. Tragulus javanicus.
30. Tragulus meminna.
31. Tragulus stanleyanus.
32. Cervus nemorivagus.
33. Capra caucasica.
34. Capra hircus.
35. Bos urus.
36. Camelopardalis giraffa.
37. Auchenia vicugna.
38. Auchenia paco.
39. Auchenia glama.
40. Camelus dromedarius.
41. Camelus bactrianus.
42. Cervus mexicanus (see page 483)

Rodentia.

43. Hydrochœrus capybara.
44. Castor fiber.
45. Sciurus cinereus.
46. Mus messorius.

Edentata.

47. Myrmecophaga jubata.
48. Bradypus didactylus.
49. Dasypus villosus.

Marsupialia.

50. Phascolomys wombat.
51. Hypsiprymnus setosus.

Monotremata.

52. Echidna hystrix.

VERTEBRATA PYRENÆMATA.

Aves.

53. Struthio camelus.
54. The same, made round and deprived of colour by water.
55. Vanga destructor.
56. Lanius excubitor.
57. Bubo virginianus.
58. Syrnea nyctea.
59. Columba rufina.
60. Columba migratoria.
61. Dolichonyx oryzivorus.
62. Buceros rhinoceros.
63. Psittacus augustus.
64. Phasianus superbus.
65. Pelecanus onocrotalus.
66. Trochilus, sp.

Reptilia et Batrachia.

Gymnotus ægyptiacus.
Crocodilus acutus.
Lacerta viridis.
Anguis fragilis.
Coluber berus.
Python tigris.
Bufo vulgaris.
Lissotriton vulgaris.
Sieboldia maxima.
Siren lacertina.
Proteus anguinus.
Amphiuma tridactylum.

Pisces.

Perca cernua, one corpuscle lying flat, the other on edge.
Tinca vulgaris.
Salmo fontinalis.
Esox lucius.
Gymnotus electricus.
Squalus acanthias.
Ammocœtes branchialis.
Lepidosiren annectens.

COMPARATIVE MAMMALIAN HAEMATOLOGY

Cellular Components and Blood Coagulation of Captive Wild Animals

C. M. HAWKEY

Nuffield Institute of Comparative Medicine
Zoological Society of London

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FOREWORD

What is a normal animal and to what extent can the results obtained in this survey be considered to be of value either as a pure contribution to the collected data on physiological normality or as a guide in assisting clinical diagnosis of disease?

Firstly, it is not possible to obtain blood samples from animals which are not affected by some influence, however subtle, at the time of bleeding. Secondly since disease processes represent a continuous change in a given animal before becoming detectable clinically, all subjects may be experiencing a degree of abnormality from disease. Thirdly, for all parameters, a range of values, sometimes wide, is used in interpreting a given result. This result will become narrower as more figures are obtained, but even a wide range is better than no range at all.

In the animals from which the data presented in this book were derived a degree of abnormality may have existed, but from the point of view of the co-existence of clinical abnormality the following observations are relevant. With a few exceptions the animals formed part of a fairly stable collection; their clinical histories were known and clinical condition assessed in a veterinary hospital at the time of bleeding. This assessment was also based, in many cases, on radiological examination. The subsequent history of the animal was also known accurately and, where illness led to death, efficient necropsy examination was carried out in all cases. Consideration of this information has allowed a more than usually accurate selection of normal data. It is uncommon for such facilities to be available to a Zoological Collection and it is hoped therefore that the data presented is the best available at the time and may be relied upon in interpreting similar parameters in clinical cases.

J. M. Hime, M.R.C.V.S.
Senior Veterinary Officer
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It is a pleasure to acknowledge the help of various technicians who, over the years have carried out most of the laboratory tests, particularly Miss S. V. M. Hook for providing the general haematology results from 1965-1969 and Mrs. N. Ouna, Miss J. Cowley, Mrs. J. Henderson, Mrs. M. Laulicht and Mr. G. F. Nevill for their more than routine involvement in the work.

Substrate plasma for clotting factor assays was kindly provided by Dr. K. M. Dormandy, Royal Free Hospital, London, Dr. N. Josso, Höpital des Enfants Malades, Paris and Professor J. L. Stafford, St. George's Hospital, London and a generous supply of streptokinase by Mr. A. M. Nichols of Kabi Pharmaceutical Ltd. The study has been supported financially by the British Heart Foundation, the Medical Research Council and the Wellcome Trust.

I also thank the Council of the Zoological Society of London for permission to reproduce the Frontispeice and Cambridge Scientific Instruments Limited for the Stereoscan photographs in Figures 1.1 and 1.3.

I am grateful to Miss W. Churchill, Royal Free Hospital, Miss B. A. Blofield, Goldsmiths College, University of London and Miss P. Wright, Nuffield Institute of Comparative Medicine for much helpful discussion concerning the contents and preparation of the manuscript, and to Mr. R. N. T.-W.-Fiennes of the Nuffield Institute and Dr. R. K. Archer, Director of the Equine Research Station, Newmarket who have read the manuscript and made many valuable suggestions. I am also grateful to Mrs. Ethlyn Hazel and Mrs. Cosette Duncan for the many hours they have spent in typing the manuscript. Finally I should like to express my sincere appreciation to Dr. L. G. Goodwin, Director of the Nuffield Institute of Comparative Medicine, for constant encouragement during the past eight years.

C.M.H.

PREFACE

The information presented in this manual has been collected over a period of eight years during a survey of the haematology of wild mammals in the Collection of the Zoological Society of London. The survey has resulted in the accumulation of a large amount of information about the blood constituents and haemostatic mechanism in a wide variety of mammals, much of which has not previously been available.

Access to blood samples from exotic animals induces the temptation to superimpose on other people the interest and curiosity with which the tests were first carried out. There are however, many problems inherent in a comparative study involving a large number of different species but only a few individual representatives of each. It is evident nevertheless that the subject illustrates many important physiological principals and that much can be learnt by considering the blood picture of an animal in relation to its environmental demands, way of life and zoological relationships. The manual is presented therefore as a beginning and, hopefully, as a basis for expansion, confirmation and modification by physiologists and haematologists who have the opportunity of studying animals other than man. It is hoped that, as it stands, the material may be of use to veterinarians faced with the problem of diagnosis of pathological conditions in exotic mammals and to research workers in the selection of experimental animals for specific projects. More important is the hope that interest will be stimulated in the extending fields of comparative physiology and medicine.

C.M.H.

KEY TO ABBREVIATIONS

Hb	Haemoglobin g/100ml blood.
RBC	Red cells x 10^6/c.mm blood.
PCV	Packed cell volume %.
Retics	Reticulocytes % of red cells.
MCV	Mean cell volume/cu.mm. (fl)
MCH	Mean cell haemoglobin/$\mu\mu$g. (pg)
MCHC	Mean cell haemoglobin concentration %.
MCD	Mean cell diameter/μ.
WBC	White cells x10^3/c.mm blood.
N	Neutrophilic polymorphs % of white cells.
L	Lymphocytes % of white cells.
M	Monocytes % of white cells.
E	Eosinophilic polymorphs % of white cells.
B	Basophilic polymorphs % of white cells.
Plts	Platelets x 10^3/c.mm blood.
ESR	Erythrocyte sedimentation rate, mm in 1 hour.
ELT	Euglobulin lysis time/mins (unless otherwise stated).
Pg	Plasminogen, units/ml plasma.
AF	Antifibrinolytic activity % of normal human value.
PT	Prothrombin time/secs.
RVV	Stypven (Russel's viper venom) time/secs.
PTT	Partial thromboplastin time/secs.
RT	Recalcification time/secs.
TT	Thrombin time/secs.
I	Factor I (fibrinogen) mg/100ml plasma.
II	Factor II (prothrombin) % of normal human value.
V	Factor V (proaccelerin) % of normal human value.
VII	Factor VII (proconvertin) % of normal human value.
VIII	Factor VIII (antihaemophilic factor) % of normal human value.
IX	Factor IX (Christmas factor) % of normal human value.
X	Factor X (Stuart Prower factor) % of normal human value.
XI	Factor XI (Plasma thromboplastin antecedent) % of normal human value.
XII	Factor XII (Hageman factor) % normal human value.
XIII	Factor XIII (fibrin stabilizing factor), present or absent.
AT	Plasma antithrombin activity units/ml.
CR	Clot retraction %.
TP	Total protein g/100ml plasma.
No.	Number of animals examined.
Av.	Average result.
SD	Standard deviation.

INTRODUCTION

There are more than 4,200 living species of mammals and, of these the haematology of only one, man, has been fully studied. Some information is available for domesticated mammals and those species commonly used in laboratories but, although Haematology as a comparative subject was introduced by Gulliver in 1875 (see frontispiece), the vast majority of mammals have not yet been examined systematically. The reasons for this are both practical and technical in nature and the problems encountered in the present survey are worth stating since they illustrate many of the difficulties likely to apply generally to comparative physiological studies on wild animals.

Collection of data

Information has been collected from 1107 individual animals of 165 different species. Thus, although the total number of species is large compared with other studies, it falls far short of the whole. The number of individuals examined from each species is small and it is not possible at this stage to calculate statistically valid normal ranges. For non-human primates and a few other species, numbers have been supplemented by including normal laboratory animals in the survey. A small number of normal rabbits and rodents have also been included for purposes of comparison. Although in no instance has statistical respectability been reached, these figures should provide some guidance for research workers in selection of species suitable for specific projects.

Throughout the survey, man has been used as the reference species. This approach cannot be validated from a zoological point of view but it has been used because the human species is the only one for which sufficient basic information is available for comparison. In addition, parallel tests carried out on normal human blood provide some means of quality control which is useful in a situation where day to day results on a variety of different species cannot be expected to give a normal distribution.

What is a 'normal' animal?

Apart from the difficulty in obtaining significant numbers of animals of the same species, other problems have become evident during the course of the study. First – what is a normal animal? Is a wild animal in captivity normal? The answer to the second question can only be an emphatic negative. The long-term effects of a captive environment on the general health of animals are impossible to evaluate at the present time and, in addition to these imposed conditions, it is probably true to say that no species of animal receives in captivity a diet exactly equivalent to that which it would select for itself in the wild. Although in many instances the balance may be in favour of the captive animal, unrecognised deficiencies may be present in apparently normal groups or individuals, the effects of which may alter haematological findings.

It is also often difficult to assess the general health of individual animals. The survey has been carried out in collaboration with the Veterinary Officers of the Zoological Society and the majority of the animals have been examined clinically and radiologically at the time of obtaining the blood sample and all animals with a detectable abnormality have been excluded. Then there is the problem of age. Unless an animal has been born in captivity it is often not possible to do more than define its age as immature, mature or aged. Thus it has rarely been attempted to comment on variation of blood count with age.

Another major problem is in obtaining blood samples from wild animals without the use of tranquillising or anaesthetizing drugs. In many instances it is not possible to approach a wild animal with (or without) a syringe without causing considerable stress to the animal and danger to the operator and handlers. Although this has been done with some species described – mainly members of the Artiodactyla – in most instances the animals have been prepared with a tranquillising drug or anaesthetic. Animals receiving gaseous anaesthetics have been omitted from the survey since these are known to affect the blood picture and activity of the haemostatic mechanism. It should be noted however that the degree of stress and its effects on the blood cannot at present be assessed.

In all cases the tests have been carried out on venous or, occasionally, on cardiac blood and throughout, meticulous standards have been imposed on preparation, storage and testing of the samples as the influence of these manipulations, particularly on coagulation, fibrinolytic and platelet tests cannot be overemphasised. The laboratory methods which have been used are mainly those in general employment in routine Haematology departments but it should be borne in mind that these are designed for use with human blood and the assumption is made that they are valid for other species. In the present survey, carefully standardised established techniques have been used whenever possible, thus avoiding methodological variation and facilitating comparison of results within the survey and with those of other workers. In some clotting tests modifications are unavoidable because of the species specificity of factors involved in extrinsic prothrombin activation. In some other areas, particularly in the centrifugation time of the haematocrit, the reading time of the erythrocyte sedimentation rate and the conditions of precipitation used to obtain plasma euglobulin fractions, the advisability of restandardisation is indicated. Specific methods used and the modifications employed in the present survey are described in the appendix. Unfortunately it has not been possible to carry out every test on each animal. The incompleteness of the data is due occasionally to the small volume of blood available but more usually to the impracticability of undertaking more than a certain number of tests each day.

Classification

The plan of the book is based on Zoological classification, the animals being grouped according to their order. For this the classification of Simpson[1] has been followed above the genus level and for genera and species we have referred to Morris[2] for all except the primates which have been classified according to Napier and Napier[3]. In all cases, common names have been included for the convenience of the non-Zoologist. The results for each species are presented separately and an attempt has been made to comment briefly on any points of special interest.

References

Considerable attention has been given to providing a comprehensive list of references to mammalian haematology (excluding man) since the information which is available is widely scattered throughout the literature. Data abstracted from the literature have also been included for some domesticated and laboratory mammals and for those wild mammals which have been studied. The information on domestic and laboratory mammals is representative rather than exhaustive and has been included for the purpose of comparison with their wild relatives. It should be noted that the problems already described in association with carrying out blood tests on animals also apply to the vast majority of results appearing in the literature.

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2. Morris, D. (1965). The mammals. Pub. Hodder and Stoughton, London.
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Chapter 1

COMPARATIVE HAEMATOLOGY OF THE VERTEBRATES

All vertebrate animals have a closed system in which blood circulates under pressure. With the exception of ice fish (family Chaenithidae) in which red cells are absent [1], the blood comprises red cells, white cells and haemostatic cells suspended in plasma containing fibrinogen. Mammals are unique in that their red cells and haemostic cells do not contain nuclei. The following discussion summarises briefly information available on vertebrate blood cells and haemostasis.

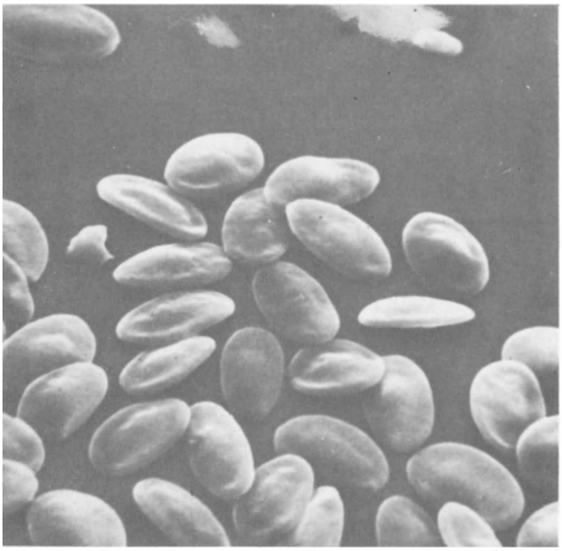
Red cells

The red cells of fish, amphibians, reptiles and birds are oval in shape, each containing a centrally placed, spherical or oval nucleus. Amongst mammals, camels and their close relatives have oval cells but in all other groups red cells take the form of biconcave discs. In all mammals, including camels, the red cells are without nuclei. Loss of nuclei is associated with increased functional efficiency since extra space is available for haemoglobin molecules and oxygen utilization by the cells themselves is reduced [1]. The total red cell count is higher in mammals than in other vertebrates and the cells are smaller (Table 1.1). Thus both the oxygen-carrying capacity and the surface area available for gaseous exchange are increased and contribute to the greater efficiency of the mammalian cell.

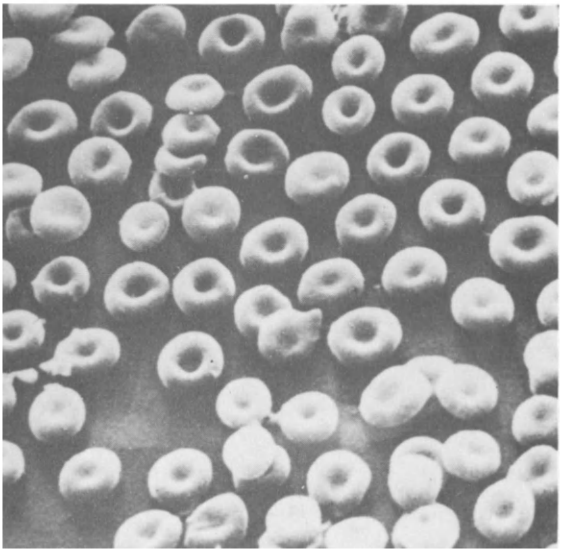
TABLE 1.1

COMPARISON OF RED CELL SIZE AND NUMBERS IN VERTEBRATE CLASSES

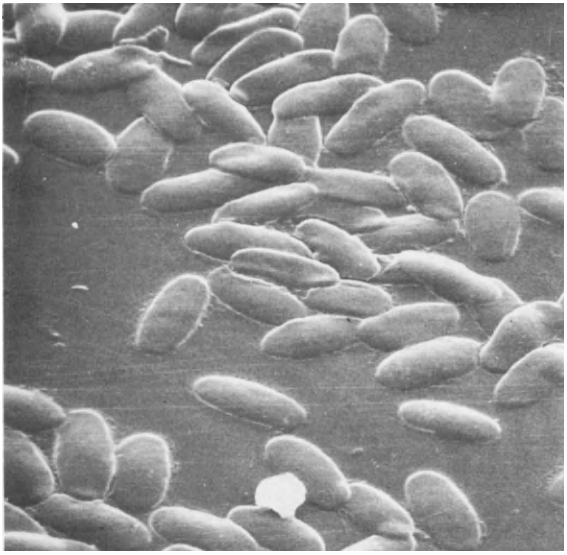
Vertebrate class	Red cell count $X10^6$/c.mm blood	MCV/cuμ	MCD/μ	Ref.
Chondrichthyes (Cartilaginous fish)	0.07-0.39	952-1,010	22.5 x 17.1-25.2 x 17.3	2
Actinopterygii (Bony fish)	0.78-4.20	108-314	7.3 x 10.7-8.6 x 12.3	2
Amphibia (Amphibians)	0.02-0.04	670-13,860	15.3 x 24.8-36.5 x 62.5	2
Reptilia (Reptiles)	0.7-1.1	171-465	8.7 x 16.4-12.1 x 23.2	2
Aves (Birds)	1.9-3.7	127-203	6.5 x 11.2-9.7 x 14.2	2
Mammalia (Mammals)	3.2-21.4	19-136	1.5 - 9.7	3 and present study



Turkey X 1000



Palm Civet X 1250



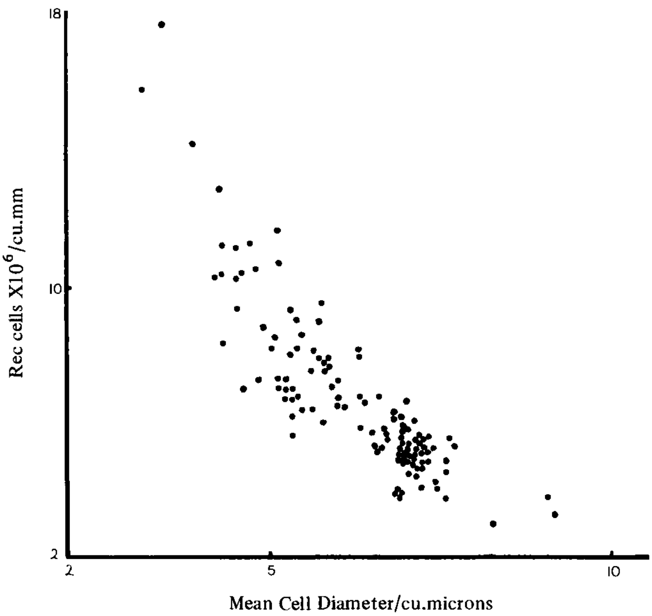
Alpaca X 2000

(Stereoscan electron microscopy)

Figure 1.1 Vertebrate red cells

Red cells of all vertebrates contain haemoglobin. In mammals the haemoglobin content of the blood and the packed cell volume are relatively constant but the total number of red cells and mean cell size varies considerably. The inverse relationship between cell size and number was first pointed out by Wintrobe [2] and has been confirmed in the present survey (Figure 1.2). Numerous small red cells are often found in those species which inhabit high altitudes (e.g. sheep and goats) where the modification is thought to be an adaptation to conditions of low oxygen availability, providing an increased surface area for gaseous exchange. However, the mammal with the smallest red cells yet described, the Malay chevrotain or lesser mouse deer *(Tragulus javanicus)* [3] is not a mountain dweller but is found in the primary and secondary forests of the lowlands and foothills of Malaya and nearby islands. In the present series the largest red cells have been found in elephants, seals, dolphins and some rodents, confirming the observations of Gulliver, reported in 1875 [4]. The presence of large cells in elephants and large marine mammals suggests a direct relationship between red cell size and body mass but this idea is rapidly disproved for mammals in general. Gulliver [4] has pointed out that, within orders or families, the relationship may hold good.

Figure 1.2 Relationship between red cell count and diameter in mammals



In seals and cetaceans where periodical exposure to anoxia occurs during diving the packed red cell volume is high and the red cells are relatively large. Calculation of absolute red cell values for these animals indicates an increased average red cell thickness. Thus the rate of diffusion into and out of the cells will be reduced, providing for a slow release of oxygen which may be advantageous during periods of submersion. Other physiological adaptations to diving found in these mammals include an increased blood volume, decreased sensitivity to accumulating carbon dioxide, tachycardia and peripheral vasoconstriction during diving [5, 6].

Although it has not been studied in detail, red cell life span and rate of release of immature red cells from the marrow apparently varies in different mammals. Some species, particularly some Cebidae, rodents and cetaceans, normally have a much higher percentage of reticulocytes and polychromatic red cells in their circulating blood than man and in these species a small proportion of circulating nucleated red cells does not have any pathological significance. In other groups, including the Perissodactyla, reticulocytes and polychromatic red cells are rarely found, even after severe blood loss. Red cell inclusion bodies indistinguishable from Howell Jolly bodies occur normally in small numbers in marsupials, feline animals and prosimians and Heinz bodies are commonly found in up to 5% of red cells of felines [10]. These inclusions have also been found in apparently healthy bottlenosed dolphins *(Tursiops truncatus)* and white rhinoceroses *(Diceros simus)*. Cabots rings are common in some camellidae.

The erythrocyte sedimentation rate, which is a trusted indicator of chronic disorders and localised inflammatory diseases in man, is difficult to interpret in other mammals. Some groups, notably the Perissodactyla, have red cells which readily form rouleaux and sediment very rapidly. In others (e.g. most bovine animals), red cell sedimentation is negligible after several hours, even in grossly diseased animals. In man the sedimentation rate is raised in association with a low red count, macrocytosis and raised levels of fibrinogen and globulins, but in other mammals the factors affecting the test are not yet fully understood [7]. A detailed comparative study of erythrocyte sedimentation should be rewarding.

Leucocytes

Amongst white cells of all vertebrate animals lymphocytes and monocytes with fairly typical morphology can be identified but polymorphonuclear white cells of non-mammals vary considerably in morphology and staining characteristics [8, 36]. In all mammals the polymorphic granulocytes can be classified as neutrophils, eosinophils or basophils which are basically similar to those of man. Neutrophils vary slightly in types of granulation present; this variation is most marked in rabbits and some hystricomorph rodents where the cells equivalent to neutrophils show marked eosinophilic granulation and are termed 'heterophils' or pseudoeosinophils. The degree of nuclear lobulation is another variable factor throughout the Mammalia. Neutrophils of mice and some other rodents are often U-shaped, doughnut-shaped or coiled without exhibiting true lobulation. At the other extreme, neutrophils of most non-human primates have nuclei which are hyperlobulated compared with man. The shape, size, concentration and staining characteristics of granules of the true eosinophils also varies in mammals and in some species, for example owl monkeys *(Aotus trivirgatus)* and bottle-nosed dolphins *(Tursiops truncatus)*, a high eosinophil count in the absence of parasitic infestation or allergy seems to be the rule. Basophils are found frequently in rabbits but are extremely rare in some species (e.g. members of the Perissodactyla and some Artiodactyla). It has been claimed that the circulating basophil count is inversely proportional to the number of tissue mast cells [9].

Reported total white cell counts in non-mammalian vertebrates indicate much variation but this estimation is difficult to carry out in the presence of nucleated red cells and thrombocytes and has not been widely used or carefully standardised. Amongst mammals the normal white cell count varies between less than $1 \times 10^3/mm^3$ of blood in deer and 15×10^3 in some carnivores and non-human primates. The neutrophil/lymphocyte ratio is also variable. In man the ratio is less than one in children and greater than one in adults but in other mammalian species examples of all possible variations can be found. In domestic cats, dogs and horses, neutrophils predominate throughout life while in cattle and sheep and lymphocyte is usually the most numerous cell [10]. In pigs, neutrophils predominate at birth but are outnumbered by lymphocytes before the end of the suckling period [10]. Because of differences in total white count and neutrophil/lymphocyte ratio the most reliable index of disease may be cell morphology rather than cell count. The presence of immature cells, toxic granulation and Döhle bodies can be significant if the normal picture for the species is born in mind.

Haemostatic cells

Strictly speaking, all blood cells which play an active part in haemostasis are defined as thrombocytes. For the sake of clarity in the present monograph, the term thrombocyte has been applied to the nucleated haemostatic cells of non-mammalian vertebrates and the cell fragments involved in haemostasis in mammals have been referred to as 'platelets'. The relationship between thrombocytes and platelets is not clear. Although morphologically very different they are apparently functionally similar. Thrombocytes are well defined, nucleated cells, similar in size to small lymphocytes, each derived from a single mononuclear haematoblast whereas platelets are small, anuclear structures produced from megakaryocytes by cytoplasmic fragmentation, each megakaryocyte giving rise to several thousand platelets. Both are involved in clot retraction and in prothrombin activation and both aggregate to form haemostatic plugs (Fig. 1.3). Reactions with different types of foreign surface [11] and the mechanisms of aggregation [12] may be different.

Amongst mammals there is considerable species variation in the number of platelets present in the circulating blood. Extremes are seen in dolphins and some equine animals where the count can be as low as $1 \times 10^5/mm^3$ and elephants and rats where counts of greater than $1 \times 10^6/mm^3$ are often recorded. Although platelet size has not been measured, observation suggests that, as with red cells, the total platelet mass may be relatively constant throughout the Mammalia and perhaps also in other vertebrates where thrombocytes are much fewer in number but considerably greater in size.

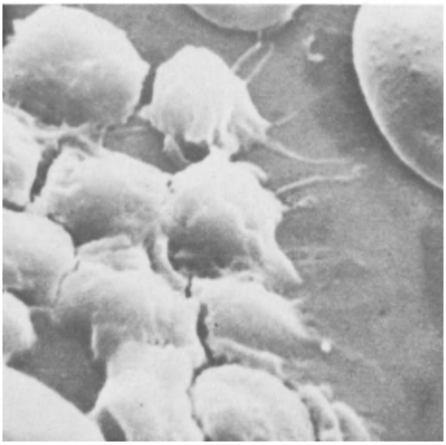
The use of experimental animals for research on platelet aggregation has made available much specialised information about platelet constituents for individual species and wide variation at the species level is indicated for adenine nucleotides [13], 5-hydroxytryptamine [14] histamine [15] and platelet surface glycoprotein types [37]. Marked species differences in response of platelets to aggregating agents and inhibitors have also been identified [13]. Comparative studies on platelet constituents and behaviour could be useful in elucidating functional mechanisms but great caution should be exercised in extrapolating results obtained in animal experiments to the human situation.

Blood coagulation

The blood coagulation mechanism has been extensively studied in man, mostly in relation to cause and treatment of congenital and acquired haemorrhagic disorders. In view of the problems faced by human patients with disordered haemostasis it can safely be assumed that all other living species possess a haemostatic process compatible with their way of life, but little is known about the mechanisms involved in non-mammals. Comparative studies have shown that thrombin-clottable fibrinogen occurs in all vertebrates [16] and a prothrombin-like precursor, converted rapidly to thrombin by homologous tissue factor is also present (Table 1.2). In mammals this reaction requires the presence of plasma factors V, VII and X but in other vertebrates the part played by plasma cofactors – if any – is not known [17]. By observing the ability of blood to clot *without* addition of tissue factor, an intrinsic pathway of prothrombin activation has been identified in some bony fish [18] in amphibians [11] and in mammals but this mechanism is apparently poorly developed in reptiles [19] and birds [20] (Table 1.2). A potent circulating anticoagulant has been identified in the blood

Figure 1.3 Aggregated Thrombocytes and Platelets

BABOON PLATELETS
(x4500)



TURKEY THROMBOCYTES
(x4000)

Baboon platelets aggregated by addition of ADP. Turkey thrombocytes obtained from clotted blood. Stereoscan electron microscopy.

of some reptiles [19], possibly present to counteract the risk of intravascular coagulation in animals with a slow circulation and sluggish way of life. In birds, absence of factors XI and XII is suggested by the fact that the plasma clotting time is not shortened by contact with glass or other activating surfaces [20]. In mammals, apart from Cetaceans and possibly the greater Kudu *(vide infra)*, both pathways of prothrombin activation are well developed. Congenital coagulation factor deficiencies have only been detected in domesticated animals existing in a protected environment.

The main reason for lack of understanding of the comparative part played in the blood coagulation mechanism by plasma factors is the fact that these factors are often species specific and do not react optimally in heterologous protein mixtures. Consequently it is difficult to devise test systems in which their activity and identity can be assessed. Substrate plasmas used for this purpose in human haematology are derived either from patients with known deficiencies of individual factors or by subjecting mammalian plasma to various well tried fractionation procedures. Thus optimum substrates are not usually available for other species. Even with other mammals, low readings obtained in heterologous mixtures of this type are difficult to interpret because they may merely reflect lack of reactivity. When extended to other vertebrates, species specificity is exaggerated and negative results become meaningless although positive findings may be acceptable. Using this kind of test system it can be demonstrated that amphibian plasma contains a factor which will replace human factor V but tests for factors VII, VIII, IX and X are negative [21]. In some birds a factor equivalent to human factor VIII is present but factors V, VII and X have not been detected [21].

In mammals the clotting factors known to be affected by species specificity are mainly those involved in the extrinsic pathway of prothrombin activation, particularly the reactions between tissue factor and factors VII and X [22, 23]. In practice this can influence the results of the one-stage prothrombin test and assay of factor VII. Factors II and X of

TABLE 1.2

SPONTANEOUS CLOTTING AND ENHANCEMENT
BY HOMOLOGOUS TISSUE FACTOR IN VERTEBRATES

Class	Whole Blood Clotting Time	One-Stage Prothrombin Time With Homologous Tissue Factor
Actinopterygii	Less than 1 min. (Blackfish) [18]	11.0 sec. (Catfish) [35]
Amphibia	6-12 mins. (Marine toad) [11]	11.5 secs. (Xenopus toad) [17]
Reptilia	Longer than 1 hour [19]	12.5 – 13.5 secs. (Lizard and tortoise) [34]
Aves	5-180 mins. [20, 32, 33]	12 secs. (chickens) [17]
Mammalia	Less than 12 mins.	9-15 secs.

mammals can be activated directly by Taipan snake venom [25] and Russell's viper venom [24] respectively, thus bypassing assay problems for these factors. There is no evidence of species specificity among factors taking part in intrinsic prothrombin activation of mammals and partial thromboplastin from those species which have been tested reacts equally well with plasma from all others. With the interesting exception that Cetaceans have no factor XII [26], and that factor XI is possibly missing in the Greater Kudu (Chapter 5) those clotting factors known to be present in human plasma can be found in all other mammals. Judged by human standards, the activity of these factors measured in conventional assay systems is often greatly increased, and confirmation that this is a true representation of clotting activity is obtained from parallel finding of short clotting times in direct tests not involving heterologous clotting mixtures, such as the whole blood clotting time, the recalcification time and thrombelastography (Figure 1.4). It can be suggested that wild animals may require a more efficient haemostatic mechanism than civilized man and it is interesting that there is no related increase in susceptibility to spontaneous thromboembolic cardiovascular diseases. These are in fact rare in animals other than man. [38]

Fibrinolysis

Amongst non-mammalian vertebrates spontaneous fibrinolytic activity has been recorded in some fish [18], amphibians [39, 27] and birds [28, 29] but not in reptiles. The difficulty in studying this mechanism in lower vertebrates is due mainly to lack of availability of artificial activators (Table 1.3) and the consequent inability to prove or disprove the presence of a plasminogen-like fibrinolytic precursor in any species except some amphibians which react with large doses of human urokinas [27], and birds in which activation can be produced by saliva from the vampire bat, *Diaemus youngi* [28, 30]. In mammals, plasminogen can be identified by its reaction with urokinase or streptokinase and quantitative tests show that the plasminogen level is high in most other mammals compared with man but levels of circulating plasminogen activator may be low. Activation by streptokinase requires the presence of a trace of normal human serum in some orders (Table 1.3); this finding has given

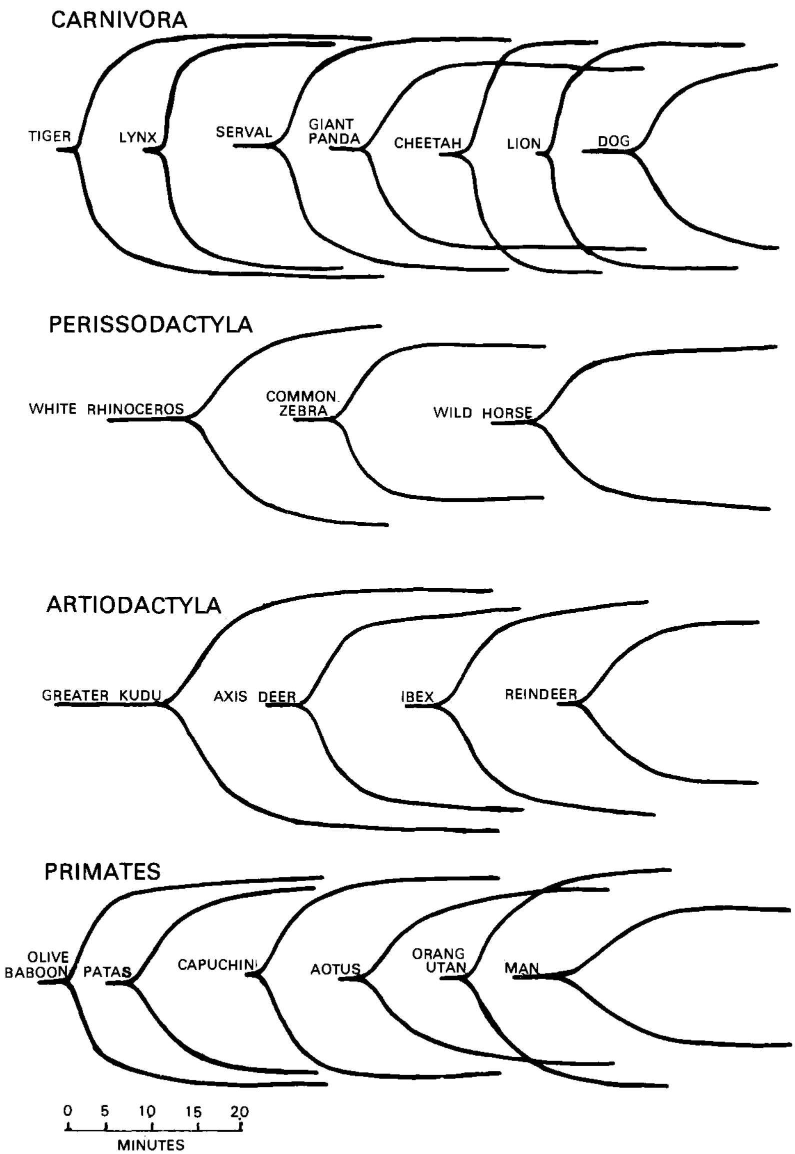
TABLE 1.3

ACTIVATORS OF FIBRINOLYSIS IN VERTEBRATE GROUPS

	Activation of fibrinolysis by:		
	UK	SK + HS	SK
Mammalia:			
Primates	+	+	+
Carnivora	+	+	+*
Insectivora	+	+	+
Edentata	+	+	+
Pinnipedia	+	+	+
Lagomorpha	+	+	+
Rodentia	+	+	0
Artiodactyla	+	+	0
Perissodactyla	+	+	0
Proboscidea	+	+	0
Hyracoidea	+	+	0
Marsupialia	+	+	0
Aves	0	0	0
Reptilia	0	0	0
Amphibia	+	0	0
Pisces	?	0	0

* Canidae require high concentrations.
UK = human urokinase
SK = streptokinase
HS = human serum 1/100

Figure 1.4 Thrombelastograph tracings on some normal mammals



rise to the theory that 'proactivator' is required for the reaction [31]. It should be borne in mind however that virtually all the streptokinase used in laboratory tests is derived from the same strain of β haemolytic streptococcus and, using other strains, different patterns of species activation can be obtained.

From the foregoing discussion it is apparent that there is much to be learnt about the blood picture and haemostatic processes at a comparative level, but that certain basic principles can be stated. In mammals, differences are quantitative rather than qualitative and, with the possible exception of platelet constituents and reactions, closely related animals generally show similar patterns. Within a zoological group, variations can often be explained by environmental adaptation and further comparative studies at this level should provide an interesting and rewarding exercise.

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Chapter 2

PRIMATES

The order Primates is divided into two suborders, the Prosimii (tree shrews, lemurs, lorises and bushbabies) and the Anthropoidea. In the Anthropoidea, three superfamilies are distinguished; the Ceboidea (New World Monkeys), the Cercopithecoidea (Old World Monkeys) and the Hominoidea (gibbons, chimpanzees, orangutans, gorilla, man). There are approximately 200 living species of primates and much sub-speciation occurs, sometimes making classification difficult. Non-human primates are distributed widely throughout central areas of the world, and although most species are threatened to a greater or lesser degree by the activities of man, the group can be considered as successful at the present time.

The haematology of non-human primates is of interest because of the close relationship of these animals with man, and laboratory data has become increasingly available since monkeys have gained popularity as experimental animals in medical research. Information is available from the literature on the blood picture of some prosimians [1-3], great apes [1, 2, 4-13, 113], old world [1, 2, 4, 6, 11, 14-72, 104], and new world [1, 2, 4, 13, 73-87] monkeys and the blood coagulation and related mechanisms have also been studied [88-112]. However, reported results are often difficult to interpret and compare because normal ranges are very wide and sometimes conflicting. There are a number of reasons for this variation including differences in sampling techniques and laboratory methods, problems with classification of the animals examined and failure to take into account the influence on the blood picture of variables such as diet [24, 75, 82, 89], the captive environment [114], diurnal and seasonal variation [31], experimental procedures [9, 11], anaesthetics, stress [13], age [5, 39, 50, 58, 64, 71], sex [3, 5, 32, 51, 64] and pregnancy [25, 50, 52, 83]. Recently comparative primate haematology has been the subject of an excellent monograph in which results from relatively large groups of sixteen species have been analysed statistically and the influence of many variables assessed [1]. This publication does much to reduce the existing confusion.

Red cells

On the whole the blood picture of non-human primates is similar to that of man. Those minor differences which are present are more exaggerated in the less closely related types (Prosimii and Cebidae) and approach human levels in the Pongidae. Red cells are similar in appearance to those of man, anisocytosis and poikilocytosis being minimal in normal animals. Haemoglobin levels, packed cell volume and MCHC are relatively constant throughout the order but the total red cell count is higher and the MCV and MCD lower in the more primitive types.

Reticulocytes are found in the peripheral blood of monkeys; in Cercopithecidae and Pongidae the response to blood loss is apparently similar to that of man. In Prosimians and and Cebidae the reticulocyte count is normally high and Howell Jolly bodies, polychromatic red cells, and late normoblasts occur in small numbers in the peripheral blood. These animals often show an exaggerated reticulocyte response to red cell loss.

Chronic iron deficiency anaemia resulting in hypochromia and lowered MCV has been described in some species of newly captured monkeys and in captive monkeys receiving inadequate dietary iron [1]. Parasitic infestation and frequent blood sampling may augment this defect. Captive monkeys are also prone to folic acid deficiency unless the intake of this vitamin is controlled [1]. Experimentally-induced folate deficiency in monkeys is associated with megaloblastic marrow changes [1, 59], and peripheral macrocytosis [18], leucopenia [59], thrombocytopenia [59] and increased hyperlobulation of the neutrophils [18]. Baboons normally have low serum B_{12} levels [60] and a progressive fall in the level of this vitamin has been reported in captive animals [61]. There is no evidence that experimentally induced [59] or acquired [61] B_{12} deficiency is associated with megaloblastic marrow changes or an abnormal blood picture in non-human species.

The erythrocyte sedimentation rate is generally slow in monkeys. It may be increased during pregnancy [26]. Occasionally raised values are encountered in apparently healthy animals. The clinical significance of the ESR in non-human primates requires further investigation.

White cells

Data available from the literature suggests that the average total white count for many monkey species is greater than that of man but in the present survey, where clinically abnormal animals have been excluded, this difference is not apparent although wide ranges are sometimes found. The white cell count of monkeys is increased by stress and is higher in females than males [1]. In adult animals, as in man, neutrophils usually outnumber lymphocytes but in rhesus monkeys and baboons a reversed neutrophil/lymphocyte ratio has been reported in immature animals [1]. This finding may well be found to apply to other species when different age groups are examined. White cell morphology is similar to that of man apart from hyperlobulation of the neutrophil nuclei which occurs in most non-human species. An interesting species difference has been noted in owl monkeys *(Aotus trivirgatus)* in which the eosinophil count is usually high, even in the absence of detectable parasites, and circulating eosinophils have cigar-shaped eosinophilic granules. In immature eosinophils in the marrow, the granules are spherical.

Because of the wide normal range in total white counts, evaluation of white cell morphology often gives a better indication of reaction to infection and increase in the proportion of immature neutrophils and the presence of toxic granulation or Döhle bodies are the most reliable signs of infection in monkeys. Chronic lymphatic leukaemia has been described in a small number of animals of this group [62, 108].

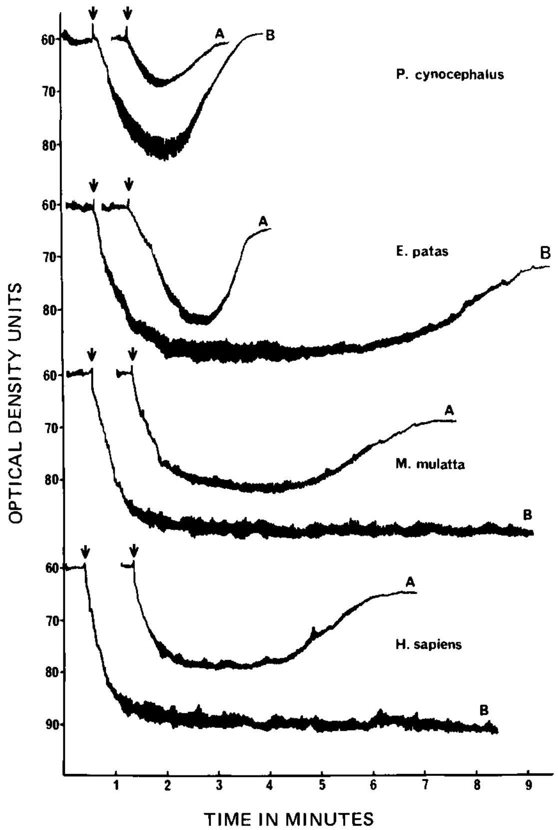
Platelets

Platelets stain well with Leishman stain and the platelet count is similar to or greater than that of man. Monkey platelets are aggregated rapidly by ADP but in some species, disaggregation occurs almost immediately [98] (Fig. 2.1). This is due to the presence in the plasma of high levels of an ADP-inactivator. There is evidence that the activity of this inhibitor decreases with increasing age [98]. Primary thrombocytopenia and functional platelet defects have not been found in monkeys. Progressive thrombocytopenia has been described in folate deficient baboons [59] and in rhesus *(Macaca mulatta)* [99] and owl monkeys *(A. trivirgatus)* [105] experimentally infected with malaria.

Blood coagulation

Clotting tests on non-human primates are relatively easy to carry out and to interpret as species specificity does not influence the reaction between monkey and human clotting proteins or tissues extract and standard human reagents and methods can be used (Table 2.1).

Figure 2.1. Patterns of ADP-induced platelet aggregation in primates.



Aggregation of platelets in PRP produced by addition of ADP. Arrows denote addition of ADP. Curve A shows the effect of 1.2 mg ADP per ml PRP. Curve B shows the effect of 12 mg ADP per ml PRP. Platelets 400 x 10^3/c.mm PRP.

TABLE 2.1

CROSS REACTIVITY BETWEEN HUMAN AND MONKEY PLASMA AND BRAIN EXTRACT

Plasma from	Prothrombin time (secs.) with brain extract from					
	M.mulatta	M.maurus	E.patas	C.ascaneus	Cebus sp.	H.sapiens
M. mulatta	14.0	13.5	13.4	14.0	14.0	15.0
M. maurus	14.0	14.0	14.5	14.0	14.0	14.5
E. patas	14.0	13.5	14.0	14.5	13.5	14.0
C. ascaneus	15.0	14.0	15.0	14.5	13.0	14.5
Cebus sp.	11.5	11.5	11.0	11.0	11.0	11.0
H. sapiens	14.5	14.0	14.0	14.0	14.0	14.0

Coagulation is rapid in the Cebidae and approaches the normal human picture in the Cercopithecidae and Pongidae. Comparative values for these groups are given in Table 2.2. Levels of factors II and X are generally within normal human range but factors V, VII, VIII, XI and XII are high. Low factor IX activity is often found in members of the Cercopithecidae but haemorrhagic symptoms are not encountered. These monkeys also have a prolonged clotting time with Russell's viper venom, due to an abnormal reaction between venom-activated factor X and monkey factors II and/or V [92].

TABLE 2.2

COMPARISON OF CLOTTING ACTIVITY IN PRIMATE GROUPS

Test	CEBIDAE	CERCOPITHECIDAE	PONGIDAE	MAN
PT/secs.	10.3	14.3	15.0	14.0
RVV/secs.	9.8	14.8	9.0	8.7
PTT/secs.	42	55	54	71
Thrombin time	8.2	7.7	7.4	6.4
Factor I mg/100ml	379	376	464	200-400
II %	90	94	63	50-150
V	680	183	86	50-150
VII	585	360	178	50-150
VIII	508	523	630	50-150
IX	230	58	94	50-150
X	221	101	153	50-150
XI		126	314	50-150
XII	487	408	542	50-150
Antithrombin units	460*	440	473	220-560

*Excluding very high results in *Aotus trivirgatus* (owl monkey).

Congenital coagulation defects have not been described in monkeys; this is not surprising since severe haemorrhagic diseases would be rapidly lethal in animals in the wild habitat. It is possible that under conditions of interbreeding and protected environment offered by the large Primate Centres, these diseases will eventually appear. There is no justification at present in regarding those monkeys in which the levels of factors II, IX and X are below the normal human limits as being abnormal. These factors are reduced in liver disease and vitamin K deficiency but the monkeys concerned have normal liver function tests and do not respond to injection of vitamin K. In the present survey, only in severe proven cases of vitamin K deficiency have haemorrhagic symptoms been encountered in monkeys.

Fibrinolysis

Plasminogen levels are generally higher in monkeys than in man. Circulating plasminogen activator is within the normal human range in most Cercopithecidae and Pongidae but is increased in some Cebidae. Since this group is also "hypercoagulable" compared with man, it provides some support for the theory that coagulation and fibrinolysis are normally present in a balanced equilibrium. Fibrinolytic inhibitors do not vary significantly in primates which have been examined [91]. Increased fibrinolysis has been encountered in monkeys in association with acute bacterial infections and anaphylactic shock, and can be induced experimentally by infusion of adrenaline.

Plasminogen of all primates is rapidly converted to plasmin by human urokinase and by streptokinase. Additional proactivator is not required for the latter reaction. The amount of SK required for plasminogen activation is considerably higher in baboons than in other primate species possibly due to a basic difference in the structure of the plasminogen molecule [100].

PROSIMII
TUPAIIDAE
Tupaia glis
Common tree shrew*

Test	Ref. 1 Av.	Ref. 1 Range	Ref. 2 Av.	Ref. 2 Range	Ref. 3 Av.	Ref. 3 Range
Hb	12.9	11.7-13.8	15.3	5.7-20.7	13.9	10.2-16.2
RBC	6.8	6.5-7.3	7.4	2.7-9.4	6.4	4.1-9.0
PCV	40.8	38-42	47.4	34.5-55.0	43	30-52
Retics						
MCV	59.8	52-64	64.0	51-90	67.6	55-97
MCH	18.97	16.1-20.5	20.8	15.4-28.7	21.7	16.4-31.4
MCHC	32.0	31-34	32.3	23-41	32.0	27.1-40.5
MCD						
WBC	3.2	2.0-5.4	3.3	0.85-6.1	4.4	1.4-11.3
N	58.5	49-70	24	5-62	15	0-52
L	26	15-34	73	13-84	80	3-100
M	4.8	1-9	0.2	0-4	0.4	0-2
E	9.3	5-19	2.5	0-12	3.8	0-15
B	3.2	0-3	0.6	0-5	0.8	0-8
Plts						
ESR						
ELT						
Pg						
AF						
	4 animals		21 males		45 females	

For blood coagulation see ref. 110.

* *The taxonomic status of tree shrews is at present uncertain but conventionally they are classified as prosimian primates.*

PROSIMII

LEMURIDAE

Lemur catta

Ringtailed lemur

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	14.6	13.4-16.4	8
RBC	6.5	5.5-7.2	8
PCV	49	45-53	8
Retics	1.3	0.6-2.6	8
MCV	77.5	70-85	8
MCH	22.6	20-25	8
MCHC	29.5	27-32	8
MCD	6.04	5.33-6.73	8
WBC	9.3	6-15	8
N	75	56-86	8
L	22	12-35	8
M	2	0.5-8.0	8
E	1	0-5	8
B	0		8
Plts	240	189-343	8
ESR	0.1	0-0.5	7
ELT		9-20h	7
Pg			
AF			

A small number of red cells contain Howell Jolly bodies.

See also ref. 2.

Survey Results

Test	*Av.*	*Range*	*No.*
PT	12.0	11.5-12.5	5
RVV	8.0	7-10	4
PTT	29	23-37	7
RT	45	35-47	7
KRT	33	38-37	5
TT	6.9	6.0-7.5	6
I	342	293-407	3
II	101		1
V	250		1
VII			
VIII	790	380-1000	3
IX	250		1
X	250		1
XI			
XII			
XIII	+		3
AT	350		1
CR			
TP	5.9	5.0-6.35	3

See also ref. 89

PROSIMII
LORISIDAE
Galago crassicaudatus
Thick-tailed bushbaby

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	14.2	12.9-16.3	6
RBC	8.0	7.3-8.6	6
PCV	43.6	39-49	6
Retics	0.8	0.1-1.5	6
MCV	55.0	46.0-58.4	6
MCH	17.9	14.6-19.7	6
MCHC	32.6	30-35	6
MCD			
WBC	17.5	12.1-24.0	6
N	57	33-75	6
L	38	22-60	6
M	4	2-7	6
E	3.7	1-8	6
B	0.3	0-1	6
Plts	427	314-662	6
ESR			
ELT	24h+		5
Pg			
AF			

A small number of red cells normally contain Howell Jolly bodies

Survey Results

Test	*Av.*	*Range*	*No.*
PT			
RVV	9.0	8-10	2
PTT	136	80-185	6
RT	170	85-390	6
KRT	98	85-108	2
TT	8.0	7-9	2
I			
II			
V			
VII			
VIII	190		1
IX	86		1
X	100		2
XI			
XII			
XIII	+		2
AT			
CR			
TP	6.5		1

PROSIMII
LORISIDAE
Galago senegelensis
Lesser galago

	Ref. 88		*Ref. 88*	
Test	*Av.*	*Range*	*Av.*	*Range*
Hb	17.2	13.6-20.4	15.8	13.2-17.6
RBC	7.3	3.4-8.4	6.6	5.9-7.4
PCV	51.5	44-58	45.8	40-51
Retics				
MCV	70.06	63.5-81.0	69.1	63.4-73.7
MCH	23.4	19.0-27.5	23.8	19.2-27.3
MCHC	33.7	30.4-37.3	34.5	34.5-40.0
MCD				
WBC	8.4	3.6-16.5	9.0	4.8-13.4
N	1.57*	0.3-3.3	1.7*	0.5-3.6
L	6.5*	3.3-12.6	6.5*	4.0-10.6
M	0.2*	0-0.5	0.3*	0.06-0.6
E	0.9*	0-0.3	0.22*	0-0.7
B				
Plts	533	431-684	591	359-1027
ESR				
ELT				
Pg				
AF				

9-11 males *11-15 females*

$*X10^3/c.mm.$

ANTHROPOIDEA
CEBOIDEA
CALLITRICHIDAE
Callithrix jaccus
Common marmoset

	Survey Results			*Ref. 73*
Test	*Av.*	*Range*	*No.*	*Av.*
Hb	14.1	12.5-15.3	6	10.8-18.7
RBC	6.15	5.8-6.3	4	4.8-7.4
PCV	44	41-51	6	36.5-62.6
Retics	0.6	0.4-0.7	4	0.2-10.1
MCV	70.9	66-78	4	58.7-90.7
MCH	23.6	21-26	4	20.3-27.7
MCHC	32.1	31-34	6	32.3-40.9
MCD	6.98	6.83-7.09	4	
WBC	6.5	2-11	5	4.1-20.3
N	76	72-83	5	
L	19	12-22	5	
M	4	3-5	5	
E	0.5	0-2	5	
B	0.5	0-2	5	
Plts	375	290-430	3	81-866
ESR				
ELT				
Pg				
AF				

A small number of red cells normally contain Howell Jolly bodies.

Immature animals have a reversed neutrophil/lymphocyte ratio.

See also ref. 2.

12-15 animals

ANTHROPOIDEA
CEBOIDEA
CALLITRICHIDAE
Saguinus geffroyi
(Geoffroy's tamarin)

	Ref. 77		*Ref. 77*	
Test	*Av.*	*SD*	*Av.*	*SD*
Hb	11.7	± 1.8	12.2	± 1.9
RBC	4.0	± 0.76	4.1	± 0.69
PCV	36.1	± 5.1	39.5	± 7.0
Retics				
MCV	91.6	± 10.5	95.8	± 1.0
MCH	29.9	± 1.4	29.7	± 0.4
MCHC	32.7	± 4.4	31.0	± 0.8
MCD				
WBC	13.0	± 3.8	11.8	± 4.9
N	75.5	± 6.9	68	± 13.5
L	22	± 7.2	29.5	± 13.7
M	1.5	± 0.5	1.8	± 1
E	1.0	± 0.9	0.5	± 0.8
B	0		0	
Plts				
ESR				
ELT				
Pg				
AF				
	7 females		*6 males*	

See also ref. 88.

ANTHROPOIDEA
CEBOIDEA
CEBIDAE
Aotus trivirgatus
Owl monkey or Douroucouli

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	16.0	12.6-18.1	125
RBC	5.6	4.8-6.7	125
PCV	47.5	38-56	125
Retics	5.9	2.2-10.3	125
MCV	85.5	70-100	125
MCH	30.8	27.4-33.8	125
MCHC	33.5	30-38	125
MCD	7.27	7.16-7.41	6
WBC	9.7	5.0-14.3	125
N	48.5	16-64	125
L	35.5	16-44	125
M	3	1-6	125
E	12	0-31	125
B	1	0-2	125
Plts	260	145-558	99
ESR	0.3	0-1	15
ELT	322	243-480	10
Pg	6.4	5.8-6.8	10
AF			

Ref. 84

Av.	*Range*
14.3	11.9-16.0
5.17	3.5-7.7
42	31-56
2.4	0.1-10.6
82.4	61.7-118.4
26.9	21.7-37.7
34.1	29.6-39.4
12.7	3.2-28.5
55.4	13-91
35.5	5-80
9.5	0-37
<0.1	0-1
397	204-734

Survey Results

Test	*Av.*	*Range*	*No.*
PT	11.6	10-12	12
RVV	11.7	11-14	12
PTT	48	43-53	12
RT	82	78-88	12
KRT	62	48-90	12
TT	7.5	6-10	12
I	459	282-612	12
II	94	70-130	12
V	417	240-540	12
VII	1000+		12
VIII	546	300-1000	12
IX	513	500-540	12
X	180	110-230	12
XI			
XII	487	230-560	4
XIII	+		12
AT	1426	1290-1610	12
CR			
TP	6.64	5.39-8.26	12

Eosinophils have cigar-shaped granules

60-157 animals

Some red cells contain
Howell Jolly bodies.

See also ref. 2.

For effect of diet on blood picture, see ref. 76

ANTHROPOIDEA
CEBOIDEA
CEBIDAE
Cebus capucinus
White-throated capuchin

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	13.9	13.3-15.6	4
RBC	5.0	4.6-5.8	4
PCV	43	40-46	4
Retics	0.4	0.2-0.6	4
MCV	85.9	79-98	4
MCH	27.6	27-29	4
MCHC	31.8	29.0-33.5	4
MCD	7.0	6.91-7.09	2
WBC	5.4	4.2-6.4	4
N	45	31-70	4
L	46	22-58	4
M	7	1.5-10	4
E	2	0-3	4
B	0		4
Plts	166	108-229	3
ESR	0.1	0-0.5	3
ELT	38	20-60	3
Pg			
AF			

Ref. 75

Av.	*±SD*
16.6	± 1.35
6.98	± 0.79
50	± 3.23
0.45	± 0.34
72.2	± 7.31
23.8	± 1.83
33.0	± 1.74
7.5	± 2.29
23.9	± 4.45
66.1	± 11.0
2.6	± 2.79
6.8	± 1.16
0.6	± 0.95

20-25 C.apella and C. capucinus Classification discussed.

Survey Results

Test	*Av.*	*Range*	*No.*
PT	10.5	9-12	5
RVV	12.5	9.5-18.5	5
PTT	41	37-46	5
RT	85	80-89	2
KRT	36	32-42	3
TT	10.5	9.0-12.0	2
I	404	301-468	3
II			
V			
VII			
VIII			
IX			
X			
XI			
XII			
XIII	+		3
AT			
CR			
TP			

PF3 release 61
Range 54-65 (4 animals)
PF3 total 96
Range 93-98 (4 animals)
Contact activation index 47
Range 41-56 (4 animals)

See also ref. 85. Species not given.

ANTHROPOIDEA
CEBOIDEA
CEBIDAE
Cebus apella
Tufted capuchin

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	13.0	11.9-14.0	3
RBC	4.6	4.4-4.8	2
PCV	44	43-45	3
Retics	0.6		1
MCV	95.5	95-96	2
MCH	30.0	29.5-30.5	2
MCHC	29.2	27-31	3
MCD	6.51	6.18-6.74	3
WBC	4.3	2.6-5.8	3
N	62	47-72	3
L	32	23-43	3
M	4	3-7	3
E	1	0-2	3
B	1	0-3	3
Plts	147		1
ESR	0.5		1
ELT	35		1
Pg			
AF			

Ref. 2

Av.
13.2
5.1
6.8
10.4
68
21
2
5
3

No. not given

Survey Results

Test	*Av.*	*No.*
PT	11.0	1
RVV	11.0	1
PTT	35	1
RT	50	1
KRT	34	1
TT	7.1	1
I	240	1
II	94	1
V	800	1
VII	420	1
VIII	1000+	1
IX	70	1
X	80	1
XI		
XII		
XIII	+	1
AT		
CR		
TP		

See also ref. 75.

ANTHROPOIDEA
CEBOIDEA
CEBIDAE
Cebus albifrons
White-fronted capuchin

	Survey Results			*Ref. 1*	
Test	*Av.*	*Range*	*No.*	*Av.*	*Range*
Hb	14.4	12.8-16.0	23	14.2	11.3-16.4
RBC	5.7	4.1-5.9	23	5.4	5.3-5.5
PCV	48	39-52	23	40.4	40-41
Retics	1.0	0.1-2.8	23		
MCV	84.2	72-93	23	73.5	72-75
MCH	25.2	24-33	23	28.6	26.4-30.8
MCHC	30.0	27.8-36.0	23	33.5	26-41
MCD	6.68	6.13-7.07	23		
WBC	6.8	3.2-9.8	23	17.5	12-22
N	48	42-57	23	28.3	16-40
L	43	33-47	23	65.3	59-74
M	7	5-8	23		
E	2	0-4	23		
B	1	0-2	23		
Plts	220	131-328	20		
ESR	0.1	0-2	12		
ELT	42	10-95	5		
Pg					
AF					

Survey Results

Test	*Av.*	*Range*	*No.*
PT	10.5	9.0-13.5	8
RVV	9.5	6-13	12
PTT	40	35-48	12
RT	54	46-69	12
KRT	34	31-41	12
TT	7.0	6.5-7.5	12
I	327	176-425	7
II	80	42-125	5
V	750	230-1000	5
VII	545	530-560	2
VIII		320-1000+	4
IX	60	30-81	4
X	95	50-300	11
XI			
XII			
XIII	+		7
AT			
CR			
TP	6.58	6.25-7.15	5

2-4 animals

ANTHROPOIDEA
CEBOIDEA
CEBIDAE
Cebus nigrivittatus
Weeper Capuchin

Survey Results

Test	*Av.*	*No.*
Hb	12.5	1
RBC	4.8	1
PCV	42	1
Retics	0.4	1
MCV	88.0	1
MCH	26.2	1
MCHC	29.2	1
MCD	7.26	1
WBC	5.0	1
N	35.5	1
L	59	1
M	4	1
E	1	1
B	0.5	1
Plts	210	1
ESR	0.2	1
ELT	51	1
Pg		
AF		

Survey Results

Test	*Av.*	*No.*
PT	11.0	1
RVV	11.5	1
PTT	43	1
RT	59	1
KRT	39	1
TT	8.0	1
I	217	1
II	90	1
V	800	1
VII		
VIII	1000+	1
IX		
X		
XI		
XII		
XIII	+	1
AT		
CR		
TP		

ANTHROPOIDEA
CEBOIDEA
CEBIDAE
Ateles paniscus
Black spider monkey

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	13.8	12.1-15.8	3
RBC	5.2	4.9-5.5	3
PCV	41	36-44	3
Retics	0.5	0-1	3
MCV	78.8	69-89	3
MCH	26.5	25-28	3
MCHC	32.5	25-37	3
MCD	7.0	6.9-7.1	3
WBC	5.5	4.3-6.7	2
N	41	33-48	2
L	56	49-64	2
M	1.5	1-3	2
E	1.5	1-3	2
B	0		2
Plts	287	229-393	3
ESR	1.2	0-2.5	2
ELT	10		1
Pg			
AF			

For blood picture of other Ateles sp.
see refs 1, 2 & 85.

ANTHROPOIDEA
CEBOIDEA
CEBIDAE
Alouatta caraya
Howler monkey

Ref 87

Test	*Av.*	*± SD*
Hb	12.6	± 2.5
RBC	4.4	± 1.3
PCV		
Retics		
MCV		
MCH		
MCHC		
MCD		
WBC	8.5	± 40
N	54	
L	42	
M	2.6	
E	1.0	
B	1.0	
Plts		
ESR		
ELT		
Pg		
AF		

5-11 animals

ANTHROPOIDEA
CEBOIDEA
CEBIDAE
Lagothrix lagothrica
Humboldt's woolly monkey

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	13.1	12.6-15.5	9
RBC	4.8	4.0-5.7	9
PCV	39	35-46	9
Retics	1.2	0.4-3.0	9
MCV	81.2	72.2-92.0	9
MCH	27.3	22.0-30.5	9
MCHC	33.7	27-36	9
MCD	6.98	6.72-7.31	9
WBC	5.0	3.8-6.6	9
N	57	26-74	9
L	33	19-66	9
M	6	3-10	9
E	4	0.5-11	9
B	0		9
Plts	274	191-543	9
ESR	0.4	0-1	9
ELT	210	150-270	2
Pg			
AF			

Survey Results

Test	*Av.*	*Range*	*No.*
PT	13.7	12.5-15.0	2
RVV	9.4	8-10	4
PTT	54	52-56	3
RT	89	75-105	3
KRT	54	53-56	3
TT	9.7	9-10	3
I	480	376-631	4
II	105		1
V	760	500-900	3
VII	210		1
VIII	180		1
IX	120	100-140	2
X	390	180-800	4
XI			
XII			
XIII	+		4
AT	460		1
CR			
TP	7.08	6.43-7.82	4

ANTHROPOIDEA
CEBOIDEA
CEBIDAE
Saimiri sciureus
Squirrel Monkey

	Survey Results			*Ref. 1*		*Ref. 78*		*Ref 86*	
Test	*Av.*	*Range*	*No.*	*Av.*	*Range*	*Av.*	*Range*	*Av.*	*Range*
Hb	13.2	12.0-15.2	9	13.2	12.4-14.3	13.7	11.6-17.1	12.9	8.2-15.4
RBC	5.6	4.7-6.8	9	6.5	6.0-7.6	6.8	5.7-8.2	7.3	5.5-9.5
PCV	40	35-43	9	41.7	37-47	41.1	35.5-51.5	38.6	25-45
Retics	1.5	0.5-3.0	9			1.1	0.2-4.1	0.97	0-3.5
MCV	74	70-78	9	64.9	57-76	59.9	48.6-66.7	53.1	43.9-69.5
MCH	24.1	22-27	9	20.2	18.9-22.9			17.8	14.6-22.4
MCHC	32.6	30-35	9	31.2	29-34	33.4	31.4-37.3	33.6	30.9-37.4
MCD									
WBC	5.6	4.3-6.8	9	10.4	4.0-20.7	11.2	5.7-23.6	10.4	4.5-23.8
N	36	16-50	9	58.5	26-89	53	23-80	40.7	8-76
L	57	39-83	9	35.9	9-68	39	18-69	48.6	18-81
M	4	1-7	9	3.4	0-11	2	0-7	3.4	0-15
E	2.5	0-6	9	1.9	0-18	6.2	0-21	6.2	0-40
B	0.5	0-1	9	0.3	0-2	0.1	0-1	0.2	0-3
Plts	396	230-534	9			448	378-561		
ESR						1.3	0.5-4.0	1.4	0-12
ELT									
Pg									
AF									
				11-25 animals		*31 animals*		*59 animals*	

See also refs. 2, 75-83, 107.

Squirrel Monkey

	Result Survey			*Ref. 78*		*Ref. 89*		*Ref. 103*	
Test	*Av.*	*Range*	*No.*	*Av.*	*Range*	*Av.*	*± SD*	*Av.*	*Range*
PT	7.5	7-8	3	7.7*	6.5-8.6	8.6	± 0.2	8.3	8.1-8.4
RVV	7.2	6.5-8.0	2	11.3	10.6-12.0				
PTT	35	31-40	3			40.3	± 0.7		
RT	55	45-65	3						
KRT	42	35-51	3						
TT	8.2	7.5-9.0	3	10.8	7.8-12.6			8.3	8.0-8.5
I	228	194-281	3			157	± 6	378	370-385
II	82	70-100	3			268	± 15	81	70-88
V	810	640-1000	3					264	220-384
VII									
VIII								311	256-376
IX								91	88-95
X								108	
XI								68	64-70
XII								388	276-536
XIII	+		3					200	118-256
AT									
CR									
TP	5.55	5.33-5.88	3						

10 animals (Ref. 78) *11 animals* (Ref. 89) *3 animals* (Ref. 103)

**rabbit brain extract*

ANTHROPOIDEA
CERCOPITHECOIDEA
CERCOPITHECIDAE
Macaca nemestrina
Pig-tailed macaque

	Survey Results			*Ref. 1*		*Ref. 21*		*Ref. 21*	
Test	*Av.*	*Range*	*No.*	*Av.*	*Range*	*Av.*	*Range*	*Av.*	*Range*
Hb	12.5	10.3-15.5	8	13.1	12.3-14.3	11.3	8.5-14.2	11.5	9.8-12.2
RBC	5.3	4.3-7.0	8	5.9	5.4-6.6	5.95	4.75-7.01	5.62	5.13-6.33
PCV	42	35-47	8	42.5	38-48	41.8	31-47	41.2	38.0-42.6
Retics	0.5	0-1.4	8						
MCV	79.3	74-82	8	71.5	63-81	70.4	60.8-85.4	71.9	66.2-79.5
MCH	23.6	19.2-25.7	8	22.1	19.0-24.8	19.0	16.3-24.4	20.4	17.1-22.9
MCHC	30.0	28.1-32.1	8	31.0	29-34	27.1	22.1-30.5	27.8	25.8-28.1
MCD	7.04	6.94-7.09	8			7.2	6.6-7.6	7.1	7.0-7.3
WBC	7.6	3.9-15.0	8	11.5	7.6-16.5	11.78	8.5-16.7	12.1	8.5-17.6
N	69	60-82	8	41	19-73	50.1	44-58	48.8	42.0-55.8
L	24.5	17-34	8	42	19-76	44.9	37-51	48.5	41.2-54.2
M	5	0-8	8	2.5	1-5	2.3	0.5-8.0	1.0	0.5-2.6
E	1	0-2	8	3.4	0-16	2.0	0-5	1.4	0.5-2.0
B	0.5	0-1	8	0.1	0-1	0.7	0-3	0.3	0.2-1.0
Plts	190	149-309	7						
ESR	8	0-13	5						
ELT	390*	240-600	6						
Pg	6.35	5.9-6.75	4						
AF									
	**One animal gave an ELT of 24 hours.*			*9 animals*		*26 males*		*4 females*	

See also ref. 63.

Pig-tailed macaque

	Survey Results			*Ref. 89*		*Ref. 103*	
Test	*Av.*	*Range*	*No.*	*Av.*	*± SD*	*Av.*	*Range*
PT	15.0	13-17	6	12.6	± 0.3	13.5	10.8-22.8
RVV	22.4	19-28	6			15.9	14.0-17.5
PTT	55	50-60	6	46.8	± 1.3	24.2	20.3-31.3
RT	81	60-103	6				
KRT	48	35-57	6				
TT	8.9	6.0-10.5	6			18.0	13.8-21.8
I	447	355-512	5	338	± 26	387	228-656
II	80	74-86	2			140	114-160
V	79	70-89	5			157	124-184
VII							
VIII	500		1			190	122-260
IX	29		1			52	29-77
X	115		1			130	100-160
XI						82	56-100
XII	120		1			426	292-512
XIII	+		5			88	61-116
AT	539		1				
CR							
TP	6.16	5.47-7.13	5				

11 animals (Ref. 89) *10 animals* (Ref. 103)

ANTHROPOIDEA
CERCOPITHECOIDEA
CERCOPITHECIDAE
Macaca fascicularis = M. irus
Cynomologous or crab-eating macaque

	Survey Results			Ref. 1		Ref. 38		Ref. 63	
Test	*Av.*	*Range*	*No.*	*Av.*	*Range*	*Av.*	*± SD*	*Av.*	*Range*
Hb	12.7	9.2-14.7	5	11.5	9.4-13.2	11.3		12.7	
RBC	6.0	4.8-7.3	5	5.9	5.3-7.4	5.2		5.6	
PCV	42	36-49	5	40	33.0-47.5	32.3		41	
Retics	1.2	0.5-2.2	4						
MCV	70.0	59-91	5	66.0	61-74	61.6			
MCH	21.2	11.2-27.5	5	18.2	17-21	21.6			
MCHC	30.2	26.5-32.1	5	28.6	26-32	35.0		31.0	
MCD	7.12	6.78-7.85	4						
WBC	7.9	6.8-8.8	5	12.7	6.2-23.2			14.8	
N	84	74-96	5	52	31-79			8.7*	
L	13.5	4-22	5	42	19-63			4.4*	
M	2	0-4	5	3	0-9			0.7*	
E	0.5	0-1	5	3	0-16			0.4*	
B	0		5	0.5	0-3			0.01*	
Plts	338	242-498	4	393	268-445			412	191-890
ESR	1	0.5-2.0	4			1.3	± 0.6		
ELT	960		1						
Pg									
AF									

7-24 animals (Ref. 1) *200 animals* (Ref. 38) *60 animals* (Ref. 63)

$* X10^3/c.mm$

See also refs. 2, 36, 37

Cynomologous (crab eating) macaque

	Survey Results			*Ref. 96*		*Ref. 103*	
Test	*Av.*	*Range*	*No.*	*Av.*	*Range*	*Av.*	*Range*
PT	18.5	15-22	2	10.9	9.5-12.5	12.1	10.8-13.3
RVV	15.0		2			15.1	14.5-16.0
PTT	67	48-85	2	44.2	30-55	21.7	18.8-25.8
RT	100		2				
KRT	53	50-55	2				
TT	9.75	9.5-10.0	2			14.0	12.3-14.8
I	418	388-448	2	274	200-450	320	178-641
II	80		1	116	90-130	146	100-176
V				70	44-118	153	122-196
VII							
VIII				120	53-170	180	102-272
IX				44	30-60	59	40-76
X	59	45-72	2	120	66-180	90	78-100
XI				115	100-130	106	72-128
XII						447	320-576
XIII	+		2			116	80-164
AT							
CR	61		1				
TP	6.64		1				
				4-21 animals		*12 animals*	

ANTHROPOIDEA
CERCOPITHECOIDEA
CERCOPITHECIDAE
Macaca mulatta
Rhesus monkey

	Survey Results			*Ref. 1*		*Ref. 40*		*Ref. 72*	
Test	*Av.*	*Range*	*No.*	*Av.*	*Range*	*Av.*	*Range*	*Av.*	*Range*
Hb	12.1	9.4-14.0	20	12.3	8.1-16.4	12.2	10.2-14.2	11.7	7.0-16.5
RBC	5.2	4.2-5.6	20	5.6	4.1-7.8	5.38	4.5-7.2	5.5	3.1-8.6
PCV	40	33-48	20	42	24-52	42.1	37-49	37	12-51
Retics	1.25	0.2-2.8	20			1.15	0-2.8	0.4	0.06-2.6
MCV	76.9	67-104	20	76	56-106	78.6	67.7-91.2		
MCH	23.3	17.7-28.0	20	22	15-33	22.8	18.8-28.8		
MCHC	30.2	25-35	20	29	21-36	28.9	25.3-35.3		
MCD	6.75	6.62-7.17	17						
WBC	7.6	3.5-16.9	20	10.9	2.6-31.4	10.95	4.3-20.0	15.1	12-43
N	67	55-84	20	40	7-95	41.1	13-70	36	4-91
L	26.9	13-42	20	55	4-90	55.7	25-86	60.5	7-95
M	4	2-9	20	1.1	0-10			0.7	0-8
E	1	0-4	20	3.3	0-24	2.7	0-12	2.6	0-16
B	0.1	0-1	20	0.25	0-3			0.2	0-4
Plts	295	134-385	20	417	120-940	454	228-760	344	250-750
ESR	3	0.5-24	20					0.9	0-28
ELT	105*	60-210	5						
Pg	6.4	4.7-7.5	6						
AF	123								

* *A further 12 animals had ELT's of 24 hours +.*

No. of animals 750 *200 animals* *538 animals*

For influence on blood count of stress see refs. 13, 30
sex see refs. 13, 32, 41
age see refs. 39, 50, 71
diet see ref. 24
pregnancy see refs. 25, 26, 51

For general haematology, see refs. 2, 14, 32, 36, 42-48, 52, 63, 70, 104

Rhesus monkey

Survey Results				*Ref. 101*		*Ref. 103*		*Ref. 111*	
Test	*Av.*	*Range*	*No.*	*Av.*	*Range*	*Av.*	*Range*	*Av.*	*Range*
PT	13.6	12-16	12			12.4	11.4-13.3	12.3	10.4-14.4
RVV	14.2	11-24	11			15.5	13.5-18.0	26	15-38
PTT	59	43-78	13			24	18-34	45	29-97
RT	112	84-138	10	124					
KRT	56	37-71	12						
TT	6.7	4-8	15			15.1	12.1-26.3		
I	395	282-518	8	259	180-440	347	224-509	230	100-400
II	64	51-80	9	94	60-110	134	86-172		
V	238	56-1000	15			146	118-192		
VII									
VIII	828	640-1000	4			237	162-340		
IX						51	34-67		
X	110	40-250	6			129	112-184		
XI						100	75-118		
XII	66		1			527	440-616		
XIII	+		15			117	100-136		
AT									
CR	57	50-63	2						
TP	6.86	6.55-6.96	7						
				10 animals		*10 animals*		*77 animals*	

PF3 release 66
Range 62-71 (5 animals)
PF3 total 103
Range 80-120 (5 animals)
Contact activation index 58
Range 55-61 (2 animals)

See also refs. 72, 89, 102.

ANTHROPOIDEA
CERCOPITHECOIDEA
CERCOPITHECIDAE
Macaca sylvana
Barbary ape

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	13.0	10.5-14.6	7
RBC	5.0	4.3-5.7	7
PCV	40.5	35-45	7
Retics	1.3	0-1.8	5
MCV	81.5	75-90	7
MCH	26.2	21.2-31.5	7
MCHC	31.7	29.5-34.4	7
MCD	6.92	6.73-7.34	7
WBC	7.0	4.8-10.4	7
N	78	45-93	7
L	18	7-48	7
M	3	0-7	7
E	1	0-2	7
B	0		
Plts	303	220-398	7
ESR	0.4	0-1	5
ELT	191	100-330	5
Pg	4.73	4.3-5.2	2
AF	112		1

For haematology see Ref. 55

Survey Results

Test	*Av.*	*Range*	*No.*
PT	14.2	13-15	5
RVV	14.2	13.5-15.0	5
PTT	50	49-53	5
RT	100	85-114	5
KRT	49	42-55	5
TT	8.5	7.5-10.5	5
I	294	233-384	4
II	86	44-115	4
V			
VII	225	210-240	2
VIII			
IX	14		1
X	110		1
XI			
XII			
XIII	+		4
AT	389	325-414	3
CR	66		1
TP	6.35	6.1-6.72	3

ANTHROPOIDEA
CERCOPITHECOIDEA
CERCOPITHECIDAE
Macaca assamensis
Assamese macaque

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	11.6	11.2-12.0	2
RBC	5.1	5.0-5.2	2
PCV	39.5	38-41	2
Retics	0.7	0-1.4	2
MCV	75.5	72-79	2
MCH	22.9	22.0-23.8	2
MCHC	29.3	29.0-29.6	2
MCD	7.18	7.17-7.19	2
WBC	13.7	12.4-15.1	2
N	80	77-83	2
L	14	11-17	2
M	5	4-6	2
E	0.25	0-0.5	2
B	0.75	0.5-1.0	2
Plts	211	178-245	2
ESR	2	1-3	2
ELT	720	700-740	2
Pg			
AF			

Survey Results

Test	*Av.*	*Range*	*No.*
PT	13.0	12-14	2
RVV	18.5	18-19	2
PTT	50	49-51	2
RT	82	55-109	2
KRT	63	52-75	2
TT	8.25	7.5-9.0	2
I	497	475-520	2
II			
V			
VII	140		1
VIII			
IX			
X			
XI			
XII			
XIII	+		2
AT	625	590-660	2
CR			
TP	6.58	5.92-7.25	2

Contact activation index 51
Range 48–54 (2 animals)

ANTHROPOIDEA
CERCOPITHECOIDEA
CERCOPITHECIDAE
Macaca speciosa
Stump-tailed macaque

	Survey Results			*Ref. 53*		*Ref. 112*		*Ref. 112*	
Test	*Av.*	*Range*	*No.*	*Av.*	*Range*	*Av.*	*Range*	*Av.*	*Range*
Hb	11.3	10.4-12.0	5	12.7	10.5-14.1	12.2	6.9-14.9	12.0	6.3-19.2
RBC	4.9	4.7-5.2	5	4.86	4.2-5.6				
PCV	37.5	34-39	5	37.8	30-43	39	14-47	40	24-56
Retics	0.2	0-0.8	5	1.9	0-8	1.38	0.1-5.8	1.2	0.1-2.9
MCV	76	70-80	5	77.7	77-88				
MCH	22.9	21.5-23.8	5	26.2	23-30				
MCHC	29.5	28.5-30.5	5	33.7	31-36				
MCD	7.0	6.79-7.5	5						
WBC	7.8	4.5-12.0	5			14.9	3.9-37.8	14.1	5.2-36.6
N	65	48-77	5			28	1-82	31	4-88
L	30	18-47	5			67	29-98	61	11-93
M	3.4	2-6	5			0.5	0-11	0.5	0-12
E	1.5	0-5	5			3.6	0-31	5.1	0-40
B	0.1	0-0.5	5			0.2	0-0.5	0.2	0-3
Plts	268	194-372	5			169	130-230	193	120-270
ESR	2	1-7	5			2.1	0-14	4	0-45
ELT	394*	210-720	4						
Pg	6.33	6.15-6.5	2						
AF	92		1						
				36 animals		*77 males*		*79 females*	

* *A further 2 animals had ELT of 24 hours.*

See also refs. 1, 54.

Stump-tailed macaque

	Survey Results			*Ref. 89*		*Ref. 103*		*Ref. 112*	
Test	*Av.*	*Range*	*No.*	*Av.*	*± SD*	*Av.*	*Range*	*Av.*	*Range*
PT	13.5	12-14	5	10.9	± 0.4	12.8	10.8-17.3	15.3	7.5-50.5
RVV	16.1	12.5-20.0	5			15.2	14.0-16.5		
PTT	50	39-64	5	44.7	± 1.1	21.9	19.3-27.2	26.5	11-46
RT	87	80-97	5						
KRT	47	43-51	5						
TT	8.8	8-10	5			15.9	11.8-21.3		
I	443	417-485	4	325	± 72	311	224-477		
II	133	110-155	2			152	124-172		
V	100		1			124	68-164		
VII	115		1						
VIII	490		1			193	140-276		
IX	70		1			52	35-80		
X						100	78-148		
XI						77	70-89		
XII	270		1			483	368-606		
XIII	+		4			134	90-174		
AT	496	430-575	3						
CR									
TP	6.81	6.73-6.90	3						

Contact activation index 55
Range 51-57 (3 animals)

No. = 3 (Ref. 89) *No. = 10* (Ref. 103) *No. = 72+* (Ref. 112)

ANTHROPOIDEA
CERCOPITHECOIDEA
CERCOPITHECIDAE
Macaca maurus
Moor monkey

Survey Results

Test	Av.	Range	No.
Hb	11.6	9.8-13.0	7
RBC	5.5	4.7-6.2	7
PCV	41.5	37-46	7
Retics	0.8	0.4-2.0	7
MCV	76.1	65-89	7
MCH	21.4	17.7-24.5	7
MCHC	27.7	24.4-29.8	7
MCD	7.14	7.0-7.28	6
WBC	8.4	3.3-12.9	7
N	57.5	34-75	7
L	36	18-62	7
M	5	2-10	7
E	1	0-3	7
B	0.5	0-2	7
Plts	195	130-274	5
ESR	2.8	0.5-8.0	5
ELT	135	15-300	5
Pg	5.62	4.85-6.25	3
AF			

Ref. 1

Av.	Range
12.2	12.0-12.6
5.5	5.1-5.8
40	37-43
75.3	75-76
22.5	21.8-23.8
30.8	29-33
12.2	11.2-14.6
43	21-66
45	32-73
4.5	1-7
7	0-17
0.5	0-1

No. = 34

Survey Results

Test	Av.	Range	No.
PT	15.1	14.0-17.5	6
RVV	21.8	18-24	5
PTT	43	40-49	6
RT	93	80-110	3
KRT	52	43-65	3
TT	9.0	7-10	5
I	364	214-539	4
II			
V	187	160-200	3
VII			
VIII			
IX			
X	59	45-72	2
XI			
XII	80		1
XIII	+		4
AT			
CR			
TP	6.99	6.52-7.30	3

See also ref. 2.

ANTHROPOIDEA
CERCOPITHECOIDEA
CERCOPITHECIDAE
Macaca silenus
Lion-tailed monkey

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	11.7	10.4-13.0	2
RBC	5.4	4.6-6.2	2
PCV	42.5	38-47	2
Retics	0.3	0-0.6	2
MCV	78.7	73-84	2
MCH	21.6	21-23	2
MCHC	27.5	27-28	2
MCD	7.22	7.0-7.45	2
WBC	8.6	7.8-9.5	2
N	77	69-85	2
L	24.5	23-26	2
M	2	1-3	2
E	0.5	0-1	2
B	0		2
Plts	380		1
ESR	10		1
ELT	35		1
Pg			
AF			

Survey Results

Test	*Av.*	*No.*
PT	15.5	1
RVV	20.0	1
PTT	40	1
RT		
KRT		
TT		
I	211	1
II		
V		
VII		
VIII		
IX		
X	42	1
XI		
XII		
XIII	+	1
AT		
CR	63	1
TP		

ANTHROPOIDEA
CERCOPITHECOIDEA
CERCOPITHECIDAE
Macaca sinica
Toque monkey

	Ref. 27		*Ref. 27*	
Test	*Av.*	*Range*	*Av.*	*Range*
Hb	14.1	11.1-19.0	14.1	11.3-19.4
RBC	6.3	4.6-8.0	5.69	4.7-7.4
PCV	43.7	32-51	49.7	45-56
Retics				
MCV	70.5	46.8-85.8	87.7	67.2-107.0
MCH	21.1	20.08-25.0	24.7	16.6-29.8
MCHC	32.5	25.7-42.9	27.9	22.5-38.8
MCD	6.78	6.4-7.04	6.55	6.4-6.8
WBC	16.6	10.0-26.5		
N	32	11-64		
L	62	33-86		
M	2.7	0-6		
E	3.2	0-20		
B	0.2	0-1		
Plts				
ESR				
ELT				
Pg				
AF				
	No. = 13		*No. = 26*	
	12 months at 6000ft above sea level.		*Newly arrived from plains.*	

ANTHROPOIDEA
CERCOPITHECOIDEA
CERCOPITHECIDAE
Cynopithecus niger
Black ape

Survey Results / *Ref. 1*

Test	*Av.*	*Range*	*No.*	*Av.* (Ref. 1)	*Range* (Ref. 1)
Hb	11.5	10.5-12.0	4	12.0	10.4-13.2
RBC	5.6	5.5-5.9	4	6.3	5.1-7.0
PCV	44.5	40-50	4	42.3	39-45
Retics	0.3	0.2-0.4	2		
MCV	79.3	73-85	4	67.9	64-77
MCH	20.8	19.4-22.0	4	19.2	17.8-20.4
MCHC	25.8	23.4-27.2	4	28.4	27-30
MCD	7.17	7.11-7.24	4		
WBC	8.3	6.5-10.8	4	15.5	11.1-20.4
N	69	48-84	4	39	19-53
L	20	15-38	4	54	40-75
M	9	4-13	4	1.9	0-4
E	1	0-2	4	4.9	1-9
B	1	0-3	4	0.2	0-1
Plts	159	152-164	2		
ESR	1.7	1.5-2.0	2		
ELT	203	200-205	2		
Pg	4.6		1		
AF					

Survey Results

Test	*Av.*	*Range*	*No.*
PT	18.8	18.5-19.0	2
RVV	20.7	19.0-22.5	2
PTT	53	46-60	2
RT	72		1
KRT	38		1
TT	8.25	7.0-9.5	2
I	464		1
II			
V			
VII			
VIII			
IX			
X	29		1
XI			
XII			
XIII	+		2
AT	360		1
CR			
TP			

10 animals

ANTHROPOIDEA
CERCOPITHECOIDEA
CERCOPITHECIDAE
Papio anubis
Olive baboon

	Survey Results			*Ref. 15*		*Ref. 19*		*Ref. 17*	
Test	*Av.*	*Range*	*No.*	*Av.*	*Range*	*Av.*	*±SD*	*Av.*	*±SD*
Hb	13.8	12.4-16.3	18	12.8	8.9-16.7	14.0	± 2.09	11.8	± 1.16
RBC	4.7	4.2-6.0	18			4.9	± 1.13	4.45	± 0.5
PCV	42	37-49	18	42	37-49			35.8	± 8.7
Retics	1.0	0-1.8	18	0.6	0-1.2				
MCV	89.4	80-94	18						
MCH	29.4	26.7-31.2	18						
MCHC	32.8	30.5-35.0	18	32	26-34				
MCD	70.6	6.74-7.18	6						
WBC	6.4	3.0-7.8	18	7.2	3.9-16.0	10.2	± 4.38	10.0	± 4.2
N	41	16-76	18	47	28-72	64	±17.9	56	±19.5
L	53	23-76	18	50	28-78	31	±15.5	32	±16.7
M	5	1-8	18	0		0.7	± 0.96	2.4	± 2.7
E	0.5	0-1	18	3	1-12	1.0	± 1.12	1.7	± 1.9
B	0.5	0-1	18	0		0.2	± 0.44	0.02	±0.13
Plts	291	143-451	18	360	260-480				
ESR	0.8	0.5-1.5	15			0.3	± 0.8		
ELT	214	100-330	13						
Pg	4.7	4.3-5.2	4						
AF	42		1						
				No. = 70		*No. = 86*		*No. = 100*	
				P. anubis and P. cynocephalus				*P. anubis and P. cynocephalus*	

See also refs. 6, 18.
For effect of age on blood picture of P. anubis see ref. 39.
For effect of age on blood picture of Papio sp. see ref. 58.
For sex differences in Papio sp. see ref. 13.

Olive baboon

	Survey Results			*Ref. 103*	
Test	*Av.*	*Range*	*No.*	*Av.*	*Range*
PT	13.7	11.5-16.0	10	16.2	14.0-19.9
RVV	15.0	9-20	10	17.1	16-19
PTT	51	38-58	10	36.5	31.5-44.0
RT	92	55-130	10		
KRT	68	35-91	10		
TT	7.7	5-10	8	11.8	10.9-13.5
I	314	144-462	10	326	277-461
II	50	47-52	6	105	85-124
V	122	76-160	9	139	89-164
VII	347	325-370	5		
VIII	470	450-500	8	147	80-224
IX	85	50-120	5	89	53-120
X	73	43-100	9	98	84-114
XI				33	23-38
XII	260		1	300	252-352
XIII	+		10	89	68-112
AT	462	365-540	4		
CR	68	66-70	2		
TP	5.45	4.57-6.09	5		

PF3 release 66
Range (3 animals) 56-78
PF3 total 99
Range (3 animals) 86-116
Contact activation index 48
Range 23-60 (3 animals)

For coagulation studies on Papio sp.

See refs. 17, 95, 97

No. = 8

P. anubis and
P. papio

ANTHROPOIDEA
CERCOPITHECOIDEA
CERCOPITHECIDAE
Papio cynocephalus
Yellow baboon

	Survey Results			*Ref. 2*	*Ref. 16*		*Ref. 20*	
Test	*Av.*	*Range*	*No.*	*Av.*	*Av.*	*Range*	*Av.*	*Range*
Hb	12.9	10.3-14.8	23	12.7	12.7	12.3-13.7	13.6	10.9-16.3
RBC	4.8	4.0-5.7	17	6.9				
PCV	42	36-50	23		38	36.5-40.5	44	37-51
Retics	0.9	0.2-2.4	16					
MCV	87.5	78-96	17					
MCH	26.9	23-33	17					
MCHC	30.7	27-34	17				31.9	29.9-33.9
MCD	7.15	6.99-7.53	14	7.7				
WBC	4.5	3.0-6.8	17	10.4	8.0	4-12	13.0	5.8-20.2
N	43	17-68	17	65	45	36-60	31	
L	49	27-77	17	29	50	40-65	65	
M	5.8	1-10	17	2	1.5	1-3	2.75	
E	2	0-9	17	2	4	2-7	1	
B	0.2	0-1.5	17	1			0.25	
Plts	238	135-349	22					
ESR	0.5	0-1	16					
ELT	269	100-585	10					
Pg	5.9	4.2-6.8	5					
AF	100	88-116	3					
				No. not stated	*No. not stated*		*No. = 37*	

See also under P. anubis

For haematology of neonates and infant yellow baboons see ref. 64.

Yellow baboon

Survey Results

Test	*Av.*	*Range*	*No.*
PT	13.9	13.0-15.5	18
RVV	12.4	9-17	18
PTT	49	45-60	18
RT	67	65-104	18
KRT	53	49-56	18
TT	6.6	5.5-8.0	18
I	396	272-475	18
II	70	60-79	7
V	125	62-160	5
VII	310	260-370	5
VIII	460	400-500	5
IX	42	35-50	4
X	94	70-125	7
XI	17	14-20	2
XII	237	130-245	2
XIII	+		8
AT	143	305-400	2
CR	69	68-70	2
TP	6.41	6.1-6.63	3

PF3 release 68 (one animal)
PF3 total 111 (one animal)
Contact activation index 42, range 28-56 (2 animals)

For coagulation studies on Papio sp. see refs. 17, 95, 97.

ANTHROPOIDEA
CERCOPITHECOIDEA
CERCOPITHECIDAE
Papio papio
Guinea baboon

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	13.0	11.2-15.0	8
RBC	4.7	4.2-5.4	8
PCV	43	39-48	8
Retics	0.8	0-1.8	8
MCV	91.4	76.5-98.0	8
MCH	27.6	24.3-32.5	8
MCHC	30.2	28.8-34.0	8
MCD	7.11	6.81-7.63	6
WBC	8.1	6.4-11.4	8
N	68	28-87	8
L	24	7-43	8
M	7	1-11	8
E	1	0-2	8
B	0		8
Plts	203	148-236	8
ESR	1.5	1-2.5	5
ELT	164	75-250	4
Pg	5.1	4.8-6.2	4
AF	85		1

Survey Results

Test	*Av.*	*Range*	*No.*
PT	14.0	10-17	5
RVV	14.6	10-20	5
PTT	77	62-90	5
RT	76	48-105	5
KRT	60	57-65	5
TT	6.8	6-7	5
I	411	306-517	5
II	87	62-99	4
V	180	110-270	4
VII	490		1
VIII	210		1
IX	55		1
X	120		1
XI			
XII			
XIII	+		5
AT	387	365-430	2
CR	65	62-67	2
TP	6.76	6.42-7.11	2

PF3 release 79
Range 77-81 (2 animals)
PF3 total 102
Range 91-114 (2 animals)
Contact activation index 65
Range 55-73 (5 animals)

See also under P. anubis

ANTHROPOIDEA
CERCOPITHECOIDEA
CERCOPITHECIDAE
Papio hamadryas
Sacred baboon

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	13.8	11.7-15.8	4
RBC	4.9	4.6-5.1	4
PCV	43.5	40-45	4
Retics	1.5	1.2-1.8	2
MCV	91.1	85.9-99.0	4
MCH	28.1	23.3-31.4	4
MCHC	31.2	29.0-34.6	4
MCD	7.03	6.96-7.17	4
WBC	7.0	4.4-8.0	4
N	73	66-80	4
L	21	16-28	4
M	4	2-6	4
E	1.5	0.5-2	4
B	0.5	0-2	4
Plts	212	205-218	2
ESR	0.25	0-0.5	2
ELT	173	90-240	3
Pg	3.77	3.45-4.1	2
AF			

Ref. 32

Av.	*SD/range*
11.5	± 0.9
5.8	± 0.04
13.4	± 9.85
55.5	± 1.42
32.8	± 0.89
	4-8
	1-6
	0-1
	2-5

No. = 187

Survey Results

Test	*Av.*	*Range*	*No.*
PT	16.2	13.5.-20.0	3
RVV	16.3	13.5-20.0	3
PTT	52	47-64	2
RT	87	80-94	2
KRT	60.5	59-62	2
TT	7.0		2
I	397	365-446	3
II	82		1
V	160		1
VII	270	160-380	2
VIII			
IX			
X	90		1
XI			
XII	175		1
XIII	+		3
AT	330	300-360	2
CR			
TP	5.56	5.42-5.80	3

Contact activation index 69
Range 66-72 (2 animals)

ANTHROPOIDEA
CERCOPITHECOIDEA
CERCOPITHECIDAE
Mandrillus sphinx
Mandrill

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	10.9	9.0-12.7	5
RBC	4.2	3.5-5.0	5
PCV	37	33-39	5
Retics	1.2	0.2-2.0	5
MCV	87.8	78-93	5
MCH	25.8	22.3-28.5	5
MCHC	28.8	27-32	5
MCD	7.42	6.89-7.96	5
WBC	6.1	4.3-9.6	5
N	67	49-83	5
L	27.5	14-43	5
M	5.0	1-10	5
E	0.4	0-1	5
B	0.1	0-0.5	5
Plts	183	134-292	5
ESR	3	0.5-12	5
ELT	249	240-260	4
Pg	5.35	5.2-5.5	2
AF			

Survey Results

Test	*Av.*	*Range*	*No.*
PT	14.0	13-15	5
RVV	19.0	17-20	5
PTT	62	53-73	5
RT	95	80-117	5
KRT	56	50-59	5
TT	5.4	6.8-8.0	5
I	395	312-524	3
II	96	39-150	3
V	405	90-720	2
VII	210		1
VIII			
IX			
X			
XI	120		1
XII			
XIII	+		3
AT	440	365-516	4
CR	52		1
TP	6.03	5.35-7.20	4

ANTHROPOIDEA
CERCOPITHECOIDEA
CERCOPITHECIDAE
Mandrillus leucophaeus
Drill

Survey Results | *Ref. 1* | *Survey Results*

Test	*Av.*	*No.*	*Av.*	*Range*	*Test*	*Av.*	*Range*	*No.*
Hb	12.0	1	12.6	11.7-13.2	PT	12.0		1
RBC	4.5	1	4.8	4.3-5.5	RVV			
PCV	40	1	41.2	38-44	PTT	49	46-52	2
Retics	0.3	1			RT	97		1
MCV	88.5	1	85.6	79-95	KRT	53		1
MCH	26.6	1	26.4	23.8-30.7	TT	6.0		2
MCHC	30	1	30.6	29-33	I	510		1
MCD	7.25	1			II	64		1
WBC	4.8	1	10.1	5.4-14.6	V	170		1
N	48	1	53.6	35-70	VII			
L	46	1	41	26-59	VIII	800		1
M	5	1	3.6	0-7	IX	70		1
E	1	1	1.4	0-3	X	100		1
B	0	1	0.4	0-1	XI			
Plts	240	1			XII			
ESR					XIII	+		1
ELT	720	1			AT	550		1
Pg	8.0	1			CR	71		1
AF					TP	5.54		1

5 animals

ANTHROPOIDEA
CERCOPITHECOIDEA
CERCOPITHECIDAE
Cercopithecus pygerethrus
Vervet monkey

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	14.0	11.9-17.0	14
RBC	5.1	4.3-5.9	14
PCV	46	36-52	14
Retics	0.8	0.2-1.5	14
MCV	84.0	78-90	14
MCH	26.8	24-30	14
MCHC	31.5	30-33	14
MCD	6.95	6.5-7.42	7
WBC	6.3	5.2-7.9	14
N	50	42-59	14
L	44	29-55	14
M	4	1-7	14
E	1.5	0-3	14
B	0.5	0-1	14
Plts	326	213-468	14
ESR	0.5	0-2	11
ELT	287	275-300	5
Pg			
AF	75		1

Survey Results

Test	*Av.*	*Range*	*No.*
PT	12.0	11.5-12.5	3
RVV	11.0	10-12	3
PTT	60	56-63	2
RT	123	71-175	2
KRT	51	38-64	2
TT	7.75	7.0-8.5	2
I	230	227-233	2
II			
V	370		1
VII			
VIII	415	230-600	2
IX	130		1
X			
XI			
XII			
XIII	+		2
AT			
CR			
TP	6.24		1

Contact activation index 32
Range 28-35 (2 animals)

ANTHROPOIDEA
CERCOPITHECOIDEA
CERCOPITHECIDAE
Cercopithecus sabaeus
Green monkey

Test	Av. (Survey Results)	Range (Survey Results)	No. (Survey Results)	Av. (Ref. 2)
Hb	12.4	10.3-15.1	3	12.7
RBC	5.3	4.4-6.0	3	6.4
PCV	44.5	43-48	3	
Retics	0.7	0.6-0.8	2	
MCV	87.6	76-97	3	
MCH	23.6	21.4-26.0	3	
MCHC	27.7	23.7-31.8	3	
MCD	7.37	7.26-7.49	2	7.8
WBC	4.9	4.1-6.0	3	12.6
N	68	59-79	3	58
L	27	16-36	3	31
M	4	3-5	3	3
E	1	0-2	3	7
B	0		3	
Plts	307	270-343	2	
ESR	5.0	0.5-9.5	2	
ELT	240		1	
Pg				
AF				

No. not given (Ref. 2)

Survey Results

Test	Av.	Range	No.
PT	16.5	16-17	2
RVV	12.0		1
PTT	54		1
RT	139		1
KRT	60	53-68	2
TT	10.25	8.5-12.0	2
I	375	360-390	2
II	160		1
V			
VII	240		1
VIII			
IX			
X			
XI	120		1
XII			
XIII	+		2
AT			
CR			
TP	6.29		1

See also refs. 34 & 66 for Cercopithecus Sp.

ANTHROPOIDEA
CERCOPITHECOIDEA
CERCOPITHECIDAE
Cercopithecus aethiops
Grass monkey

Ref. 33

Test	*Av.*	*± SD*
Hb		
RBC	5.64	± 0.6
PCV		
Retics		
MCV		
MCH		
MCHC		
MCD		
WBC	16.5	± 3.4
N	15	12-17
L	68	65-70
M	15	13-16
E	1.4	± 0.5
B	1.4	± 0.5
Plts	466	± 0.6
ESR		
ELT		
Pg		
AF		

No = 5

Ref. 103

Test	*Av.*	*Range*
PT	13.5	11.9-17.0
RVV	13.5	12.0-14.5
PTT	24.2	21.9-26.9
RT		
KRT		
TT	12.0	10.9-14.0
I	224	176-266
II	126	104-162
V	105	57-156
VII		
VIII	236	156-320
IX	48	38-68
X	217	116-328
XI	85	56-108
XII	392	300-560
XIII	127	79-180
AT		
CR		
TP		

No = 11

For blood picture see also refs. 34, 68, 69

ANTHROPOIDEA
CERCOPITHECOIDEA
CERCOPITHECIDAE
Cercopithecus mona
Mona monkey

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	13.6	12.4-15.6	3
RBC	5.7	5.3-6.2	3
PCV	44.5	37-54	3
Retics	1.6	1.3-1.9	2
MCV	77.0	69-88	3
MCH	23.4	21.2-27.0	3
MCHC	30.2	30.0-30.5	3
MCD	6.46	6.34-6.62	3
WBC	8.8	5.2-12.6	3
N	67	45-76	3
L	29	14-51	3
M	3	1-6	3
E	1	0-2	3
B	0		
Plts	288	184-400	3
ESR	0.6	0-1	3
ELT	180		2
Pg			
AF			

Survey Results

Test	*Av.*	*Range*	*No.*
PT	20.0		1
RVV	13.0	12-14	2
PTT	50		2
RT	80	70-99	2
KRT	51	48-54	2
TT	13.5	12-15	2
I	324	266-383	2
II	85	78-92	2
V	83	77-90	2
VII	1000+		1
VIII			
IX			
X	140		1
XI			
XII			
XIII	+		2
AT			
CR			
TP			

ANTHROPOIDEA
CERCOPITHECOIDEA
CERCOPITHECIDAE
Cercopithecus talapoin
Talapoin monkey

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	14.2	12.1-16.3	6
RBC	5.4	4.7-6.0	6
PCV	45	40-52	6
Retics	1.5	0.6-2.6	6
MCV	84.5	79-87	6
MCH	26.5	25.5-27.2	6
MCHC	30.8	29.2-33.0	6
MCD	6.97	6.76-7.25	7
WBC	7.3	4.3-12.0	10
N	70	56-84	10
L	36	12-38	10
M	3	1-7	10
E	0.5	0-1	10
B	0.5	0-1	10
Plts	188	135-248	10
ESR	0.3	0-0.5	10
ELT	150	120-180	2
Pg			
AF			

Survey Results

Test	*Av.*	*Range*	*No.*
PT	14.8	14.5-15.0	3
RVV	18.8	17.5-20.0	2
PTT	58	55-62	3
RT	75		1
KRT	66		1
TT	9.0	8-10	2
I			
II			
V			
VII			
VIII			
IX			
X			
XI			
XII			
XIII			
AT			
CR			
TP			

ANTHROPOIDEA
CERCOPITHECOIDEA
CERCOPITHECIDAE
Cercopithecus sclateri
Sclater's spotnosed monkey

Survey Results

Test	*Av.*	*No.*
Hb	15.0	1
RBC	5.5	1
PCV	47.5	1
Retics	0.8	1
MCV	86.0	1
MCH	27.0	1
MCHC	31.0	1
MCD	7.23	1
WBC	11.4	1
N	75	1
L	17	1
M	8	1
E	0	1
B	0	1
Plts	625	1
ESR	1	1
ELT	480	1
Pg		
AF		

Survey Results

Test	*Av.*	*No.*
PT	15.0	1
RVV	13.5	1
PTT	40	1
RT	74	1
KRT	55	1
TT	9	1
I	324	1
II		
V		
VII		
VIII		
IX		
X		
XI		
XII		
XIII	+	1
AT		
CR		
TP		

ANTHROPOIDEA
CERCOPITHECOIDEA
CERCOPITHECIDAE
Cercopithecus albigularis
Syke's monkey

Survey Results

Test	*Av.*	*No.*
Hb		
RBC		
PCV		
Retics		
MCV		
MCH		
MCHC		
MCD	7.17	1
WBC	6.6	1
N	41	1
L	52	1
M	1	1
E	5	1
B	1	1
Plts	468	1
ESR	0.5	1
ELT	170	1
Pg		
AF	74	1

Survey Results

Test	*Av.*	*Range*	*No.*
PT	13.5		1
RVV	13.5		1
PTT	45		1
RT	103		1
KRT	44		1
TT	7.5		1
I			
II			
V			
VII			
VIII			
IX			
X			
XI			
XII	160		1
XIII			
AT			
CR			
TP	6.0	5.7-6.3	2

Contact activation index 55
Range 54-56 (2 animals)

ANTHROPOIDEA
CERCOPITHECOIDEA
CERCOPITHECIDAE
Cercopithecus diana
Diana monkey

Survey Results

Test	*Av.*	*No.*
Hb	11.9	1
RBC	5.1	1
PCV	40	1
Retics	0.2	1
MCV	79.0	1
MCH	23.7	1
MCHC	29.2	1
MCD	7.23	1
WBC	4.4	1
N	69	1
L	24	1
M	6	1
E	1	1
B	0	1
Plts		
ESR	1	1
ELT	105	1
Pg		
AF		

Survey Results

Test	*Av.*	*Range*	*No.*
PT	14.0		1
RVV	12.0		1
PTT	85		1
RT	127		1
KRT	67		1
TT	8		1
I	461		1
II			
V			
VII			
VIII			
IX			
X			
XI			
XII			
XIII	+		1
AT			
CR	65	63-67	3
TP			

ANTHROPOIDEA
CERCOPITHECOIDEA
CERCOPITHECIDAE
Cercopithecus l'hoesti
L'hoest's monkey

Survey Results

Test	*Av.*	*No.*
Hb	12.5	1
RBC	4.9	1
PCV	42	1
Retics	0.5	1
MCV	86.1	1
MCH	25.5	1
MCHC	29.9	1
MCD		
WBC	5.3	1
N	66	1
L	23	1
M	5	1
E	4	1
B	2	1
Plts		
ESR	0.5	1
ELT	480	1
Pg	5.8	1
AF		

Survey Results

Test	*Av.*	*No.*
PT	11.0	1
RVV	10.0	1
PTT	54	1
RT	132	1
KRT	90	1
TT	5.5	1
I	481	1
II	270	1
V	270	1
VII		
VIII	1000+	1
IX		
X		
XI		
XII		
XIII	+	1
AT		
CR		
TP	6.14	1

ANTHROPOIDEA
CERCOPITHECOIDEA
CERCOPITHECIDAE
Erythrocebus patas
Patas monkey

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	12.6	11.0-13.6	24
RBC	5.0	4.4-5.5	24
PCV	42	40-45	24
Retics	0.4	0-1	24
MCV	83.9	76.5-94.0	24
MCH	25.5	20.5-28.8	24
MCHC	29.6	25.4-32.0	24
MCD	6.92	6.47-7.39	10
WBC	5.3	3.5-10.2	24
N	39	24-60	24
L	53	23-75	24
M	6.5	2-10	24
E	1	0-4	24
B	0.5	0-2	24
Plts	303	205-445	24
ESR	0.3	0-0.5	19
ELT	135	85-355	28
Pg	5.15	3.4-6.4	5
AF	67	26-92	6

Survey Results

Test	*Av.*	*Range*	*No.*
PT	16.0	14.5-18.0	23
RVV	12.5	8-16	22
PTT	63	47-89	26
RT	97	83-120	23
KRT	60	44-80	19
TT	8.3	6.5-10.0	26
I	295	182-410	17
II	58	28-123	12
V	240	110-400	23
VII	180	110-230	7
VIII	400	210-640	19
IX	45	20-64	7
X	93	62-170	18
XI			
XII	215	180-260	3
XIII	+		18
AT			
CR	68		1
TP	5.6	4.88-6.3	8

PF3 release 71
Range (7 animals) 63-85
PF3 total 110
Range (7 animals) 92-117
Contact activation index 43
Range 28-51 (8 animals)

ANTHROPOIDEA
CERCOPITHECOIDEA
CERCOPITHECIDAE
Theropithecus gelada
Gelada baboon

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	11.75	11.1-12.4	4
RBC	4.2	3.9-4.6	4
PCV	36	34-38	4
Retics	1.4	0.2-3.5	4
MCV	85.7	81.5-91.0	4
MCH	27.9	25.2-30.5	4
MCHC	32.6	30.9-33.5	4
MCD			
WBC	5.5	3.3-8.4	6
N	68	56-84	6
L	27	10-42	6
M	3	1-6	6
E	1	0-2	6
B	1	0-2	6
Plts	243	153-394	5
ESR	3	1-5	3
ELT			
Pg			
AF			

Survey Results

Test	*Av.*	*No.*
PT	12.5	1
RVV	12.0	1
PTT	95	1
RT	171	1
KRT	75	1
TT	10	1
I	624	1
II		
V		
VII		
VIII		
IX		
X		
XI		
XII		
XIII	+	1
AT		
CR		
TP	6.14	1

ANTHROPOIDEA
CERCOPITHECOIDEA
CERCOPITHECIDAE
Cercocebus torquatus
White-collared mangabey

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	13.4	12.6-14.2	2
RBC	4.8	4.5-5.1	2
PCV	43		1
Retics	0.1		1
MCV	90.0		1
MCH	27.8	27.6-28.0	2
MCHC	33.0		1
MCD	7.35		1
WBC	4.9	4.4-5.2	3
N	56	41-75	3
L	36	23-48	3
M	7.5	4-10	3
E	0.5	0-1	3
B	0		3
Plts	300		1
ESR	0.5	0-1	2
ELT	304	90-600	3
Pg	4.65		1
AF			

See also refs 66, 67

Survey Results

Test	*Av.*	*Range*	*No.*
PT	13.8	13.5-14.0	3
RVV	16.0	15-18	3
PTT	51	49-52	3
RT	90		1
KRT	59		1
TT	8.5	7-10	2
I	408	388-428	3
II	40		1
V	120		1
VII	900		1
VIII			
IX	38		1
X	221		1
XI			
XII			
XIII	+		1
AT	550		1
CR	71		1
TP	5.54		1

ANTHROPOIDEA
HOMINOIDEA
HYLOBATIDAE
Hylobates lar
Lar gibbon

Survey Results				*Ref. 1*		*Survey Results*			
Test	*Av.*	*Range*	*No.*	*Av.*	*Range*	*Test*	*Av.*	*Range*	*No.*
Hb	11.7	9.7-14.2	6	13.9	9.2-17.1	PT	10.0		1
RBC	5.6	5.2-6.4	6	5.7	3.8-6.9	RVV	7.0		2
PCV	40	34-43	6	45	33-54	PTT	56	52-60	2
Retics	0.8	0-1.5	6			RT	80	75-85	2
MCV	67.4	62-74	6	78.5	66-100	KRT	54	50-57	2
MCH	20.3	18-22	6	24.2	18.9-33.1	TT	7.5	6-9	2
MCHC	29.7	28-32	6	30.9	27-38	I	608	417-800	2
MCD	6.66		2			II	66	62-70	2
WBC	6.7	2.8-9.7	6	7.8	2.9-19.2	V	57	37-78	2
N	50	30-70	6	46	2-82	VII			
L	47	36-52	6	48	14-98	VIII	700		1
M	5	0-10	6	2.7	0-14	IX	150		2
E	2	0-5	6	2.1	0-21	X	200	180-220	2
B	1	0-2	6	0.5	0-3	XI			
Plts	283	266-320	6	210	120-250	XII			
ESR	2	0-5	5			XIII	+		2
ELT	260		1			AT			
Pg						CR			
AF						TP			

No. = 64

ANTHROPOIDEA
HOMINOIDEA
HYLOBATIDAE
Hylobates hoolock
Hoolock gibbon

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	12.3	10.5-14.1	2
RBC	5.3	5.2-5.4	2
PCV	44	39-49	2
Retics	0.4		1
MCV	82.2	72.0-92.3	2
MCH	23.4	19.8-26.9	2
MCHC	27.8	27.2-28.4	2
MCD	7.20	7.17-7.23	2
WBC	12.3	11.9-12.7	2
N	78	74.0-82.5	2
L	12	11-13	2
M	7	4.5-10.0	2
E	2.5	0-5	2
B	0.5	0-1	2
Plts	278		1
ESR	0.5		1
ELT	105		1
Pg			
AF			

Survey Results

Test	*Av.*	*Range*	*No.*
PT	22.0		1
RVV	10.5		1
PTT	49		1
RT	88		1
KRT	46		1
TT	7.5		1
I	419		1
II	57		1
V	78		1
VII	240		1
VIII			
IX	50		1
X	180		1
XI			
XII	325	230-420	2
XIII	+		1
AT			
CR	61		1
TP	5.24		1

ANTHROPOIDEA
HOMINOIDEA
PONGIDAE
Pan troglodytes
Chimpanzee

	Survey Results			*Ref. 1*		*Ref. 5*		*Ref. 5*	
Test	*Av.*	*Range*	*No.*	*Av.*	*Range*	*Av.*	*SD*	*Av.*	*SD*
Hb	13.4	9.7-18.2	23	12.5	7.2-19.0	13.6	1.4	13.9	1.3
RBC	5.1	3.8-6.8	23	4.6	2.8-7.0	5.34	0.49	5.37	0.58
PCV	44.5	38-58	23	39.7	22-59	42.4	3.7	42.8	3.4
Retics	0.8	0-2.4	14						
MCV	87.8	81-98	23	86	71-123	79.6	5.4	80.1	5.7
MCH	26.6	23.8-29.0	23	27	21-40	25.4	2.0	26.0	2.4
MCHC	29.7	25.2-34.3	23	31.2	26-38	32.1	2.1	32.5	2.2
MCD	7.2	6.86-7.51	12						
WBC	8.3	3.1-13.1	23	12.5	1.8-30.0	12.0	4.8	12.1	4.3
N	55	42-81	12	63	19-92	42.3	14.4	41.8	14.4
L	38	10-54	12	31	7-78	50.1	13.4	53.0	14.3
M	5	1-12	12	1	0-7	1.5	2.6	0.9	2.1
E	1.5	0-6	12	2.6	0-16	3.6	4.2	2.7	2.7
B	0.5	0-2	12	0.2	0-3	0.2	0.4	0.2	0.4
Plts	222	129-302	16	349	120-650	363	115	339	116
ESR	6	0.5-20.0	15			18.0		15.3	
ELT	107	25-240	22						
Pg	3.95	2.75-5.18	5						
AF	131	110-152	2						
				No. = 138+		*Males*		*Females*	

399 tests on 115 animals

See also refs. 2, 6, 7, 10, 11, 66, 93, 113.

Chimpanzee

	Survey Results			Ref. 103		Ref. 94	
Test	*Av.*	*Range*	*No.*	*Av.*	*Range*	*Av.*	*± SD*
PT	15.7	13-20	13	14.7	14-19		
RVV	10.6	7-16	20	7.6	7-8	49	± 0.3
PTT	52	39-73	22	30.5	27-34	80	± 2.5
RT	73	47-99	20				
KRT	47	35-70	18				
TT	6.7	4-8	20	13.5	11-17		
I	447	198-843	19	416	367-481		
II	68	37-170	14	70	64-75		
V	96	58-140	12	87	70-100		
VII	120	45-240	9				
VIII	538	270-1000	14	164	146-180		
IX	90	63-300	9	113	100-130		
X	97	49-250	17	97	67-112		
XI	400	380-420	2	130	108-144		
XII	247	180-370	3	423	328-520		
XIII	+		14	206	130-288		
AT	542	390-725	6				
CR	67	66-68	2				
TP	5.25	5.04-6.68	9				
				5 animals		*6 animals*	

PF3 release 66.3
Range (3 animals) 66-67
PF3 total 114
Range (3 animals) 94-133
Contact activation index 52
Range 37-60 (5 animals)

ANTHROPOIDEA

HOMINOIDEA

PONGIDAE

Gorilla gorilla

Gorilla

	Survey Results			*Ref. 1*		*Ref. 7*		*Ref. 8*	
Test	*Av.*	*Range*	*No.*	*Av.*	*Range*	*Av.*	*Range*	*Av.*	*Range*
Hb	12.0	10.4-12.9	4	11.7	9.4-15.1	12.25	12.0-12.5	16.6	15.3-19.5
RBC	4.3	3.8-4.8	4	4.1	3.6-5.1	4.5	4.3-4.7	4.6	3.1-5.4
PCV	36.3	34-38	4	39.1	31.5-47.0	42	41-43		
Retics	0.6	0.2-1.5	4					0.82	0.4-1.2
MCV	87.7	83-90	4	86.2	71-104	86.8	86.5-87.3		
MCH	29.0	25-33	4	25.7	22.8-30.2	25.4	25.3-25.4	36.1	
MCHC	32.6	29-36	4	30.1	26-37	29.2	29.1-29.3		
MCD						7.73	7.64-7.82		
WBC	6.1	4-12	4	10.7	3.7-26.2				
N	56	50-68	4	59	33-89				
L	29	25-37	4	30	9-65				
M	7	4-12	4	1.9	0-7				
E	1	0-3	4	2.4	0-10				
B	0		4	0.1	0-2				
Plts	206	155-286	4						
ESR	9	0-17	4						
ELT	100	90-110	2						
Pg	5.15		1						
AF									
				No. = 37-59		*No. = 2*		*No. = 10*	

For blood picture see also refs. 2, 113

Gorilla

Survey Results

Test	*Av.*	*Range*	*No.*
PT	16.8	12-20	3
RVV	9.0	7-11	2
PTT	52	41-64	3
RT	71	58-78	3
KRT	44	40-47	3
TT	8.0	5-13	3
I	307	124-434	3
II	49	47-51	2
V	64	51-80	3
VII	125	110-140	3
VIII	925	850-1000	2
IX	93	80-100	3
X	130	90-200	3
XI	230		1
XII	150		1
XIII	+		3
AT			
CR			
TP	5.85		1

ANTHROPOIDEA
HOMINOIDEA
PONGIDAE
Pongo pygmaeus
Orang utan

	Survey Results			*Ref. 1*	
Test	*Av.*	*Range*	*No.*	*Av.*	*Range*
Hb	11.2	10.0-12.2	5	10.8	6.4-15.0
RBC	4.8	4.0-5.5	5	4.2	2.3-5.6
PCV	38.5	36-42	6	36.7	24-46
Retics	0.18	0.1-0.2	6		
MCV	80.6	76-93	5	85.6	72-104
MCH	22.9	21-25	5	25.5	19.3-30.5
MCHC	28.9	27-30	5	29.7	24-39
MCD	7.01		1		
WBC	9.8	8.4-11.1	6	13.6	4.6-26.8
N	59	46-78	6	55.5	14-91
L	33	21-49	6	40	7-82
M	3	1-5	6	1.8	0-11
E	3	0-8	6	2.6	0-16
B	0		6	0.1	0-2
Plts	261	230-307	5	416	175-750
ESR	0	0-1	6		
ELT	170	60-300	3		
Pg	4.3	2.7-5.4	3		
AF	92		1		

No. = 100-145

Survey Results

Test	*Av.*	*Range*	*No.*
PT	12.3	10.0-16.8	5
RVV	9.7	6-13	5
PTT	63	50-71	5
RT	104	60-160	5
KRT	62	45-70	5
TT	8.1	5-13	5
I	550	343-722	5
II	80	47-120	5
V	136	60-230	6
VII	240	110-380	3
VIII	427	155-1000	7
IX	85	27-140	6
X	160	100-220	5
XI	136	52-220	2
XII	135	120-150	2
XIII	+		5
AT	405		1
CR	64		1
TP	6.44	5.98-7.0	3

PF3 release 67 (1)
PF3 total 120 (1)
Contact activation index 43 (1)

See also refs. 2, 7, 113

ANTHROPOIDEA
HOMINOIDEA
HOMINIDAE
Homo sapiens
Man

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	14.4	12.3-17.3	69
RBC	4.8	4.1-6.1	69
PCV	43.9	37-51	69
Retics	0.7	0-1.8	69
MCV	91.0	70-99	69
MCH	30.0	26-35	69
MCHC	32.8	27-37	69
MCD	7.21	6.92-7.75	14
WBC	6.6	4.1-12.0	69
N	56.5	38-79	69
L	35	16-55	69
M	5	1-12	69
E	3	0-7	69
B	0.5	0-1	69
Plts	210	140-342	165
ESR	5.7	1-22	48
ELT	145	60-240	90
Pg	2.8	1.9-4.0	42
AF	100	84-117	25

Survey Results

Test	*Av.*	*Range*	*No.*
PT	14.0	12-15	102
RVV	8.7	7-10	102
PTT	71	48-90	102
RT	122	74-144	102
KRT	67	48-78	102
TT	6.4	4.5-8.0	102
I	302	194-408	45
II	94	70-125	35
V	107	83-140	33
VII	112	70-180	25
VIII	102	64-160	45
IX	96	60-150	30
X	101	54-200	34
XI	100	50-150	10
XII	100	50-150	10
XIII	+		45
AT	329	220-560	37
CR	63	57-68	75
TP			

Contact activation index 39
Range 31-50 (20 subjects)
PF3 release 79
Range 71-90 (20 subjects)
PF3 total 104
Range 100-120 (20 subjects)

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Chapter 3

THE CARNIVORA

The Carnivora comprise a highly successful group of flesh-eating mammals in which the main characteristics are associated with the predatory way of life. Animals belonging to this order are generally fast moving and intelligent, with highly developed teeth and claws for offensive purposes, and are therefore well equipped for hunting, killing and devouring their prey. The success of the order is demonstrated by the fact that there are 252 living species which are widely distributed over most of the land surfaces of the earth.

The order is divided into two superfamilies, the Canoidea and the Feloidea. The Canoidea comprises four families, the Canidae (Dogs, Foxes, Wolves), the Ursidae (Bears), the Procyonidae (Racoons, Coatis) and the Mustelidae (Weasels, Martens, Badgers, Skunks etc.). The Feloidea contains three families, the Viverridae (Genets, Civets, Mongooses), the Hyaenidae (Hyaenas) and the Felidae (Cats, Lions etc.). In the present survey, most of the carnivores examined have been Canidae or Felidae; the following remarks apply mainly to these two families.

In the past, haematological examinations of carnivores have been confined mainly to domestic cats [1-13] and dogs [1-3, 14-24]. Wild carnivores studied include arctic and silver foxes [25-27], dingos [27], coyotes [27], wolves [27] and jackals [28], some bears [29-37], racoons [29, 38] and a kinkajou [28], mink [39-41] and some other mustelids [27, 28, 30] and the African lion [1, 36, 42, 43]. Normal ranges for blood counts on cats and dogs reported in the literature are extremely wide. One major reason for this is probably that both species react violently to stress which causes an instantaneous increase in red and white cell counts [1, 3, 21]. It has been stated that the red count is raised as much as fifty percent in a dog barking at the sight of a cat and a similar response occurs in the cat on hearing the bark [1]. Other variables which may influence results are diet [16], feeding [14, 21], age [3, 14-16, 22] pregnancy and oestrus [14, 15], exercise [3, 14], altitude [23], anaesthetics [44] and breed [1, 3, 14]. Seasonal [24] and diurnal [15, 18] variation have also been noted.

Red cells

Domestic cats and dogs represent two different families of the order Carnivora and the physiological variables which influence their blood picture probably operate in other members of the order. Nevertheless it is possible to define a basic difference in the haematology of cats and dogs which can be extended to other members of the Felidae and Canidae. Compared with dogs, cats have smaller erythrocytes and although the total red count is higher, the degree of compensation is not complete, and consequently in cats the packed cell volume and total haemoglobin are consistently lower than in dogs. This difference is also present in other representatives of the two families which have been examined and, as a general rule, felids are anaemic by canine standards (Table 3.1). The relatively high haemoglobin content of the blood of canine animals may be related to the fact that in their wild environment these animals often run for long distances at fast rates in search and pursuit of their prey whereas felids, although capable of short bursts of very high speed, generally rely on stealth and cunning when hunting for food. It has been estimated that a hunting wolf pack covers on an average 40 miles a day whereas a cheetah, reputed to be the fastest mammal on earth and capable of reaching 70 miles per hour over short distances, rarely continues the chase if it fails to overtake its prey in the first burst of speed.

Table 3.1

RED CELLS OF CARNIVORES

Family	Hb	RBC	PCV	MCV	MCH	MCHC	MCD
CANIDAE	13.8	6.1	44	72.5	23.3	31.4	6.58
URSIDAE	13.0	6.9	41	61.6	20.1	31.2	6.25
PROCYONIDAE	13.7	6.9	44	63.9	20.0	31.0	6.07
MUSTELIDAE	13.8	8.2	49	55.7	17.8	30.5	6.05
VIVERRIDAE	13.8	10.5	44	35.7	13.3	31.5	4.68
FELIDAE	12.1	6.7	36.5	54.0	17.9	32.6	5.32

Reticulocytes can be demonstrated in carnivore blood by the usual method and the response of the bone marrow to red cell loss is apparently similar to that of man. Inclusion bodies indistinguishable from Howell Jolly bodies have been reported in a significant proportion of the red cells of normal cats [4, 45], and this has proved to be a common finding in most species of Felidae which have been examined. In man, Howell Jolly bodies are usually indicative of some abnormal condition, but in Felidae they are apparently without pathological significance. In normal domestic cats, up to 4% of the erythrocytes may contain refractile bodies similar to Heinz bodies and the number may be increased in sick cats [1]. In the present survey, Heinz bodies have been found in two normal lions and a cheetah, but not in any canine species examined.

In blood samples collected by normal methods, red cells of carnivores often show some degree of crenation. A tendency for red cells to sickle has been found in one species, the slender mongoose *(Herpestes sanguineus)* [48]. Sickle-shaped red cells, similar to those seen in human sickle-cell anaemia and in some normal deer (chapter 5) are found in blood films allowed to dry slowly in air and can be induced by raising the ionic concentration of the surrounding medium (Figure 3.1). This trait is apparently without clinical significance in the mongoose [48].

Animals suffering from anaemias resulting from haemorrhage or parasitic infestation have been excluded from the present series. Nevertheless, the blood picture of some apparently healthy captive wild carnivores is suggestive of low grade anaemia when compared with that of other related animals and of man, although this cannot be proved in the absence of statistically significant normal values. Nutritional anaemia, characterised by a fall in haemoglobin and red count, has been reported in mink *(Mustela vison)* [46]. This condition is reversed by feeding the animals on liver and has been compared with pernicious anaemia in man [46].

The red cells of carnivores form rouleaux and sometimes show an increased rate of sedimentation. Normal values for erythrocyte sedimentation rates in cats and dogs have been worked out by Irfan who considers values of more than 8mm in one hour for dogs and 18mm in one hour for cats to be indicative of some underlying pathological condition [47]. Some of the animals examined in the present series have had high sedimentation rates in the absence of definable clinical abnormalities; the significance of these findings is at present not known.

White cells

As has been pointed out the total white count in animals of this order can be greatly influenced by stress and other physiological variables. In many instances high white counts have been recorded in the absence of obvious pathological cause and it is difficult to use this parameter alone as an index of infection or marrow hyperplasia. Reliance must, therefore, be placed on examination of the stained blood film in which the presence of a high proportion of immature cells has the same significance as in man. In kittens [3] and puppies [1] and in adult cats and dogs, neutrophils outnumber lymphocytes and this picture is also seen in mature wild carnivores. Apart from the presence of an unusually high proportion of large lymphocytes in kittens [10] and minor differences in the eosinophils, the morphology of the white cells of carnivores is similar to that of man. Basophils are rare. High eosinophil counts are found in animals with parasitic infestations but in dogs [1, 14] and in wild carnivores eosinophilia apparently occurs with some frequency in normal animals, possibly as an allergic response or an individual idiosyncrasy. The granules of carnivoran eosinophils vary considerably in size and shape and may be spherical, bacilliform, cylindroidal or ovoid [3]. In the Canidae, eosinophil granules are only weakly acidophilic [1] and consequently do not show up well with Romanowsky stains.

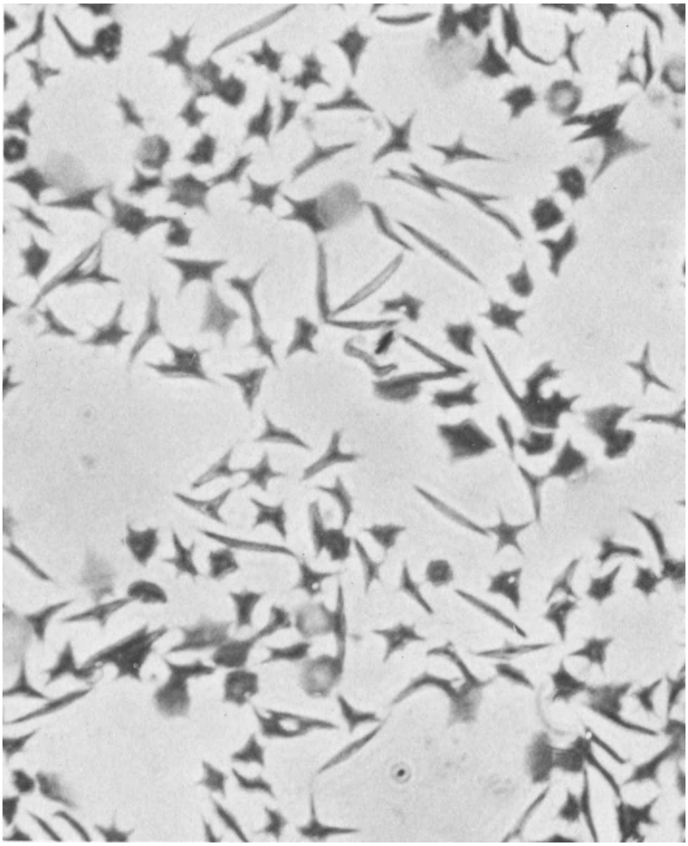

Figure 3.1. Sickled red cells of the slender mongoose *(Herpestes sanguineus)*.

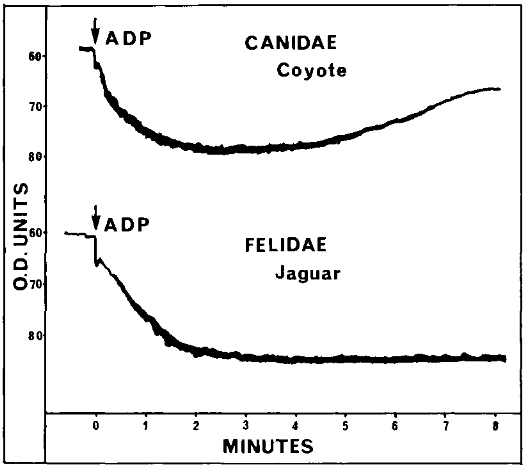

Figure 3.2. Typical patterns of platelet aggregation induced by ADP in Candidae and Felidae.

Platelets

The platelet count in carnivores is usually within the normal human range. The number of circulating platelets is increased by stress in cats [49]. In stained films the platelets are similar in size and structure to those of man. Clot retraction is rapid and complete. The platelets of all species of Carnivora tested are rapidly aggregated by ADP but the level of ADP-inhibitor is consistently higher in canine than in feline plasma and consequently ADP-induced platelet aggregation is more rapidly reversed in the former (Figure 3.2). In dogs but not in cats, ADP-induced aggregation is inhibited by adenosine [50]. Dog and cat platelets are aggregated by 5 hydroxytryptamine; in cats the aggregation is biphasic and is inhibited by high concentrations [50, 51]. Adrenaline does not produce aggregation *in vitro* in PRP of these species [50, 51].

Blood coagulation

The main point of interest in the blood coagulation mechanism of carnivores is that it is "hyperactive" when compared with that of man. Prothrombin (factor II) and fibrinogen levels and the rate of conversion of fibrinogen to fibrin by thrombin are generally within the normal human range but, as judged by the one-stage prothrombin time and the partial thromboplastin time, both extrinsic and intrinsic prothrombin activator are generated at an increased rate. This is apparently a function of the high levels of plasma coagulation factors present, particularly factors V, VIII, IX, XI and XII. Some Felidae have low levels of factor X, occasionally low enough to be classed as pathological if they occurred in man although haemorrhagic symptoms have not been noted in the animals concerned. Other than this, congenital deficiencies of coagulation factors have not been found in wild carnivores. Haemophilia [53-58], Christmas Disease [59, 60], factor VII deficiency [61-65], factor XI deficiency [66], congenital hypofibrinogenaemia [67] and von Willebrand's Disease [68] have been described in domestic dogs and factor XII deficiency in cats [73], probably revealed by domestication and interbreeding. It would in fact be surprising if such hazardous congenital pathological conditions could survive the process of natural selection in wild animals.

Fibrinolysis

Levels of plasminogen activator and fibrinolytic inhibitors in the blood of carnivores are within the normal human range but the amount of plasminogen in dogs [69] and wild species is significantly greater, indicating a higher fibrinolytic potential. Plasminogen is directly activated by human urokinase and by streptokinase without the addition of extrinsic pro-activator. The amount of streptokinase required is greater in Canidae than in Felidae. It has not been possible to activate the fibrinolytic mechanism of carnivores by injection of adrenaline or nicotinic acid or by physical exercise suggesting that the mechanism of spontaneous fibrinolysis may differ from that of man. Pharmacological activation of fibrinolysis in dogs has been studied by Rahn and von Kaulla [70].

Carnivores provide an example of animals in which the coagulation mechanism is "hyper-active" and platelets aggregate readily but which apparently have no balancing increase in naturally occurring anti-coagulants or circulating fibrinolytic activity although potential fibrinolytic activity (plasminogen) is high. These animals are therefore well prepared to deal with traumatic haemorrhage, the risk of which is likely to be high in their natural environment. There is no evidence that the "hypercoagulability" is associated with spontaneous atherosclerosis and thrombosis in carnivores; in fact these conditions are rare [71].

CANOIDEA
CANIDAE
Canis lupus
Wolf

Survey Results				*Ref. 27*
Test	*Av.*	*Range*	*No.*	*Av.*
Hb	15.0	14.0-15.5	3	12.0
RBC	5.8	4.9-6.3	3	5.3
PCV	42	39-48	3	35
Retics	0.4	0-0.8	3	
MCV	71.5	70-72	3	65
MCH	26.0	25.2-27.5	3	23
MCHC	35.0	31-37	3	35
MCD	6.95	6.93-7.17	3	
WBC	7.6	6.8-8.1	3	13.9
N	75	65-85	3	61
L	18	9-26	3	33
M	4	2-5	3	1
E	3	1-6	3	5
B	0		3	0
Plts	244	115-338	3	
ESR	1.0	0.5-2.0	3	
ELT	273	260-285	2	
Pg	5.2	4.75-6.1	3	
AF				

5 counts on 1 animal

Survey Results

Test	*Av.*	*Range*	*No.*
PT	9.5	7.0-11.5	4
RVV	7.0	5.5-9.0	4
PTT	30	23-35	4
RT	57	44-69	3
KRT	31	30-34	4
TT	5.0	4-6	4
I	482	185-952	4
II	100	90-110	3
V		600-1000+	4
VII	88		1
VIII	1000+		4
IX	470	260-640	3
X	270	55-560	4
XI	1000+		1
XII	370		1
XIII	+		4
AT	509	460-580	3
CR			
TP	5.01	4.56-5.34	3

Contact activation index 70
Range 61-78 (2)
PF3 release 50 (1)
PF3 total 74 (1)

CANOIDEA
CANIDAE
Canis latrans
Coyote

Survey Results

Test	Av.	Range	No.
Hb	15.4	11-20	14
RBC	6.1	4.5-7.1	14
PCV	48	37-58	14
Retics	0.6	0.1-1.2	14
MCV	78.6	62-89	14
MCH	24.9	20-28	14
MCHC	31.3	29-33	14
MCD	6.91	6.64-7.08	8
WBC	7.5	4.4-11.2	9
N	62.9	43-92	9
L	20	5-35	9
M	6	1-14	9
E	11	1-25	9
B	0.1	0-0.5	9
Plts	240	162-420	14
ESR	1.5	0-8	14
ELT	213	150-330	12
Pg	4.88	3.75-6.1	5
AF			

Ref. 27

Av.	Range
15.7	15.0-16.5
7.8	6.7-9.7
56	48-60
72	59-90
20	17-23
29	26-31
12.5	7.1-15.3
66	52-79
25	20-37
0	
7	1-11
0	
2	1-4

6 counts on 2 animals

Survey Results

Test	Av.	Range	No.
PT	10.0	9.5-10.5	5
RVV	6.0	5.0-8.5	13
PTT	32	21-52	13
RT	52	30-80	13
KRT	32	24-38	13
TT	7.4	5-9	13
I	316	149-544	12
II	126	78-160	12
V	1000+		12
VII			
VIII	1000+		11
IX		700-1000+	4
X	300	82-450	12
XI	1000+		1
XII	390	330-450	2
XIII	+		12
AT	563	516-650	5
CR	65	54-71	6
TP	5.25	4.05-6.16	11

PF3 release 54.5
Range 50-60(8)
PF3 total 80
Range 60-100(8)
Contact activation index 73
Range 60-86(9)

CANOIDEA
CANIDAE
Canis familaris
Domestic dog

	Survey Results			*Ref. 2*		*Ref. 2*		*Ref. 14*	
Test	*Av.*	*Range*	*No.*	*Av.*	*Range*	*Av.*	*Range*	*Av.*	*Range/SD*
Hb	14.4	12.4-16.9	14	15.2	10.8-21.3	15.1	11.1-21.1	17.2	13.3-20.0
RBC	5.8	5.4-7.3	14	6.2	4.3-8.9	6.0	4.1-8.8	6.1	4.6-7.8
PCV	43	40-48	14	46	34-63	46	35-63	50.5	47-57
Retics	0.3	0-0.7	14	0.13	0.02-1.0	0.14	0.1-1.1		
MCV	75.2	70-83	14					83.9	69-98
MCH	25.0	22-28	14					28.9	23.5-35.5
MCHC	32.2	30-34	14	33	30-36	32	29-25	34.0	27.5-38.0
MCD	6.85	6.63-7.13	10						
WBC	8.7	4.3-14.9	14	11.6	5.0-27.2	12.8	5.3-30.8	10.06	6.2-14.0
N	78	62-90	14	7.5*	3.0-18.7	8.7*	3.3-23.1	6.6*	± 1.0
L	12	5-23	14	2.8*	0.8-9.0	2.4*	0.5-10.9	1.9*	± 0.79
M	5	3-8	14	0.53*	0.2-1.42	0.57*	0.18-1.83	0.4*	± 0.26
E	4	0-9	14	0.52*	0.12-2.25	0.51*	0.03-1.16	0.58*	± 0.5
B	0		14	0.01*		0.01*		0	
Plts	333	147-500	14	323	106-986	357	153-833		
ESR	1	0-4	14					0.8	
ELT	120	93-240	12						
Pg	6.55	5.3-7.8	12						
AF									

Breeds: *Whippet 1*
Labrador 4
Beagle 5
Dalmatian 1
Poodle 1
Great dane 1
Border terrier1

40 Beagles — *51 mongrels* — *41 animals*

**Cells X10^3/c.mm blood.*

See also refs 1, 3, 15, 19, 20

Domestic dog

	Survey Results			*Ref. 52*		*Ref. 73*
Test	*Av.*	*Range*	*No.*	*Av.*	*SD*	*Av.*
PT	9.5	8.0-10.5	7	6.7	± 0.7	
RVV	5.3	5-6	7			
PTT	35	28-45	7	24	± 5	
RT	65	44-92	7			
KRT	33	30-39	7			
TT	6.3	4.5-7.5	7			
I	305	269-340	7			210
II	115	105-125	7			139
V	1000+		6			1370
VII	175	50-300	4			1140
VIII	1000+		6			46
IX	120	98-170	3			120
X	375	250-500	8			
XI						
XII						60
XIII	+		14			
AT	300	240-520	5			
CR						
TP	5.16	4.9-6.0	7			
				33 animals		*6 animals*

See also refs. 69, 79.

For review of blood coagulation and its disorders, see ref. 72.

For blood coagulation factors in newborn pups, see ref. 74.

CANOIDEA
CANIDAE
Canis aureus (Asiatic jackal) and C. adustus (Side-striped jackal)

C. aureus
Survey Results

Test	*Av.*	*Range*	*No.*
Hb	13.7	13.2-14.2	2
RBC	5.2	4.2-6.2	2
PCV	40.5	35-46	2
Retics	1.6		1
MCV	77.8	73.5-82.0	2
MCH	28.4	25.5-31.2	2
MCHC	34.0	30.5-37.5	2
MCD	6.55		1
WBC	9.4	8.3-10.5	2
N	84	80-88	2
L	10	8-12	2
M	3	2-5	2
E	2.5	0-5	2
B	0.5	0-1	2
Plts	175		1
ESR	1		1
ELT			
Pg			
AF			

PF3 release 80 (1)
PF3 total 88 (1)

See also ref 28

C. adustus
Survey Results

Test	*Av.*	*Range*	*No.*
PT			
RVV	6.0		1
PTT	33		1
RT	77		1
KRT	30		1
TT	7.0		1
I	268		1
II	140		1
V	950		1
VII			
VIII			
IX			
X	450		1
XI			
XII			
XIII	+		1
AT			
CR			
TP	5.77		1

ELT 200 mins. (1)

CANOIDEA
CANIDAE
Canis familaris dingo
Dingo

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	14.3	11.2-20.0	10
RBC	5.5	4.3-6.3	10
PCV	42.5	35-55	10
Retics	0.65	0.4-1.4	10
MCV	77.5	69-87	10
MCH	26.6	20.9-30.5	10
MCHC	33.2	29.5-36.6	10
MCD	6.72	6.52-6.93	10
WBC	10.4	7.8-12.7	10
N	69	57-78	10
L	19	14-25	10
M	5	3-6	10
E	7.9	5-15	10
B	0.1	0-0.5	10
Plts	225	147-341	10
ESR	18	0-41	10
ELT	162*	75-295	4
Pg	4.98	4.82-5.15	2
AF	107.5	107-108	2

** A further 3 animals had ELT's of 5-16 hours*

Ref. 27

Av.	*Range*
14.9	13.2-17.0
6.8	5.5-8.9
46	33-54
68	52-83
22	18-25
33	22-38
13.7	8.6-17.9
51	32-72
34	25-47
1	1-5
13	3-32
0.3	1-2
10	1-29

14 tests on 5 animals

Survey Results

Test	*Av.*	*Range*	*No.*
PT	9.2	7-14	10
RVV	6.5	4-10	11
PTT	32	21-65	12
RT	67	33-128	11
KRT	32	24-38	13
TT	6.8	5-9	11
I	415	266-761	11
II	162	110-390	8
V		400-1000+	8
VII	330	300-360	2
VIII	1000+		6
IX	390		1
X	190	45-480	10
XI	1000+		1
XII	450		1
XIII	+		10
AT	513	460-618	4
CR	55		1
TP	5.27	4.61-5.74	7

PF3 release 71 (1)
PF3 total 88 (1)
Contact activation index 70
range 69-71 (2)

CANOIDEA
CANIDAE
Alopex lagopus
Arctic fox

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	14.6	12.9-16.8	7
RBC	8.1	6.9-9.8	7
PCV	48	41-52	7
Retics	0.33	0.2-0.4	7
MCV	59.6	57-64	7
MCH	18.1	16.0-20.7	7
MCHC	29.9	26-34	7
MCD	6.31	6.22-6.41	4
WBC	5.4	3.6-9.2	7
N	56	38-73	7
L	24	7-43	7
M	9	5-14	7
E	11	3-34	7
B	0		7
Plts	247	179-405	7
ESR	0.6	0.5-1.0	3
ELT			
Pg	6.45	6.1-6.8	5
AF			

Ref. 27

Av.	*Range*
15.6	15.6-15.8
7.9	5.6-9.5
48	44-50
64	51-90
21	16-28
33	31-36
4.9	3.5-5.9
48	34-66
45	25-63
1	1-3
3	4-6
0.7	0-2
0.5	0-1

Survey Results

Test	*Av.*	*Range*	*No.*
PT	9.5		1
RVV	5.6	5-6	4
PTT	37	30-58	4
RT	68	51-97	4
KRT	29	19-43	4
TT	7.0	5-9	4
I	320	188-547	4
II	187	125-270	4
V		760-1000+	4
VII			
VIII	1000+		4
IX			
X	172	86-220	4
XI			
XII			
XIII	+		4
AT			
CR			
TP	6.33	5.6-6.8	3

3 counts on 1 animal

CANOIDEA
CANIDAE
Vulpes vulpes
Red fox

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	11.5	7.3-15.7	2
RBC	5.9	3.3-8.4	2
PCV	33	20-46	2
Retics	0.5	0-1	2
MCV	57.0	54-60	2
MCH	20.0	18-22	2
MCHC	34.9	33.7-36.1	2
MCD	6.32		1
WBC	7.4	4.3-10.5	2
N	50.75	37-64	2
L	23	18-28	2
M	8		2
E	17	8-27	2
B	0.25	0-0.5	2
Plts	205	130-279	2
ESR	25	0-50	2
ELT			
Pg			
AF			

Survey Results

Test	*Av.*	*Range*	*No.*
PT			
RVV	7.0		1
PTT	24		1
RT	52		1
KRT	20		1
TT	10		1
I			
II			
V	950		2
VII			
VIII	1000+		1
IX	250	180-320	2
X			
XI			
XII			
XIII			
AT			
CR			
TP			

CANOIDEA
CANIDAE
Urocyon cinereoargenteus
Grey fox

Survey Results

Test	*Av.*	*No.*
Hb	11.0	1
RBC	6.7	1
PCV	39	1
Retics	0.2	1
MCV	58	1
MCH	16.4	1
MCHC	27.9	1
MCD	6.04	1
WBC	4.4	1
N	52	1
L	15	1
M	7	1
E	26	1
B	0	1
Plts	150	1
ESR	6	1
ELT		
Pg		
AF		

Survey Results

Test	*Av.*	*No.*
PT		
RVV	6.0	1
PTT	42	1
RT	90	1
KRT	32	1
TT	9.0	1
I		
II		
V		
VII		
VIII	1000+	1
IX		
X		
XI		
XII		
XIII		
AT		
CR		
TP		

CANOIDEA
CANIDAE
Vulpes fulva
Silver fox

	Ref. 27		Ref. 26		Ref. 26
Test	*Av.*	*Range*	*Av.*	*Range*	*Av.*
Hb	15.0	14.5-15.5	11.0	8.3-14.2	15.0
RBC	9.1	7.8-9.8	8.8	6-12	8.0
PCV	50	46-55			59
Retics					
MCV	57	47-71			74.8
MCH	17	15-19			
MCHC	30	27-34			
MCD					
WBC	5.7	4.6-7.1	9.3	4.2-15.8	
N	31	21-38	4.5*	2-18.5	
L	58	49-69	3.8*	2.2-8.5	
M	0		0.2*	0-0.4	
E	9	4-16	0		
B	1	1-2	0.9*	0-2	
Plts					
ELT	1	1-2			
Pg					
AF					
	3 tests on 1 animal animal		*7 animals *X10³/c.mm*		*No. not given*

CANOIDEA
CANIDAE
Speothos venaticus
Bush dog

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	13.8	12.7-14.6	5
RBC	5.63	4.9-6.1	5
PCV	48	39-57	5
Retics	1.2	0.4-3.0	5
MCV	85.2	79-94	5
MCH	24.5	23.1-26.0	5
MCHC	28.7	27-32	5
MCD	6.74	6.7-6.8	3
WBC	10.8	9.6-12.5	5
N	69	53-80	5
L	22	15-25	5
M	4	1-7	5
E	5	0-8	5
B	0		5
Plts	276	246-321	5
ESR	4	0-10	5
ELT	300		2
Pg			
AF			

Survey Results

Test	*Av.*	*Range*	*No.*
PT	13.3	13.0-13.5	2
RVV	6.0		2
PTT	24	21-26	2
RT	40	35-45	2
KRT	26	23-29	2
TT	7.0	6-8	2
I	235	211-260	2
II			
V	1000+		1
VII			
VIII	1000+		2
IX			
X	190		2
XI			
XII			
XIII	+		2
AT			
CR			
TP			

CANOIDEA
CANIDAE
Lycaon pictus
Hunting dog

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	15.8	14.9-16.8	2
RBC	7.17	6.74-7.60	2
PCV	48.5	48-49	2
Retics	0.85	0.8-0.9	2
MCV	68.2	65.0-71.5	2
MCH	22.2	19.5-24.9	2
MCHC	32.2	29.5-35.0	2
MCD	5.62		1
WBC	4.1		1
N	76		1
L	15		1
M	5.5		1
E	3.5		1
B	0		1
Plts	257	149-366	2
ESR	1.75	0.5-3.0	2
ELT			
Pg			
AF			

Survey Results

Test	*Av.*	*Range*	*No.*
PT	7.5		1
RVV	5.5		2
PTT	26	24-28	2
RT	49	45-53	2
KRT	25	24-26	2
TT	8	7-9	2
I	278	252-304	2
II	89	78-100	2
V	1000+		2
VII			
VIII	1000+		2
IX			
X	450	400-500	2
XI			
XII			
XIII	+		2
AT			
CR			
TP	6.19	6.05-6.34	2

CANOIDEA

CANIDAE

Otocyon megalotis

Bat-eared fox

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	13.0	11.8-14.2	2
RBC	6.6	5.7-7.4	2
PCV	46	42-50	2
Retics	0.6	0.4-0.8	2
MCV	70.7	67.4-74.0	2
MCH	19.9	19.0-20.8	2
MCHC	27.8		2
MCD	6.38	6.31-6.47	2
WBC	6.2	6.0-6.3	2
N	67	65-69	2
L	22	20-24	2
M	10	5-14	2
E	1	0.5-2	2
B	0		2
Plts	334	312-356	2
ESR	5	0.5-10	2
ELT	118	50-180	2
Pg	5.4		1
AF			

Survey Results

Test	*Av.*	*Range*	*No.*
PT	9.0	8.5-9.5	3
RVV	8.5	7.0-10.5	3
PTT	57	40-85	3
RT	73	65-81	2
KRT	44	39-49	2
TT	9.0	7-11	3
I	380		1
II	140		1
V	1000+		3
VII			
VIII			
IX	1000+		1
X	293	260-310	3
XI			
XII			
XIII	+		1
AT			
CR			
TP	6.15		1

PF3 release 71 (1)

Total PF3 89 (1)

CANOIDEA
URSIDAE
Tremarctos ornatus
Spectacled bear

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	11.0	8.7-13.0	7
RBC	7.7	6.4-9.6	7
PCV	38	29-42	7
Retics	0.3	0-0.6	4
MCV	47.9	30-58	7
MCH	14.6	11-19	7
MCHC	29.0	22-35	7
MCD	5.78	5.09-6.25	7
WBC	6.4	4.3-10.2	7
N	71.9	61-82	7
L	22	12-37	7
M	3.5	2-7	7
E	2.5	0-7	7
B	0.1	0-1	7
Plts	438	328-526	4
ESR	16	1-34	5
ELT	150		1
Pg	5.8		1
AF	50		1

Survey Results

Test	*Av.*	*Range*	*No.*
PT	11.5	9.0-16.5	3
RVV	7.3	6.5-8.5	3
PTT	41	36-45	2
RT	76	51-96	3
KRT	34	27-41	2
TT	6.0	5-7	3
I	664	500-806	2
II	90		1
V		400-1000+	2
VII			
VIII		480-1000+	2
IX	680		1
X	457	115-800	2
XI			
XII	950		1
XIII	+		2
AT	500		1
CR			
TP	6.39	6.22-6.8	3

Contact activation index 69 (1)

For variation of blood picture with age, pregnancy and season see Ref. 34.

CANOIDEA
URSIDAE
Selenarctos thibetanus
Asiatic black bear

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	15.2	10.7-19	4
RBC	6.1	3.9-7.9	4
PCV	44	29-56	4
Retics	0.1	0-0.2	3
MCV	75.7	72.0-80.3	4
MCH	25.7	24-27	4
MCHC	33.5	32-36	4
MCD	6.75	6.69-6.92	4
WBC	12.3	6.3-19.6	4
N	82	72-93	4
L	10	4-16	4
M	4	1-8	4
E	4	0-7	4
B	0		4
Plts	333	214-454	3
ESR	4	1-8	3
ELT	256	182-330	3
Pg			
AF	122		1

Survey Results

Test	*Av.*	*Range*	*No.*
PT	9.0	8.5-9.5	3
RVV	8.5	7-10	3
PTT	41	39-43	2
RT	81	76-85	3
KRT	37	34-43	3
TT	6.0		3
I	845	787-902	2
II	390		1
V	1000+		1
VII			
VIII	800	600-1000	2
IX			
X	258		1
XI			
XII	540		1
XIII	+		2
AT			
CR	60		1
TP	6.8	6.6-6.9	2

Contact activation index 55 (1)

For variation of blood picture with age, pregnancy and season see Ref. 34.

CANOIDEA
URSIDAE
Thalarctos maritimus (Polar bear) *and Ursus arctos* (Brown bear)

Polar bear
Survey Results

Test	*Av.*	*Range*	*No.*
Hb	21.7		1
RBC	8.7		1
PCV	60		1
Retics	0.6		1
MCV	68.9		1
MCH	24.9		1
MCHC	35.8		1
MCD			
WBC	10.0		1
N	72		1
L	15		1
M	5		1
E	8		1
B	0		1
Plts	379		1
ESR	0		1
ELT			
Pg			
AF			

Brown bear
Survey Results

Test	*Av.*	*Range*	*No.*
Hb	17.1	16-18	3
RBC	6.93	6.6-7.4	3
PCV	47.3	45-50	3
Retics	0.1		3
MCV	68.3	67.5-70.0	3
MCH	24.7	24.1-26.0	3
MCHC	36.1	35.5-37.0	3
MCD			
WBC	7.8	4.2-10.2	3
N	79	76-84	3
L	15.5	10-22	3
M	4.5	1-8	3
E	1	0-2	3
B	0		3
Plts	328	185-475	2
ESR	0		3
ELT			
Pg			
AF			

For variation in blood picture with age, pregnancy and season, see Ref. 34.

CANOIDEA
URSIDAE
Ursus americanus
American black bear

	Ref. 27		*Ref. 32*		*Ref. 33*	
Test	*Av.*	*Range*	*Av.*	*Range*	*Av.*	*Range*
Hb	15.3	14-17	15.9	10.2-21.6	11.6	
RBC	8.7	6.8-10.3	7.5	5.3-8.9	7.7	7.0-8.1
PCV	49	43-55	49	44-59	37.9	
Retics						
MCV	56	53-63				
MCH	18	17-21				
MCHC	31	29-33				
MCD						
WBC	14.5	11.7-20.7	19.0	11.5-26.7		
N	49	29-63				
L	40	26-56				
M	1	0-2				
E	11	10-13				
B	0.5	0-2				
Plts						
ESR	6				9.4	
ELT						
Pg						
AF						
	4 tests on 2 animals		*16 animals*		*4 animals*	

See also refs. 29, 30, 31, 34, 35, 37.

For variation in blood picture with species, age, pregnancy and season in Helarctos malayanus (sun bear) *and Melurus ursinus* (sloth bear) *see ref. 34.*

CANOIDEA
PROCYONIDAE
Nasua nasua
Coati

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	11.9	9-14	7
RBC	6.7	5-9	7
PCV	39.5	29-46	7
Retics	0.9	0.2-3.8	7
MCV	59.4	45-67	7
MCH	18.1	12-20	7
MCHC	29.3	27-31	7
MCD	6.27	5.27-6.47	7
WBC	13.7	6.6-23.0	7
N	63	39-87	7
L	26	5-44	7
M	3	0-8	7
E	7	1-13	7
B	1	0-2	7
Plts	634	434-770	7
ESR	17	5-46	7
ELT	187	140-240	3
Pg	5.35	4.5-7.0	3
AF			

Survey Results

Test	*Av.*	*Range*	*No.*
PT	13.2	12.5-14.5	6
RVV	7.7	6-10	6
PTT	44	40-46	6
RT	75	42-110	6
KRT	45	39-53	6
TT	8.7	6-11	6
I	475	339-725	6
II	73	47-90	6
V	290	190-380	6
VII			
VIII	359	160-540	6
IX	168	36-400	6
X	175	100-300	5
XI			
XII			
XIII	+		6
AT			
CR			
TP	7.17	5.5-7.9	6

CANOIDEA
PROCYONIDAE
Procyon lotor
North American racoon

	Survey Results			*Ref. 29*	*Ref. 38*		*Ref. 38*	
Test	*Av.*	*Range*	*No.*	*Av.*	*Av.*	*Range*	*Av.*	*Range*
Hb	12.6	11.5-13.7	2		9.1	6.0-11.5	8.7	5.5-10.5
RBC	7.0	6-8	2		10.3	8.4-11.8	9.7	8.0-11.1
PCV	41.5	39-44	2	34.5				
Retics	0.4	0.2-0.6	2					
MCV	60.0	55-65	2					
MCH	18.2	17.1-19.3	2					
MCHC	29.9	29.2-30.5	2					
MCD	5.88	5.86-5.91	2					
WBC	5.9	5.4-6.4	2	7.0	17.9	9.5-28.1	18.2	12.9-26.6
N	61	57-65	2	67	37.6	28-44	40	30-46
L	26.5	21-32	2	29	58.6	51-67	56	49-67
M	5	4-6	2	3	1.2	0.3-2.4	1.3	0.4-2.2
E	7.5	6-9	2	0	2.7	1.4-4.1	3.3	2.4-4.3
B	0		2	1	0.1	0-0.2	0.14	0-0.3
Plts	181	173-189	2					
ESR								
ELT	523	172-1410	3					
Pg	3.7		1					
AF								
				1 animal	*21 males*		*23 females*	

CANOIDEA
PROCYONIDAE
Procyon lotor
North American racoon

Survey Results

Test	*Av.*	*Range*	*No.*
PT	9.5	8-12	3
RVV	7.6	5-10	3
PTT	33	31-38	3
RT	53	46-60	3
KRT	27	12-40	3
TT	9.0	6.0-13.5	3
I	291	196-458	3
II	470		1
V	880	500-1000	3
VII			
VIII	597	330-1000	3
IX	850	700-1000	3
X	420	340-540	3
XI			
XII	310		1
XIII	+		3
AT			
CR	68.5	68-69	2
TP	7.16	6.58-7.85	3

CANOIDEA
PROCYONIDAE
Potos flavus
Kinkajou

Survey Results

Test	*Av.*	*No.*
Hb	16.8	1
RBC	7.1	1
PCV	51	1
Retics	1.0	1
MCV	72.4	1
MCH	23.8	1
MCHC	33.9	1
MCD		
WBC	9.8	1
N	41	1
L	53	1
M	4	1
E	2	1
B	0	1
Plts	242	1
ESR		
ELT		
Pg		
AF		

Ref. 28

Test	*Av.*
Hb	10.9
RBC	6.5
PCV	36
Retics	
MCV	55
MCH	17
MCHC	30
MCD	
WBC	
N	32
L	53
M	15
E	0
B	0
Plts	
ESR	
ELT	
Pg	
AF	

1 animal

CANOIDEA
MUSTELIDAE
Mustela putorius furo
Domestic ferret

Ref. 28

Test	*Av.*	*No.*
Hb	15.2	3
RBC	9.98	3
PCV	51	3
Retics		
MCV	48	3
MCH	16	3
MCHC	30	3
MCD		
WBC		
N		
L		
M		
E		
B		
Plts		
ESR		
ELT		
Pg		
AF		

Survey Results

Test	*Av.*	*Range*	*No.*
PT	16.0	14-18	7
RVV	7.6	6-10	7
PTT	42	35-50	7
RT	75	52-101	7
KRT	36	31-45	7
TT	7.8	6-9	7
I	285		1
II	148	115-180	2
V			
VII			
VIII	642	400-800	5
IX			
X	173	120-200	3
XI			
XII	510		1
XIII	+		5
AT			
CR	30	20-40	2
TP	5.47		1

CANOIDEA
MUSTELIDAE
Mustela vison
American mink

	Refs. 39, 40.		*Refs. 39, 40.*		*Ref. 41*	
Test	*Av.*	*Range*	*Av.*	*Range*	*Av.*	*Range*
Hb	11.9	9.5-15.6	15.0	11.4-17.3	14.7	13.5-17.5
RBC	9.7	8.9-10.4	9.7	7.5-11.3	7.5	5.7-9.3
PCV					48	41-57
Retics						
MCV					68	62-82
MCH						
MCHC						
MCD	7.8	6.0-9.5	7.8	6.0-9.5		
WBC	6.4	3.8-10.2	7.6	5.2-12.2	6.0	3.2-11.2
N	47	18-69	46	26-65	66	45-88
L	43	22-57	47	30-68	32	14-50
M	1.1	0-5	1.5	0-5	1	0-3
E	7.2	2.5-16.0	4.0	0-13	1	0-3
B	0.8	0-2.5	0.8	0-1.5	0	
	10 males		*9 females*		*15 animals*	

For influence of age on blood picture see ref. 40

CANOIDEA
MUSTELIDAE
Marten americana **(Pine marten)**
Mephitis mephitis **(Striped skunk)**
Mustela ermina **(Richardson's weazel)**

	Pine marten *Ref. 27*		**Striped skunk** *Ref. 28*		**Weazel** *Ref. 30*	
Test	*Av.*	*Range*	*Av.*	*Range*	*Av.*	*Range*
Hb	18.4	17.2-20.0	15.1			
RBC	14.9	14.4-15.8	10.0			
PCV	64	63-65	51.4			
Retics						
MCV	43	40-45	54			
MCH	12.2	12-13	16			
MCHC	29.9	29-32	30			
MCD					6.35	
WBC	5.9	5.4-6.7	16.0			
N	24	20-31	48		44	
L	65	59-72	42		40	
M	0.3	0-1	7		2.1	
E	11	9-15	0		4.2	
B	0.3	0-1	3		5.7	
Plts			540			
ESR	1					
	3 tests on 1 animal		*2 animals*		*2 animals*	

CANOIDEA

MUSTELIDAE

Eira barbara

Tayra

Survey Results

Test	*Av.*	*No.*
Hb	12.5	1
RBC	6.4	1
PCV	40.5	1
Retics	0.5	1
MCV	63.5	1
MCH	19.6	1
MCHC	30.9	1
MCD	6.05	1
WBC	10.0	1
N	70	1
L	21	1
M	7	1
E	1	1
B	1	1
Plts	536	1
ESR		
ELT	180	1
Pg		
AF		

Survey Results

Test	*Av.*	*No.*
PT	10.0	1
RVV	6.0	1
PTT	34	1
RT	63	1
KRT	39	1
TT	6.0	1
I	310	1
II	30	1
V	1000+	1
VII		
VIII	1000+	1
IX	120	1
X	150	1
XI		
XII		
XIII	+	1
AT		
CR		
TP	5.62	1

FELOIDEA
VIVERRIDAE
Paradoxurus hermaphroditus
Common palm civet

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	12.3	11.2-13.5	3
RBC	10.3	10.0-10.9	3
PCV	40	39-41	3
Retics	0.75	0-1	3
MCV	39.5	36-42	3
MCH	12.0	11.3-13.6	3
MCHC	32.6	32.0-33.2	3
MCD	4.24		1
WBC	6.4	4.6-8.1	3
N	58	54-63	3
L	37	32-41	3
M	2	1-3	3
E	3	2-4	3
B	0		3
Plts	366	238-430	3
ESR			
ELT		150-21h	3
Pg			
AF			

Survey Results

Test	*Av.*	*Range*	*No.*
PT	15.0	12.5-17.5	2
RVV	8.0		1
PTT	39	27-51	2
RT	43	40-45	2
KRT	42		1
TT	8.5	6-11	2
I	265	256-273	2
II	96		1
V	74		1
VII			
VIII	1000		1
IX			
X	140		1
XI			
XII			
XIII	+		1
AT			
CR			
TP	5.1		1

FELOIDEA
VIVERRIDAE
Herpestes sanguineus
Slender mongoose

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	14.0	13.0-15.4	5
RBC	9.8		1
PCV	43		1
Retics			
MCV	43.4		1
MCH	13.3		1
MCHC	30.0		1
MCD			
WBC	5.4		1
N	62		1
L	37		1
M	1		1
E	0		1
B	0		1
Plts	272	238-306	2
ESR	1		1
ELT	400	397-403	2
Pg			
AF			

Red cells of 5 animals became sickle-shaped when exposed to hypertonic solutions. This condition is apparently non-pathological.

Survey Results

Test	*Av.*	*Range*	*No.*
PT	15.3	14.0-16.5	2
RVV	11.3	10.0-12.5	2
PTT	53		1
RT	83		1
KRT			
TT	5.0		1
I	238	213-264	2
II	77	76-78	2
V			
VII	52		1
VIII	950	900-1000	2
IX			
X			
XI			
XII			
XIII	+		2
AT			
CR			
TP			

FELOIDEA
VIVERRIDAE
Herpestes auropunctatus (small Indian mongoose)
H. urva (Crab-eating mongoose)

Crab-eating mongoose
Survey Results

Test	*Av.*	*Range*	*No.*
Hb	15.3	14.4-16.2	2
RBC	11.6	11.2-12.1	2
PCV	48.5	45-52	2
Retics	0		2
MCV	41.5	40.1-42.9	2
MCH	13.3	12.9-13.7	2
MCHC	31.5	31-32	2
MCD	5.13	5.0-5.65	2
WBC	4.2	4.0-4.4	2
N	41	35-47	2
L	51	47-55	2
M	6	5-7	2
E	2	0-4	2
B	0		2
Plts	272	238-306	2
ESR			
ELT	400	397-403	2
Pg			
AF			

Small Indian mongoose
Survey Results

Test	*Av.*	*No.*
PT	17.0	1
RVV	14.5	1
PTT	46	1
RT		
KRT	27	1
TT	5.0	1
I		
II		
V		
VII		
VIII		
IX		
X		
XI		
XII		
XIII		
AT		
CR		
TP		

FELOIDEA
HYAENIDAE
Hyaena brunnea
Brown hyaena

Survey Results

Test	Av.	No.
Hb	13.2	1
RBC	7.0	1
PCV	40	1
Retics	0.5	1
MCV	57.0	1
MCH	18.8	1
MCHC	33.0	1
MCD		
WBC	13.4	1
N	83	1
L	12	1
M	2	1
E	3	1
B	0	1
Plts	278	1
ESR		
ELT	180	1
Pg	5.4	1
AF		

Survey Results

Test	Av.	No.
PT	10.0	1
RVV	6.0	1
PTT	52	1
RT	77	1
KRT	27	1
TT	6.0	1
I	443	1
II	70	1
V		
VII		
VIII	1000+	1
IX	1000+	1
X	21	1
XI		
XII	330	1
XIII	+	1
AT		
CR		
TP	6.4	1

FELOIDEA

HYAENIDAE

Hyaena hyaena

Striped hyaena

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	13.4	12.5-15.1	3
RBC	7.4	6.8-8.5	3
PCV	45	42-49	3
Retics	0.4	0.3-0.5	3
MCV	60.8	58-63	3
MCH	18.1	17.8-18.2	3
MCHC	29.7	29.1-30.5	3
MCD			
WBC	16.6	16.1-17.3	3
N	78	71-82	3
L	13.6	8.0-16.5	3
M	5.6	4.0-7.5	3
E	1.6	0-3.5	3
B	1.2	0-2	3
Plts	331	304-350	3
ESR	14	11-16	3
ELT			
Pg			
AF			

FELOIDEA

FELIDAE

Felis catus

Domestic cat

	Ref. 2		Ref. 4		Ref. 6		Ref. 76	
Test	*Av.*	*Range*	*Av.*	*SD*	*Av.*	*Range*	*Av.*	*Range*
Hb	10.7	7.0-16.2	12.5	± 1.72	11.2	8.7-14.5	12.98	10.1-16.8
RBC	7.2	4.5-11.3	6.5	± 0.87	7.2	4.6-9.7	8.19	6.1-10.6
PCV	32	21-49	36.5	± 4.9	40.2	28.5-47.0	38.95	31-52
Retics	0.1	0-3.6	0.05	± 0.09			0.25	0-2
MCV			56.2	± 3.26	50	41-58	47.7	40.2-56.9
MCH					15.4	12-18	15.9	11.9-19.3
MCHC	33	29-37	34.5	± 3.26	31.0	29-34	33.4	29.1-37.1
MCD								
WBC	16.5	7.9-34.7	13.86	± 5.18	15.0	5.6-28.9	12.01	5.1-25.0
N	9.5*	3.2-28.4	61	±15.4	59	35-79	55.5	20-80
L	4.5*	1.9-10.2	28.4	±12.2	32	11-52	37.7	12-76
M	0.56*	0.1-0.3	1.9	± 1.8	0.7	0-4	2.0	0-7
E	1.0*		8.9	± 2.4	8	2-31	4.8	0-10
B	0.01*		0.03	± 0.11	0.01	0-0.4	0	
Plts	371	157-876					443	286-668
ESR							18.2	5-38
ELT								
P'gen								
AF								

114 cats — *128 cats* — *10-100 cats* — *100 cats*

**cells X10³/c.mm.* — Ref. 2

Howell Jolly bodies in 1% of red cells — Ref. 4

See also refs. 1, 3, 5, 7-14.

Domestic Cat

	Ref. 52		Ref. 73
Test	*Av.*	*±SD*	*Av.*
PT	8.6	± 0.5	19.8
RVV			
PTT	36	± 4	
RT			
KRT			
TT			
I			45
II			49
V			1080
VII			129
VIII			200
IX			150
X			
XI			
XII			168
XIII			
AT			
CR			
TP			
	No. = 26		*No. = 5*

FELOIDEA
FELIDAE
Felis silvestris
European wild cat

Survey Results

Test	*Av.*	*No.*
Hb	9.0	1
RBC	5.3	1
PCV	31.5	1
Retics	0.4	1
MCV	54.4	1
MCH	15.5	1
MCHC	28.6	1
MCD		
WBC	5.2	1
N	57	1
L	35	1
M	5	1
E	3	1
B	0	1
Plts	334	1
ESR		
ELT	210	1
Pg		
AF		

Survey Results

Test	*Av.*	*No.*
PT	11.5	1
RVV	7.0	1
PTT	45	1
RT	34	1
KRT	21	1
TT	7.0	1
I	128	1
II	70	1
V	1000+	1
VII		
VIII	1000+	1
IX	1000+	1
X	40	1
XI		
XII	1000+	1
XIII	+	1
AT		
CR		
TP	4.91	1

FELOIDEA

FELIDAE

Felis chaus

Jungle cat

Survey Results

Test	*Av.*	*No.*
Hb	**12.2**	**1**
RBC	**5.6**	**1**
PCV		
Retics		
MCV		
MCH	**21.5**	**1**
MCHC		
MCD	**5.28**	**1**
WBC	**9.4**	**1**
N	**91**	**1**
L	**7**	**1**
M	**1.5**	**1**
E	**0.5**	**1**
B	**0**	**1**
Plts	**224**	**1**
ESR		
ELT	**490**	**1**
Pg		
AF		

A small number of the red cells contain Howell Jolly bodies.

Survey Results

Test	*Av.*	*No.*
PT	**11.5**	**1**
RVV	**7.5**	**1**
PTT	**41**	**1**
RT	**84**	**1**
KRT	**37**	**1**
TT	**6.0**	**1**
I	**542**	**1**
II		
V		
VII		
VIII		
IX		
X		
XI		
XII		
XIII	**+**	**1**
AT		
CR		
TP		

FELOIDEA

FELIDAE

Felis bengalensis

Leopard cat

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	13.7	12.4-17.5	4
RBC	7.9	7.1-9.8	4
PCV	39	35-45	4
Retics	1.0	0.5-1.5	4
MCV	48.9	46-50	4
MCH	17.2	16.2-17.9	4
MCHC	35.2	32.5-38.0	4
MCD			
WBC	17.3	14.6-19.4	4
N	62	46-79	4
L	33.8	19-49	4
M	2	1-4	4
E	3	0-8	4
B	0.2	0-1	4
Plts	462	243-684	4
ESR	10	3-16	3
ELT	232	225-240	3
Pg			
AF			

A small number of the red cells normally contain Howell Jolly bodies

FELOIDEA
FELIDAE
Felis caracal
Caracal lynx

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	12.6	9.8-14.5	6
RBC	8.2	6.1-10.0	6
PCV	39	30-45	6
Retics	0.2	0-0.4	2
MCV	47.5	44-60	6
MCH	15.6	14.5-19.5	6
MCHC	32.2	31-34	6
MCD	5.01	4.32-5.92	6
WBC	6.5	5.2-9.6	6
N	72	53-88	6
L	24	11-42	6
M	3	1-5	6
E	1	0-3	6
B	0		6
Plts	260	194-310	4
ESR	14	1-62	6
ELT	175		1
Pg			
AF			

A small number of the red cells normally contain Howell Jolly bodies.

Survey Results

Test	*Av.*	*Range*	*No.*
PT	12.3	12.0-12.5	2
RVV	9.0		1
PTT	70	47-93	2
RT	80		1
KRT	23		1
TT	4.5	4-5	2
I	621	303-940	2
II			
V			
VII			
VIII			
IX			
X			
XI			
XII	1000+		1
XIII	+		2
AT			
CR			
TP			

FELOIDEA
FELIDAE
Felix lynx
Northern lynx

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	12.3	10.4-13.7	6
RBC	7.25	6.1-9.2	6
PCV	33.7	30-41	6
Retics	0.4	0-1.4	6
MCV	48.5	44.6-51.8	6
MCH	17.1	14.9-18.7	6
MCHC	34.8	33-36	6
MCD			
WBC	7.8	5.9-9.5	6
N	82	71-90	6
L	13	9-23	6
M	2	0-6	6
E	3	0-8	6
B	0		6
Plts	404	200-632	6
ESR	12	1-28	3
ELT			
Pg			
AF			

A small number of the red cells normally contain Howell Jolly bodies.

Survey Results

Test	*Av.*	*No.*
PT	10.0	1
RVV	8.0	1
PTT	26	1
RT	40	1
KRT	24	1
TT	7.0	1
I	266	1
II		
V		
VII		
VIII	1000+	1
IX		
X	62	1
XI		
XII	600	1
XIII	+	1
AT		
CR	70	1
TP	5.8	1

FELOIDEA
FELIDAE
Felis serval
Serval

Survev Results

Test	Av.	Range	No.
Hb	13.5	11.8-16.8	5
RBC	5.72	5.1-6.5	5
PCV	39.5	33-48	5
Retics	0.2	0-0.5	5
MCV	70.4	62-77	5
MCH	22.9	21.5-25.4	5
MCHC	32.7	28-35	5
MCD			
WBC	9.0	4.7-13.7	5
N	70	66-77	5
L	25	19-30	5
M	2	0-4	5
E	3	0-4	5
B	0		5
Plts	197	148-286	3
ESR	13	2-26	3
ELT	270		1
Pg			
AF			

A small number of the red cells normally contain Howell Jolly bodies

Survey Results

Test	Av.	No.
PT		
RVV		
PTT		
RT		
KRT		
TT		
I		
II	20	1
V	250	1
VII		
VIII	1000+	1
IX	620	1
X	20	1
XI		
XII	360	1
XIII	+	1
AT		
CR		
TP		

FELOIDEA
FELIDAE
Felis leo
Lion

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	12.0	10.2-13.9	19
RBC	7.0	5.4-8.3	19
PCV	36.8	31-44	19
Retics	0.2	0-0.8	18
MCV	52.5	44-58	19
MCH	17.2	13.9-19.3	19
MCHC	32.3	29.5-37.2	19
MCD	5.34	4.93-5.53	12
WBC	7.9	2.3-17.0	19
N	71	61-89	19
L	22	7-37	19
M	3	1.5-5.0	19
E	4	0.5-11.0	19
B	0.1	0-0.5	19
Plts	291	199-571	19
ESR	19	2-46	12
ELT	212	60-330	9
Pg	4.8	3.5-5.1	7
AF	108	84-132	5

A small number of the red cells normally contain Howell Jolly bodies

	Ref. 43		*Ref. 43*		*Ref. 42*	*Ref. 1*
Test	*Av.*	*Range*	*Av.*	*Range*	*Av.*	*Av.*
Hb					12.2	11.5
RBC	9.3	6.9-10.9	7.6	6.2-10.1	7.25	7.9
PCV						36
Retics						
MCV						46
MCH						
MCHC						
MCD					7.0	
WBC	14.2	8.2-19.8	12.4	7.2-20.8	15.6	4.5
N	74*	54-97	63*	45-82	79*	60
L	23	7-37	34	21-49	17	31
M	0.1	0-2	0.2	0-0.5	3	9
E	2.8	0-6	2.5	0.5-12.0	1	0
B	0		0		0	0
Plts						
ESR						
ELT						
Pg						
AF						
	14 mature lions		*25 6-10 month lions*		*1 lion*	*1 lion*

**Many immature cells present.*

Lion

Survey Results

Test	*Av.*	*Range*	*No.*
PT	11.9	8.5-16.0	15
RVV	8.5	6-10	15
PTT	30	25-38	15
RT	63	44-80	15
KRT	37	30-42	11
TT	6.6	5-8	15
I	490	291-754	11
II	85	62-210	10
V	1000+		7
VII			
VIII	1000+		10
IX	275	150-400	7
X	46	13-138	10
XI	1000+		1
XII		600-1000+	3
XIII	+		15
AT	496	404-630	5
CR	64.5	64-65	2
TP	6.75	5.89-7.6	7

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FELOIDEA
FELIDAE
Felis pardalis
Ocelot

Survey Results

Test	*Av.*	*No.*
Hb	12.4	1
RBC	6.8	1
PCV	38	1
Retics	2.0	1
MCV	56.0	1
MCH	18.3	1
MCHC	32.6	1
MCD		
WBC	16.9	1
N	84	1
L	10	1
M	1	1
E	5	1
B	0	1
Plts		
ESR		
ELT		
Pg		
AF		

A small number of the red cells contain Howell Jolly bodies

Survey Results

Test	*Av.*	*No.*
PT		
RVV	9.0	1
PTT	43	1
RT	85	1
KRT	40	1
TT	9.0	1
I		
II		
V		
VII		
VIII	1000+	1
IX	19	1
X		
XI	1000+	1
XII	1000	1
XIII	+	1
AT		
CR		
TP		

FELOIDEA
FELIDAE
Felis concolor
Puma

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	13.9	11.3-17.2	12
RBC	7.87	6.0-10.4	11
PCV	38	30-49	12
Retics	0.9	0-3.1	12
MCV	48.2	38-52	11
MCH	17.6	14.6-18.8	11
MCHC	36.5	31-37	12
MCD	5.38	5.11-5.72	4
WBC	7.3	3.1-12.8	11
N	69	35-85	11
L	28	14-65	11
M	2	0-7	11
E	1	0-4	11
B	0		11
Plts	192	131-240	8
ESR	6.5	0-14	9
ELT			
Pg			
AF			

A small proportion of the red cells normally contain Howell Jolly bodies.

Survey Results

Test	*Av.*	*Range*	*No.*
PT			
RVV			
PTT	44		1
RT	87		1
KRT	39		1
TT	5.0		1
I			
II	270		1
V			
VII			
VIII			
IX			
X			
XI			
XII			
XIII	+		1
AT			
CR			
TP			

FELOIDEA
FELIDAE
Neofelis nebulosa
Clouded leopard

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	12.5		1
RBC	5.3		1
PCV	30		1
Retics			
MCV			
MCH			
MCHC			
MCD			
WBC			
N			
L			
M			
E			
B			
Plts			
ESR			
ELT			
Pg			
AF			

Survey Results

Test	*Av.*	*Range*	*No.*
PT			
RVV			
PTT			
RT			
KRT			
TT			
I			
II			
V	500		1
VII			
VIII			
IX	1000+		1
X			
XI			
XII			
XIII			
AT			
CR			
TP			

FELOIDEA
FELIDAE
Panthera tigris
Tiger

Survey Results

Test	Av.	Range	No.
Hb	13.4	10.1-16.2	15
RBC	6.7	5.5-7.7	15
PCV	40	34-47	15
Retics	0.2	0-1	15
MCV	59.7	54.8-69.0	15
MCH	20.0	17.1-21.0	15
MCHC	33.5	28.2-35.0	15
MCD	5.34	4.98-5.54	4
WBC	10.4	6.7-13.7	13
N	75	64-87	13
L	20	12-29	13
M	3	1-5	13
E	0.8	0-2	13
B	0.2	0-1	13
Plts	325	169-514	10
ESR	4	1-14	8
ELT	213	130-360	6
Pg	6.9		1
AF	90		1

Survey Results

Test	Av.	Range	No.
PT	7.5		1
RVV	5.5		1
PTT	37	28-46	2
RT	72	50-93	2
KRT	27	23-31	2
TT	6.5	6-7	2
I	292	256-328	2
II	70	50-90	3
V	1000+		5
VII			
VIII	1000+		5
IX	900		1
X	65	34-125	4
XI	1000+		1
XII	950		1
XIII	+		3
AT			
CR	57		1
TP	5.95	5.46-6.45	2

A small number of red cells normally contain Howell Jolly bodies.

Contact activation index 73 (1).

FELOIDEA
FELIDAE
Panthera pardus
Leopard

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	12.3	11.0-13.4	10
RBC	7.82	6.4-8.9	10
PCV	36.8	34-38	10
Retics	0.7	0.1-1.5	10
MCV	48	44-53	10
MCH	15.7	12.7-17.5	10
MCHC	33.4	31.0-35.2	10
MCD	4.89	4.60-5.43	3
WBC	12.1	6.5-17.5	10
N	76	72-84	10
L	17	10-27	10
M	3	0-5	10
E	4	0-7	10
B	0		10
Plts	374	292-468	10
ESR	10	4-15	5
ELT			
Pg			
AF			

Red cells often appear crenated on stained films. A small number normally contain Howell Jolly bodies.

Survey Results

Test	*Av.*	*Range*	*No.*
PT	12.5	10-15	4
RVV	7.8	7.0-9.5	5
PTT	35	27-49	5
RT	59	45-82	5
KRT	29	27-38	5
TT	5.5	4-7	5
I	274	161-477	5
II			
V	920	900-940	2
VII	135	97-210	3
VIII	1000+		2
IX	750		1
X	64	35-96	3
XI	1000+		1
XII	900		1
XIII	+		2
AT	570		1
CR	57		1
TP	6.35	5.84-6.86	2

Contact activation index 83

Range 81-85 (2 animals)

FELOIDEA
FELIDAE
Panthera onca
Jaguar

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	12.3	9.6-13.9	8
RBC	6.7	5.9-7.7	8
PCV	37	30-43	8
Retics	0.2	0-0.6	8
MCV	55.0	47-62	8
MCH	18.2	15.5-20.7	8
MCHC	32.5	21.7-34.2	8
MCD	5.2	5.12-5.41	5
WBC	7.1	4.6-8.4	8
N	80	66-82	8
L	14	7-16	8
M	3	0.5-7.0	8
E	3	1-5	8
B	0		8
Plts	201	158-238	8
ESR	23	0-58	8
ELT	272	195-350	8
Pg	4.71	3.25-5.8	4
AF			

Survey Results

Test	*Av.*	*Range*	*No.*
PT	12.3	10.5-16.0	3
RVV	8.6	8.0-10.5	4
PTT	36	27-49	4
RT	67	54-82	4
KRT	45	32-73	4
TT	7.4	5-10	4
I	477	273-737	4
II	67	51-90	3
V	800	600-1000	3
VII			
VIII	1000+		3
IX	310		1
X	57	30-100	4
XI	1000+		1
XII	450		1
XIII	+		
AT	538	455-610	3
CR	65	63-68	4
TP	6.78	6.10-7.42	4

A small number of red cells contain Howell Jolly bodies.

Contact activation index 79, range 71-87 (2)

PF3 release 55.5, range 51-60 (2)
Total PF3 74, range 68-80 (2)

FELOIDEA
FELIDAE
Acinonyx jubatus
Cheetah

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	12.6	11.2-14.0	11
RBC	7.0	5.8-8.5	11
PCV	40	37-48	11
Retics	1.0	0.4-2.2	11
MCV	58.5	48-69	11
MCH	18.1	16.0-21.5	11
MCHC	31.8	28-36	11
MCD	5.22	5.12-5.32	6
WBC	5.8	3.4-9.7	11
N	72	59-77	11
L	21	12-35	11
M	4	3-11	11
E	3	0-12	11
B	0		11
Plts	352	201-526	9
ESR	8	1-43	9
ELT	200	120-270	3
Pg	5.5		1
AF	109		1

Survey Results

Test	*Av.*	*Range*	*No.*
PT	12.5	10.5-16.0	3
RVV	8.4	8.0-10.5	4
PTT	36	28-49	5
RT	57	45-82	5
KRT	33	27-38	3
TT	6.5	5-8	5
I	423	277-737	4
II	95	76-115	3
V	425	250-600	3
VII			
VIII	1000+		7
IX	300		1
X	145	100-235	4
XI	1000+		1
XII	540		1
XIII	+		5
AT	60		1
CR	68		1
TP	6.24	5.88-6.51	3

A small proportion of red cells normally contain Howell Jolly bodies.

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Chapter 4

PERISSODACTYLA

This order comprises the odd-toed ungulates and is represented at the present time by only sixteen living species although at least 152 genera have been identified from fossil remains. The living species are separated into two sub-orders, the Hippomorpha (horses, asses and mules) and the Ceratomorpha. The Ceratomorpha are further sub-divided into two super-families, the Tapiroidea (tapirs) and the Rhinocerotoidea (rhinoceroses). Of the sixteen living species, twelve have been examined in the present survey.

Red cells

The blood picture of the domestic horse is well documented [1-15], [20, 21, 36-40], and mules [15, 16, 37] and burros (donkeys) have also been examined previously [17, 18, 37]. In the literature on domestic horses a distinction has been made between 'hot-blooded' and 'cold blooded' animals which are reported to have markedly different red cell counts, haemoglobin levels and packed cell volume [13]. For the purpose of differentiation, horses of Arabian descent and thoroughbreds resulting from crossing Arabian stallions with English mares are considered to be hot blooded; these include pure-blooded Arabs, American saddle-horses, standard-bred trotters, cow ponies, wild mustangs and quarter horses. Cart horses and ponies are cold blooded. In hot blooded varieties the reported total red count is from 7-13 x 10^6 per c.mm compared with 6-11 x 10^6/c.mm in cold blooded types. Since the MCH and MCD are relatively constant, the oxygen carrying capacity is higher in hot blooded animals, and has been held at least partially responsible for their high speed and stamina [3, 9]. Mules, donkeys and wild Hippomorpha examined in the present survey appear to resemble hot blooded horses with regard to their red cell characteristics.

Red cells of Perissodactyla are small but comparable in shape and staining characteristics with those of man. The smallest cells are found in the South American tapir *(Tapiris terrestris)* and the largest in the black rhinoceros *(Diceros bicornis)* and the mule [16]. Reticulocytes are absent from the circulating blood of horses [13] and mules [16] and most other members of the group. In the present series, reticulocytes have only been found in zebras and in one black rhinoceros. Absence of circulating reticulocytes indicates that the red cells become fully mature before leaving the marrow. Polychromatic and nucleated red cells are rare in the peripheral blood, even in cases of marked cell regeneration [13]. Howell Jolly bodies are seen occasionally in normal animals of the order and more frequently in anaemic ones. Heinz bodies have been found in several apparently normal white rhinoceroses.

The red cell and white cell count in horses is markedly increased by stress and exercise, probably as a result of splenic contraction in response to adrenaline secretion [19]. Stress association with blood sampling can increase the PCV by 16-64% [13, 44], a finding which has caused many investigators to express doubts as to the diagnostic value of blood counts on animals of this order. Wild perissodactyls examined in the present survey have been anaesthetised before obtaining blood samples, thus obviating stress effects. Other variables influencing red cell parameters in horses are age [5, 20] and lactation [21]. These variables have not been studied in wild Perissodactyla.

The erythrocytes of domestic horses [12, 13] and of mules [16] have a marked tendency for rouleaux formation and this property is shared by most other representatives of the order. The erythrocyte sedimentation rate is rapid in all perissodactyls and this test is consequently of limited diagnostic value. It is claimed that the 20 minute reading is the most useful; this is increased in anaemia and decreased in inflammatory conditions [13]. Rouleaux formation may be related to the presence in horse plasma of a well marked β_1 globulin fraction [41] rather than to high fibrinogen levels. It would be of interest to examine this protein in other members of the order.

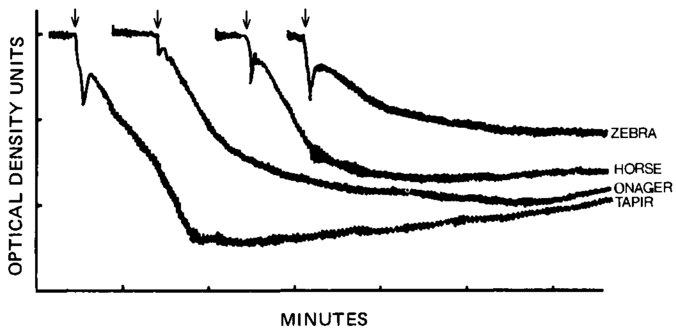
White cells

Unlike the red count, the total white count of horses is not influenced by breed [13] and does not vary significantly in other species of Perissodactyla. A neutrophilic leucocytosis occurs in horses in association with exercise and stress [13]. When stained with Leishman stain the neutrophil cytoplasm is only slightly granular. The nuclei often have as many as seven or eight lobes. Drumstick appendages are easily identified in females. Eosinophils, particularly in members of the Hippomorpha, contain strongly eosinophilic granules which are strikingly large, irregular in size and spherical or ovaloid in shape. In Ceratomorphs the granules are smaller, regular and spherical. Eosinophil nuclei have one or two lobes in domestic and wild horses and a large number of less distinct lobes in other equidae. Large lymphocytes are common in animals of this order. Monocytes are unremarkable and the basophils are only sparsly granular.

Platelets

The platelet count is usually at the lower end of the normal human range in Hippomorpha but may be higher in the Ceratomorpha. Platelets of these animals stain well with Leishman's stain. Clot retraction is generally poor in hippomorphs. Adenosine diphosphate causes aggregation of perissodactyle platelets but the aggregates formed are smaller than those of most other mammals and are comparable only with those of the Artiodactyla (Figure 4.1). This is apparently caused by low platelet reactivity rather than by the presence of high plasma ADP-inhibitor levels.

Figure 4.1. ADP-induced aggregation of perissodactyl platelets



Aggregation produced by addition of ADP, 1.2 mg per ml of plasma in the Malayan tapir, onager, horse and mountain zebra. Plasma standardised to contain 400 x 10^3 platelets per cu.mm. Arrows denote addition of ADP.

Blood coagulation

The blood coagulation mechanism of horses has been fairly extensively studied because these animals sometimes have relatively long whole blood clotting times, so stimulating the interest of coagulation experts. It has been variously reported that normal horses have low levels of factor VII [22], factor VIII [23, 25], factor IX [25, 26], factors XI and XII [25-29] and platelet phospholipid [27, 30]. Fantle and Marr [31] suggest that the thrombin-fibrinogen reaction is abnormal in horses but exclude the presence of an inhibitor of this reaction as an explanation of their findings. Results obtained in the present survey suggest that, compared with man, levels of fibrinogen and factors V, VIII, X and XII are normal or increased in perissodactyls. Factor II and XI may be low. The thrombin-fibrinogen reaction, measured by clotting horse plasma with bovine thrombin, is prolonged; this could result from the unusually high antithrombin levels found in the group.

True haemophilia has been reported in horses [31-35, 42]. The disease apparently resembles human haemophilia in its mode of inheritance, clinical manifestations and response to treatment [32, 35, 42].

Fibrinolysis

Circulating plasminogen activator can be detected in animals of this order by the euglobulin lysis test. Plasminogen levels are often high compared with the normal human range. Plasminogen is activated by human urokinase and by streptokinase, if human serum is added as a source of proactivator.

HIPPOMORPHA
EQUOIDEA
EQUIDAE
Equus caballus
Horse

	Survey Results			*Ref. 12*		*Ref. 13*		*Ref. 39*	
Test	*Av.*	*Range*	*No.*	*Av.*	*Range*	*Av.*	*Range*	*Av.*	*Range*
Hb	13.8	11.4-17.5	12	14.7	10.5-19.2	15.0	11-19	9.5	8.1-11.0
RBC	7.3	6.1-9.9	12	9.45	6.2-13.1	9.5	6.5-12.5	6.95	5.7-8.8
PCV	38	33-51	12	41.2	30-57	42	32-52	27	24-34
Retics	0		12						
MCV	51.9	47-60	12	45.2	30.7-60.5	46			
MCH	18.6	15.1-21.8	12	15.9	10.8-20.6				
MCHC	35.3	31.3-40.9	12	35.1	29.8-40.6	35	31-37		
MCD	5.22	5.0-5.33	9						
WBC	8.0	5.7-11.5	12	8.4	4.5-13.4	9.0	5.5-12.5	8.8	6.6-12.4
N	71	40-90	12	5.5*	4.5-13.4	49.5	30-65	55	34-78
L	25	6-58	12	2.7*	0.85-6.17	44	25-70	31.5	13-56
M	3.4	1-8	12	0.25*	0.0-0.925	4	0.5-7.0	5	1-8
E	0.5	0-2	12	0.14*	0.0-1.04	4	0-11	8	1-28
B	0.1	0-1	12	0.06*	0.0-0.13	0.5	0-3	0.5	0-3
Plts	202	104-368	6						
ESR	36	5-56	12	40.1	1-61				
ELT	720		3						
Pg	2.0		1						
AF									

'Hot-blooded' horses — *132 Thoroughbreds* — *40 Thoroughbreds* — *36 Clydesdales*

**WBC X10³/c.mm*

See also references 4-9, 15, 20, 36-38, 40.

Horse

Survey Results

Test	*Av.*	*Range*	*No.*
PT	49	21-57	6
RVV	11.0	9-15	6
PTT	92	64-110	6
RT	140	90-200	6
KRT	64	39-78	6
TT	11.0	8.0-16.5	6
I	344	150-481	6
II	60	50-76	5
V	700	410-1000	6
VII			
VIII	90	45-180	6
IX			
X	140	78-200	6
XI	84	54-94	2
XII	80	79-80	2
XIII	+		6
AT	1160	1010-1321	4
CR			
TP	5.69		1

'Hot-blooded' horses

	Ref. 22		*Ref. 43*	
Test	*Av.*	*± SD*	*Av.*	*Range*
PT	11.6	± 0.9	14.2	
RVV				
PTT	80	± 6		
RT				
KRT				
TT				
I				
II				
V				
VII			250	220-295
VIII				
IX				
X				
XI				
XII				
XIII				
Plts	240	± 30		
CR	52	± 3		
TP				

No. = 29

PF3 release 58, range 45-70 (2)
PF3 total 83, range 79-87 (2)
Contact activation index 72.5, range 70-75 (2 animals)

See also refs. 23-30.

HIPPOMORPHA
EQUOIDEA
EQUIDAE
Equus przewalski
Przewalski's wild horse

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	**16.3**	**14.3-20.0**	**4**
RBC	**8.6**	**6.8-10.4**	**4**
PCV	**47**	**38-50**	**4**
Retics	**0**		**4**
MCV	**55.1**	**45-66**	**4**
MCH	**19.2**	**17.0-21.6**	**4**
MCHC	**35.2**	**32-36**	**4**
MCD	**5.49**	**5.35-5.63**	**2**
WBC	**9.6**	**8.4-10.8**	**4**
N	**55**	**49-61**	**4**
L	**42**	**37-50**	**4**
M	**1**	**0-2**	**4**
E	**2**	**0-4**	**4**
B	**0**		**4**
Plts	**292**	**200-385**	**4**
ESR	**25**	**5-57**	**3**
ELT			
Pg			
AF			

Red cells occasionally contain Howell Jolly bodies.

Survey Results

Test	*Av.*	*No.*
PT	**25**	**1**
RVV	**13**	**1**
PTT	**135**	**1**
RT	**270**	**1**
KRT	**170**	**1**
TT	**8.0**	**1**
I	**460**	**1**
II	**38**	**1**
V	**160**	**1**
VII		
VIII	**95**	**1**
IX	**78**	**1**
X	**55**	**1**
XI	**30**	**1**
XII	**260**	**1**
XIII	**+**	
AT		
CR		
TP		

HIPPOMORPHA
EQUOIDEA
EQUIDAE
Equus hemionus
Onager

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	14.5	14-15	3
RBC	7.0	6.3-7.7	3
PCV	44	41-47	3
Retics	0		3
MCV	68.1	61-74	3
MCH	22.6	19.5-25.3	3
MCHC	32.5	31.5-33.8	3
MCD	5.12	4.44-5.81	2
WBC	7.6	7.0-8.2	3
N	62	58-67	3
L	34	33-35	3
M	2	1-6	3
E	2	0-3	3
B	0		3
Plts	162	134-190	2
ESR	30	19-48	3
ELT	260	60-600	3
Pg			
AF			

Survey Results

Test	*Av.*	*Range*	*No.*
PT	19.0	16-25	3
RVV	10.2	8.5-13.5	3
PTT	94	82-102	3
RT	142	106-222	3
KRT	110	94-125	2
TT	9.8	5-16	3
I	471	319-740	3
II	76	57-95	2
V	275	50-500	2
VII			
VIII	140	100-180	2
IX	84	78-90	2
X	108	64-160	2
XI	45		1
XII	160		1
XIII	+		3
AT			
CR	46	42-50	2
TP			

HIPPOMORPHA
EQUOIDEA
EQUIDAE
Equus asinus

Donkey or ass

Survey Results			*Ref. 17*		*Ref. 17*		*Ref. 37*	
Test	*Av.*	*No.*	*Av.*	*Range*	*Av.*	*Range*	*Av.*	*Range*
Hb	14.6	1	11.6	9.3-15.5	12.1	8.0-16.7		
RBC	6.2	1	6.9	5.7-8.6	7.1	5.0-10.3	6.4	4.5-8.5
PCV	38	1	36	31-45	37	26-51	37	30-48
Retics	0	1						
MCV	61.8	1						
MCH	23.7	1						
MCHC	38.0	1						
MCD	5.33	1						
WBC	6.9	1	12.6	7.0-17.7	14.4	9.3-28.5	14.4	11.5-21.9
N	38	1	43	26-65	43	28-64	34	15-37
L	52	1	42	18-64	42	24-59	53	33-71
M	7	1	6	1-14	5.5	0-12	4	2-15
E	3	1	7.5	0-18	8	0.5-26	8	1-14
B	0	1					1	0-1
Plts	229	1						
ESR	47	1						
ELT	540	1						
Pg	5.8	1						
AF								
			16 males		*12 females*		*14 animals*	

Survey Results		
Test	*Av.*	*No.*
PT	22	1
RVV	9.0	1
PTT	83	1
RT	238	1
KRT	99	1
TT	10.0	1
I	377	1
II	230	1
V	310	1
VII		
VIII	1000 +	1
IX		
X	140	1
XI		
XII		
XIII	+	
AT		
CR		
TP		

See also ref. 18.

HIPPOMORPHA
EQUOIDEA
EQUIDAE
Equus caballus X E asinus
Mule

	Ref. 15		*Ref. 16*		*Ref. 37*	
Test	*Av.*	*Range*	*Av.*	*Range*	*Av.*	*Range*
Hb			14.2	11.6-15.7		
RBC	7.4	6.2-9.9	7.2	6.3-8.6	8.04	
PCV			39	33-46	35	
Retics			0			
MCV			54.2	52.5-58.0		
MCH						
MCHC			36.6	35.1-37.8		
MCD			6.83	5.3-7.8		
WBC	8.9	6.0-10.8	11.7	8.4-15.4	12.9	9.0-18.3
N	43	33-60	52	35-67	49	32-70
L	47	36-60	39	26-54	41	22-60
M	4	2-7	2.3	1-5	3	1-5
E	5	2-11	6.5	3-9	6	2-13
B	0.6	0-1			1	0-2
Plts						
ESR			98*	43-133		
ELT						
Pg						
AF						
	20 English army mules		*10 Indian mules *Westergren's method*		*15 South African mules*	

HIPPOMORPHA
EQUOIDEA
EQUIDAE
Equus zebra
Mountain zebra

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	14.2	13.2-15.3	5
RBC	8.5	7.7-9.5	5
PCV	39	36-46	5
Retics	0.1	0-0.4	5
MCV	46.1	38.6-54.0	5
MCH	16.5	16.0-17.3	5
MCHC	34.3	31.5-38.0	5
MCD	5.14	4.98-5.26	4
WBC	8.1	7.3-8.9	4
N	63	54-76	4
L	32	21-40	4
M	4	1-9	4
E	1	0-2	4
B	0		4
Plts	214	162-360	4
ESR	21	12-36	4
ELT	144	80-190	4
Pg	3.55	2.9-4.2	2
AF			

PF3 release 56, range 51-62 (2 animals)
PF3 total 72, range 71-73 (2 animals)
Contact activation index 70 (1 animal)

Survey Results

Test	*Av.*	*Range*	*No.*
PT	31	21-41	4
RVV	9.7	8-15	4
PTT	63	52-73	4
RT	147	109-183	4
KRT	107	95-119	4
TT	17	13-23	4
I	447	287-586	4
II	61	39-115	4
V		800-1000+	2
VII			
VIII	298	125-470	2
IX			
X	102	90-120	2
XI	172	160-185	2
XII	150	125-175	2
XIII	+		4
AT	1200		1
CR	55	43-65	4
TP	6.79	6.24-7.53	2

HIPPOMORPHA
EQUOIDEA
EQUIDAE
Equus burchelli (Common zebra) and *E. grevyi* (Grevy's zebra)

Survey Results
Common Zebra

Test	*Av.*	*Range*	*No.*
Hb	15.4	13.2-17.6	5
RBC	8.3	7.4-9.7	5
PCV	44	38-54	5
Retics	0.1	0-0.5	5
MCV	54.0	42-66	5
MCH	18.7	15.2-21.7	5
MCHC	34.7	31.5-39.0	5
MCD			
WBC	8.3	7.4-9.7	5
N	67	43-83	5
L	28	14-52	5
M	3	2-6	5
E	1.5	0-4	5
B	0.5	0-1	5
Plts	193	155-258	4
ESR	16	5-38	3
ELT	90		2
Pg	6.9		1
AF			

Survey Results
Grevy's Zebra

Test	*Av.*	*No.*
Hb	17.4	1
RBC	9.4	1
PCV	48	1
Retics	0	1
MCV	51.0	1
MCH	18.6	1
MCHC	36.0	1
MCD	5.01	1
WBC	9.9	1
N	83	1
L	14	1
M	6	1
E	0	1
B	0	1
Plts	253	1
ESR	1.5	1
ELT		
Pg		
AF		

CERATOMORPHA
TAPIROIDEA
TAPIRIDAE
Tapirus indicus
Malay tapir

Survey Results

Test	Av.	No.
Hb	15.0	1
RBC	6.7	1
PCV	42	1
Retics	0	1
MCV	62.0	1
MCH	22.3	1
MCHC	36.0	1
MCD		
WBC	12.3	1
N	78	1
L	24	1
M	1	1
E	0	1
B	0	1
Plts	480	1
ESR	7	1
ELT	300	1
Pg		
AF		

Survey Results

Test	Av.	Range	No.
PT	21		1
RVV	9.0		1
PTT	30		1
RT	76		1
KRT	45		1
TT	5.5		1
I	632		1
II			
V			
VII			
VIII	850		1
IX	1000+		1
X			
XI	245	220-270	2
XII	540		1
XIII	+		1
AT			
CR			
TP			

CERATOMORPHA
TAPIROIDEA
TAPIRIDAE
Tapirus terrestris
South American tapir

Survey Results

Test	*Av.*	*No.*
Hb	9.8	1
RBC	7.3	1
PCV	37	1
Retics	0	1
MCV	50.5	1
MCH	13.5	1
MCHC	26.2	1
MCD	4.7	1
WBC	8.5	1
N	50	1
L	34	1
M	10	1
E	6	1
B	0	1
Plts	335	1
ESR	56	1
ELT		
Pg	5.6	1
AF		

Survey Results

Test	*Av.*	*No.*
PT	24	1
RVV	7.5	1
PTT	42	1
RT	82	1
KRT	41	1
TT	8.0	1
I	615	1
II	16	1
V	1000+	1
VII		
VIII		
IX		
X	150	1
XI		
XII		
XIII	+	1
AT		
CR	48	1
TP	5.62	1

CERATOMORPHA
RHINOCEROTOIDEA
RHINOCEROTIDAE
Diceros simus
White rhinoceros

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	17.5	15.3-19.9	21
RBC	7.2	5.9-9.8	21
PCV	46.5	41-54	21
Retics	0		21
MCV	65.2	57-71	21
MCH	24.7	20-29	21
MCHC	37.4	34-41	21
MCD			
WBC	9.0	5-12	21
N	63	35-84	21
L	30	14-51	21
M	4	1-9	21
E	3	0-9	21
B	0		21
Plts	328	146-664	21
ESR	21	5-34	21
ELT			
Pg			
AF			

Survey Results

Test	*Av.*	*No.*
PT	17.5	1
RVV	7.0	1
PTT	54	1
RT	108	1
KRT	53	1
TT	9.0	1
I	501	1
II	120	1
V	510	1
VII		
VIII	1000+	1
IX		
X		
XI		
XII	125	1
XIII	+	1
AT		
CR		
TP		

Red cells often contain inclusion bodies resembling Heinz bodies.

CERATOMORPHA
RHINOCEROTOIDEA
RHINOCEROTIDAE
Diceros bicornis (black rhinoceros)
and Rhinoceros unicornis (Indian rhinoceros)

Black rhinoceros
Survey Results

Test	*Av.*	*Range*	*No.*
Hb	19.2	18.8-19.5	2
RBC	7.3	7.1-7.5	2
PCV	50.5	50-51	2
Retics	0.5		2
MCV	69.2	68.0-70.4	2
MCH	26.2	26.0-26.4	2
MCHC	37.9	37.6-38.2	2
MCD	6.51	6.21-6.81	2
WBC	5.9	5.6-6.1	2
N	59	48-68	2
L	32	25-37	2
M	3	2-4	2
E	5.5	1-10	2
B	0.5	0-1	2
Plts	313	220-480	3
ESR	59	57-61	2
ELT			
Pg			
AF			

Indian rhinoceros
Survey Results

Test	*Av.*	*Range*	*No.*
Hb	13.5	11.5-15.5	3
RBC	6.0	5.7-6.3	3
PCV	39	34-44	3
Retics	0		3
MCV	65.0	59-70	3
MCH	22.1	20-25	3
MCHC	33.8	33-34	3
MCD			
WBC	8.3	4.3-10.8	5
N	73	65-76	5
L	22	20-27	5
M	3		5
E	2	0-5	5
B	0		5
Plts	154	134-180	3
ESR	42	27-57	2
ELT			
Pg			
AF			

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Chapter 5

ARTIODACTYLA

This order comprises the even-toed ungulates or cloven-hoofed animals. There are 194 living species, and apart from the polar regions, distribution is world wide. Most artiodactyls are herbivorous and are the prey of the large, wild carnivores. Thus evolutionary trends in the order include the development of long legs for fast speed, acute senses for locating predators and weapons of defence such as horns, antlers or tusks. A marked herding instinct is present in many species and the ruminants are unique in possessing specialised dentition and a digestive mechanism which enables them to obtain and store food rapidly when circumstances may be dangerous, to be digested at leisure in safer surroundings. Associated with rumination, true sleep rarely occurs in these animals.

The order is divided into three suborders, the Suiformes (pigs, peccaries, hippopotomuses), the Tylopoda (camels, llamas, alpacas) and the Ruminantia (ruminants). Of these, the Suiformes is generally considered to be the most primitive because its members are without most of the specialised features listed above, and survive only in protected forest, aquatic or domesticated environments. Camels and their relatives are adapted for life in arid situations or at high altitude. The Ruminantia is the suborder of the Artiodactyla regarded as the most successful on grounds of number of living species and distribution. Ruminants are divided into four superfamilies, the Traguloidea (chevrotains), the Cervoidea (deer), the Giraffoidea (giraffe, okapi) and the Bovoidea. The Bovoidea is further classified into two families, the Antilocapridae (pronghorn antelopes) and the Bovidae. Within the Bovidae four main subfamilies are distinguished; the Bovinae (kudu, eland, ox, bison, yak etc.), the Hippotraginae (oryx, blesbok, gnu), the Antilopinae (blackbucks) and the Caprinae (goats and sheep).

The fact that this order includes many species which have been domesticated for food, transport and provision of wool or hair for clothing is reflected in the haematological data available from the literature. Cattle [1-16, 89, 90], sheep [4, 8, 9, 17-24, 91] and pigs [4, 25-28] have been fairly extensively studied. Other species which have received attention include goats [4, 29, 92, 96], buffalo [4, 30-32, 87, 97, 98] and deer of the species *Cervus elephas* (red deer) [33], *Odocoileus hemionus* (mule deer) [34, 35], *O. virginianus* (white-tailed deer) [36], *O. columbianus* (black-tailed deer) [35] and *Rangifer tarandus* (reindeer) [37]. Because of the unusual shape of their red cells, animals of the suborder Tylopoda (camels, llamas etc.) have also proved of interest [38-42, 88, 95]. Animals examined in the present survey include mainly members of the Tylopoda, Cervidae, Bovinae and Capinae. The sum total of the information available demonstrates a wide haematological variation throughout the order, much of which can be related to environmental demands and/or phylogenetic relationships.

Erythrocytes

Throughout the order, the inverse relationship between red cell size and number is well demonstrated. A clear distinction can be made between the red cells of animals of the three different suborders (Table 5.1). Red cells of Suiformes are relatively large in contrast to the cells of the Ruminantia. The large number of small erythrocytes often found in ruminants has been related to the high altitudes usually inhabited by these animals where the availability of a large total surface area for gaseous exchange in situations of low oxygen tension is advantageous. This suborder includes the animal with the smallest red cells yet described, the mouse deer or lesser Malay chevortain *(Tragulus javanicus)* in which the mean cell diameter is 1.5μ [43] but which is not a mountain dweller. Camels and their relatives (suborder Tylopoda) are unique amongst mammals in that their red cells are oval in contrast to the biconcave discs found in all other mammalian species. Reticulocyte and nucleated red cells in camels are round. Contrary to some reports in the literature the mature oval cells do not contain nuclei although they tend to be flat rather than concave (Figure 1.1). The mean cell haemoglobin concentration is usually higher than that of other mammals and the packed cell volume lower. Oval cells do not form rouleaux. It is interesting that alpacas, llamas, guanacos and vicunas which inhabit mountainous regions of South America and Bactrian camels from mountain plateaus of the Gobi desert have higher total red counts and smaller cells than the Sahara desert-dwelling Arabian camel.

TABLE 5.1

RED CELLS OF ARTIODACTYLS. AVERAGE VALUES

Suborder	Hb	RBC	PCV	MCV	MCH	MCHC	MCD
SUIDAE	14.1	7.2	44.8	62.9	19.7	31.1	5.66
TYLOPODA	13.8	11.5	36.1	31.2	12.0	38.7	
RUMINANTIA	14.5	10.1	43.3	44.7	15.0	33.2	4.8

In sheep [44] and cattle [1, 4] the packed cell volume, haemoglobin and red count are increased by stress. This reaction is likely to operate in wild species but has not been studied. In domestic ruminants the red count, haemoglobin and packed cell volume are high and the mean cell volume low in suckling animals and tend towards normal adult levels within the first few months of life [2, 3, 21, 28, 30]. In cattle it has been reported that the red count is influenced by breed [13], climate [4], altitude [45] and parturition and there is some evidence of diurnal variation which may be related to changes in water balance [46, 104]. Some reports suggest that bulls have a higher red count than cows [4, 9], but the apparent sex difference, together with other physiological differences, may reflect individual variation and environmental influences [1, 90]. In sheep there is no evidence of a sex or breed difference [17, 19, 20]. Sheep are particularly susceptible to infestation with intestinal parasites which may cause low-grade anaemia. This may explain the low normal ranges often given in the literature for red cell indices of this species and the possibility of parasitic infestation should be borne in mind when studying wild ruminants. Pigs have larger red cells than ruminants and a correspondingly lower total count [25, 26]. This species is prone to develop iron deficiency anaemia, particularly in early life [4]. Reticulocytes and nucleated red cells are common in suckling pigs and in sows during the farrowing period [26]. This is in contrast to ruminants in which reticulocytes and polychromatic red cells are rare after the first few days of life; even in cases of resolving anaemia the reticulocyte count is rarely above 2% of red cells. Cabot's rings can often be found in red cells of normal Bactrian camels *(Camelus bactrianus)*.

The red cells of deer are also unusual in that, in many species, a sickling tendency is present (Figure 5.1). Sickled deer erythrocytes are often similar in shape to those seen in human sickle cell anaemia; it is interesting that the phenomenon was first recognised in deer in 1840 [47], seventy years before the human condition was noticed.

Sickle cells have so far been found in deer of the species *Cervus mexicanus* [47], *C. reevesii* (Reeves' muntjac) [47], *C. porcinus* (hog deer) [47], *C. elephas* (red deer) [33, 48], *C. equinus* (elk) [48], *C. nippon* (Sika deer) [48], *Dama dama* (fallow deer) [48], *Odocoileus virginianus* (Virginian white-tailed deer) [49-53], *O. columbianus* (black-tailed deer) [54], *Axis axis* (axis deer) [48], *Pseudoaxis hortulorum* [48], *Elaphurus davidianus* (Père David's deer) [48] and *Cervus canadensis* (Wapiti). It has been suggested that the condition can occur in all species of Cervidae. Amongst other ruminants, sickling has been reported in Soay and Clun Forest sheep [55] and in young goats [56]. The sickling trait is apparently inherited but the mode of inheritance has not yet been determined.

In man, sickle cell disease is a congenital condition occurring as a result of the presence of an abnormal haemoglobin molecule, (Hb-S), in which two glutamine residues are replaced by valine. In deoxygenated Hb-S, apolar bonds are formed between valine residues of adjacent molecules, giving rise to linear aggregation of the molecules to form stiff tactoids. These distort the red cells into the characteristic sickle shape. *In vitro,* sickling can be produced in the blood of affected humans by addition of reducing agents; *in vivo* sickling occurs in situations of low oxygen tension. Human sickle cells have a reduced mechanical fragility and are structurally rigid in nature. Their presence in blood causes a marked rise in viscosity. Pathological consequences include haemolytic anaemia and occlusion of small blood vessels by rigid cells. In white-tailed deer, multiple haemoglobin types have been found in animals with sickle cells, some of which can be associated with the red cell shape change [49], but the molecular characteristics have not yet been determined. In affected animals, evidence of sickling can usually be seen on air-dried blood films and the degree of sickling can be increased in anticoagulated blood by storage at 4°C overnight or by saturation with oxygen, carbon monoxide or nitrogen [48]. Exposure to carbon dioxide and the addition of reducing agents brings about reversal of the cell shape to the normal discoid form [48]. Sickling is correlated to some extent with blood pH and above pH 7.2, sickling is rapid [48]. *In vivo* sickle cells are formed in conditions of exercise-induced respiratory alkalosis and can be produced experimentally by infusion of sodium bicarbonate [53]. Sickled deer cells do not show increased mechanical fragility or the rigid structure of human sickle cells although the viscosity of the blood is increased [53]. Apart from one report of 'watery blood' and splenic atrophy in affected animals dying of cold exposure and malnutrition in America [51], the sickling condition has not been correlated with any haematological or other abnormality and is generally accepted as being non-pathological in deer [53]. Subjective observations indicate that affected animals have a higher death risk in stress situations associated with hyperventilation. It has been suggested that, although the conditions associated with sickle cell production in deer differ from those affecting human Hb-S, the basic cellular mechanisms may be similar [52]. A fuller study of sickling in deer would be of great interest.

In domestic ruminants, erythrocytes show little tendency to sediment [3, 4, 57, 58] and the same is true for other animals of this order. The ESR is apparently not useful as a clinical test in cattle [59] although some information may be gained by reading the result after 18-24 hours [58]. The oval red cells of Camelidae do not form rouleaux and sedimentation is negligible. In the present survey, erythrocyte sedimentation rates of less than one mm have been recorded in camels with severe anaema, acute bronchitis, chronic wound infections and advanced arthritis.

Red cell osmotic fragility is apparently comparable with that of mammals in all artiodactyl groups except the Tylopoda. Camel red cells possess the ability to withstand the effects of lower ionic concentrations in the surrounding medium than most other mammals (Figure 5.2). The reason for this is not clear. A teleological explanation has been proposed, suggesting that, since camels may exist for many months without drinking, but when given access to

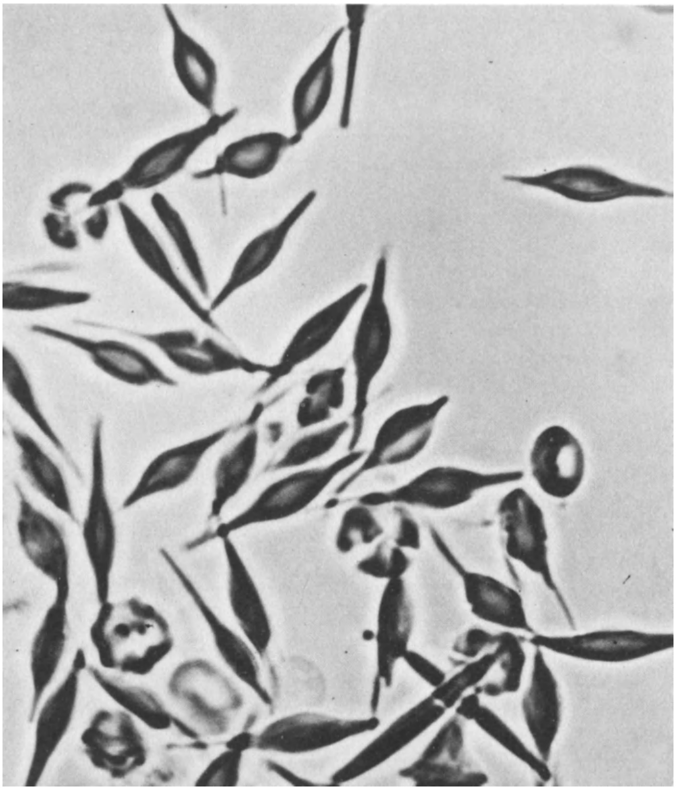
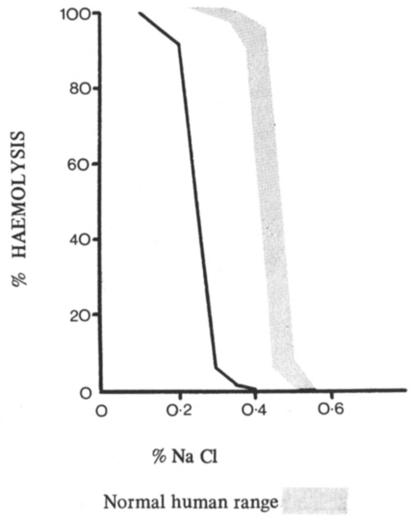


Figure 5.1 Sickled red cells of the fallow deer.

Figure 5.2 Red cell osmotic fragility in the Bactrian Camel



water, imbibe vast quantities very rapidly, the ionic strength of their plasma may vary within wide limits [60]. Thus high resistance of red cells to ionic changes in their environment may be essential. Confirmation of this theory by monitoring changes in plasma ionic strength of camels would be of interest.

White cells

The white cell count of artiodactyls is of interest because, in many species, the total number of circulating white cells is significantly below the normal human range. This finding could lead to misinterpretation of results if not appreciated. Low white counts have been reported in red deer [33], white-tailed deer [36] and reindeer [37] and, in the present survey, have been found in some bovine animals belonging to the subfamilies Caprinae and Bovinae, in most deer and in the Arabian camel. In domestic artiodactyls, including cattle, goats and sheep, the total white count in normal animals is between 4 and 12 thousand/c.mm of blood and may be higher in pigs [4]. However, in domestic artiodactyls the white cell response to infections may be less than expected [4].

Total white counts of domestic ruminants may be influenced by age [1], breed [14, 24], pregnancy and parturition [1, 12] although it has been suggested that individual variation and environmental factors may account for some of the results on which reported claims are based [1]. In cattle [1], buffalo [32], sheep [20], goats [29] and pigs, and in some wild Bovinae and Cervidae, lymphocytes outnumber neutrophils in adult animals although the ratio may be reversed in newborn animals [2, 3]. Monocytes are present in usual numbers. Basophils are relatively common in some individuals. Eosinophils are low at birth but numbers increase with increasing age, probably as a result of parasitic infestation [1, 4].

When stained with Leishman stain, the cytoplasma of neutrophils contains sparse to moderate basolphilic granulation. The nuclear lobes are not always well defined. Drumstick appendages are easily identified in female animals. Eosinophils have small, well staining spherical or ovaloid granules which generally do not fill the cell. The cytoplasm of these cells is greyish blue. Of lymphocytes, the large forms usually predominate and in some species cytoplasmic granules are prominent. Basophils are moderately granular.

Lymphocytic leukaemia possibly due to viral infection occurs in domestic cattle with some frequency [4], and leukaemia of various types has been recorded in sheep, pigs, goats [4] and some wild ruminants [80]. It has already been mentioned that the white cell response of cattle to bacterial infections is often less marked than expected [4]. In those species with a low neutrophil/lymphocyte ratio, localised inflammatory processes may lead to the draining off of circulating neutrophils at a rate greater than their replacement by the bone marrow, resulting in the development of a temporary neutropenia in the initial stages of infective conditions. This situation may be augmented by lymphopenia associated with stress, leading to frank leucopenia [4]. In domestic animals, leucopenia is also found in viral infections [81-85].

Platelets

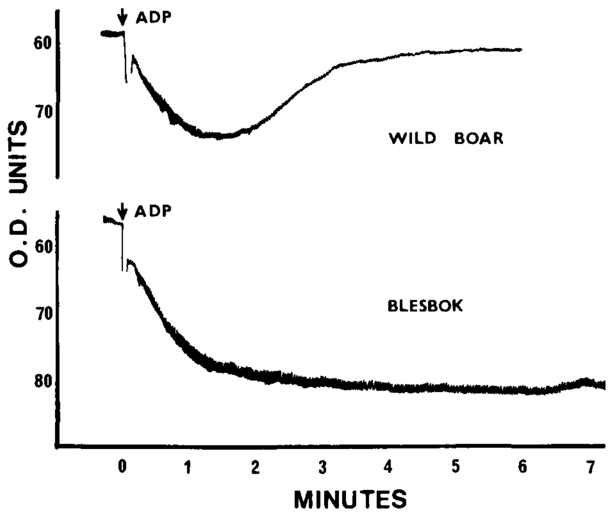
The platelet count is within or above the normal human range in animals of this order. Platelets appear small in wet preparations but not on stained films. When stained with Leishman stain, they differ in morphology from platelets of other mammals in that each contains several discrete, evenly spaced, purple granules in contrast to the irregularly clumped basophilic material usually seen. The adhesive platelet count is higher in sheep than in man [61]. Platelets are aggregated by ADP *in vitro* but the process does not proceed as rapidly as in carnivores and primates and the aggregates are comparatively small (Figure 5.3). Clot retraction is often less than expected in samples with plentiful platelets. Experience has shown that platelets of Caprinae are small and often appear partly aggregated even in blood samples collected with the utmost care; this may explain their reduced reactivity in *in vitro* tests. Total PF3 and PF3 release is normal in the few species which have been tested.

Blood coagulation

Blood coagulation studies on cattle [1-3, 93, 94, 99, 100], sheep [17, 24, 61, 94] and buffalo [32, 86] suggest that the mechanism is active in these animals but that levels of activity of specific clotting factors may vary from human values. Because of availability of large volumes of blood from domestic ruminants and the presence of high levels of some clotting factors in their plasma, separation of clotting factors for use as laboratory reagents and therapeutic material has been extensively studied [62-65]. Peptide mapping and amino acid analysis of bovine, porcine and sheep fibrinogen have also been carried out [66-68].

Studies on bovine plasma indicate that the reaction between bovine clotting factors and the protein fraction of human brain extract is impaired [69] and similar lack of reactivity in other artiodactyls is indicated by the prolonged prothrombin time using human brain. This prolongation is most marked in members of the Cervidae. In homologous test systems however the prothrombin time is within the expected range. Intrinsic prothrombin activation is usually rapid but in some ruminants, standardized contact with kaolin does not shorten the recalcification time, probably as a result of low levels of factor XI. Levels of fibrinogen and factor V are within the normal human range or higher. Factors VIII and XII are high and factors II, VII and sometimes IX and X are low even when measured in artificially prepared homologous test systems or when activated by specific snake venoms. Factor XI is low in Tylopoda and in most ruminants excluding some deer. Factor XI levels of less than 1% have been found in two apparently normal greater kudu *(Tragelephas strepsiceros)*; it remains to be determined if this is a general characteristic of the species or an inherited defect. Factor XIII is present in all artiodactyls tested and antithrombin levels are within the expected range.

Figure 5.3. TYPICAL PATTERNS OF PLATELETS AGGREGATION INDUCED BY ADP IN ARTIODACTYLA



Aggregation produced by addition of ADP 12.5 mg per ml of PRP containing 400×10^3 platelets per c.mm

The acquired coagulation defect arising in cattle eating spoiled sweet clover is well documented [70] and study of this condition led to the discovery of the anticoagulant properties of the coumarin and indanedione drugs [71]. A bleeding disease due to deficiencies in factors I, II, V, VII, IX and X has been reported in newborn calves [103]. Perhaps surprisingly, only one congenital coagulation defect has been described in domestic cattle, namely factor XI deficiency [105]. A bleeding defect, originally thought to be analogous with human haemophilia [72, 73] but now shown to be similar to von Willebrand's disease, has been found in pigs. Affected animals have reduced levels of factor VIII, reduced platelet adhesiveness and prolonged bleeding times [74, 79]. Congenital afibrinogenaemia has been described in goats [101].

Fibrinolysis

Plasminogen levels of Artiodactyla are usually within the normal human range although lower levels have been recorded in some Cervoidea and Caprinae. Plasminogen is activated directly by human urokinase but not by streptokinase unless 'proactivator' is provided. With the exception of the Cervoidea, animals in this order have prolonged euglobulin lysis times, their euglobulin clots often remaining stable for longer than 24 hours. In sheep the euglobulin lysis time is reduced by stress in association with acute haemorrhage but not by infusion of adrenaline. Lack of fibrinolytic activity in the intima and media of blood vessels of pigs and cows has been described [102]. Fibrinolytic inhibitors in sheep and in those wild species where they have been measured are within the expected range. Complete lysis within a few hours of clots of some 8-10 day old buffalo calves has been reported [86].

SUIFORMES
SUOIDEA
SUIDAE
Sus scrofa
Wild boar

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	14.9	13.8-15.6	4
RBC	6.4	6.1-6.6	4
PCV	45.5	42-48	4
Retics	1.1	0.2-1.8	4
MCV	71.0	69.5-73.5	4
MCH	23.5	22.8-24.0	4
MCHC	32.4	31.5-33.8	4
MCD	5.66	5.61-5.77	4
WBC	8.3	6.6-10.4	4
N	53	34-73	4
L	38	17-60	4
M	8	5-10	4
E	1	0-2	4
B	0	0	4
Plts	170	120-217	4
ESR	4	1-6	4
ELT		12-24h	7
Pg	2.7	2.6-2.8	6
AF			

Survey Results

Test	*Av.*	*Range*	*No.*
PT	12.2	10-14	7
RVV	7.0	5.5-8.0	7
PTT	27	20-32	7
RT	49	38-62	7
KRT	26	20-31	7
TT	11.3	8.5-17.0	5
I	482	278-667	7
II	49	30-66	7
V		500-1000+	7
VII			
VIII	1000+		7
IX	1000+		3
X	157	80-200	7
XI	1000+		1
XII	630	510-750	2
XIII	+		7
AT	384	265-485	7
CR	52	50-54	2
TP	6.22	5.08-7.18	7

SUIFORMES
SUOIDEA
SUIDAE
Sus scrofa
Domestic pig

	Ref. 4		Ref. 27		Ref. 92	
Test	*Av.*	*Range*	*Av.*	*Range*	*Av.*	*Range*
Hb	13.0	10-16	13.4	11-15	13.0	10-16
RBC	6.5	5-8	6.8	6.1-7.8	7.0	5-9
PCV	42	32-50	41	37-47	40	35-50
Retics						
MCV	63	50-68	60.3	56-68		
MCH			19.5	17.5-21.0		
MCHC	32	30-34	32.3	29-36		
MCD						
WBC	16.0	11-22	19.6	12-30	16.0	10-22
N	37	28-47	6.3*	2.2-12.0	6.0*	2-10
L	53	39-62	10.6*	7.7-15.8	8.0*	3-13
M	5	2-10	1.2*	0.5-2.2	0.1*	0.05-1.0
E	3	1-11	0.98*	0.3-1.8	0.1*	0-1
B	0.5	0-2	0.13*	0-0.2	0.05*	0-0.5
Plts						
ESR						
ELT						
Pg						
AF						

25 animals
* $X10^3$*/c.mm.*

For blood coagulation tests on pigs, see refs. 77, 78, 99.

SUIFORMES
SUOIDEA
SUIDAE
Potamochoerus porcus (Bush pig)
Phacochoerus aethiopicus (Wart Hog)

Bush Pig
Survey Results

Test	*Av.*	*No.*
Hb	17.0	1
RBC	8.9	1
PCV	50	1
Retics	0	1
MCV	56.3	1
MCH	19.2	1
MCHC	34.0	1
MCD	5.69	1
WBC	16.0	1
N	80	1
L	13	1
M	7	1
E	0	1
B	0	1
Plts		
ESR	3	1
ELT		
Pg		
AF		

Wart Hog
Survey Results

Test	*Av.*	*No.*
Hb	14.3	1
RBC	6.9	1
PCV	43.5	1
Retics	1.2	1
MCV	63.0	1
MCH	20.7	1
MCHC	32.8	1
MCD		
WBC	13.8	1
N	53	1
L	41	1
M	3	1
E	2	2
B	1	1
Plts	322	1
ESR	2	1
ELT		
Pg		
AF		

SUIFORMES
SUOIDEA
TAYASSUIDAE
Tayassu tajacu
Collared peccary

Survey Results

Test	*Av.*	*No.*
Hb	10.5	1
RBC	6.4	1
PCV	39	1
Retics	0.3	1
MCV	61.4	1
MCH	16.5	1
MCHC	27.0	1
MCD	5.42	1
WBC		
N		
L		
M		
E		
B		
Plts	344	1
ESR		
ELT	24h+	1
Pg	2.42	1
AF		

Survey Results

Test	*Av.*	*No.*
PT		
RVV	10.0	1
PTT	40	1
RT	80	1
KRT	41	1
TT	8	1
I	330	1
II	55	1
V	500	1
VII		
VIII	1000+	1
IX	1000+	1
X	130	1
XI		
XII		
XIII	+	1
AT		
CR	72	1
TP	6.4	1

PF3 release 43 (1)
PF3 total 84 (1)
Contact activation index 49 (1)

TYLOPODA
CAMELIDAE
Lama glama
Llama

Survey Results				*Ref. 41*	*Ref. 88*	
Test	*Av.*	*Range*	*No.*	*Av.*	*Av.*	*Range*
Hb	14.3	12.0-16.1	12	13.0	12.8	11.6 - 14.5
RBC	11.9	8.3-13.7	12	11.3	9.9	8.3 - 12.5
PCV	34	28-39	12			
Retics	0		12			
MCV	28.3	25.6-31.0	12			
MCH	11.6	10.6-12.3	12			
MCHC	39.2	28.5-44.4	12			
MCD	7.55 x 3.74	7.3-7.8 x 3.6-4.2	5	3.9 x 7.2		
WBC	10.8	4.8-16.4	12	10.3	16.2	8.9-22
N	66	47-84	12	65		28-95
L	22	3-43	12	11		15-59
M	3	2-11	12	4		0.5-2
E	3	0-5	12	10		3.5-6
B	0.5	0-1	12	10		0.5-3
Plts	344	320-368	5			
ESR	0		3			
ELT	520	480-600	3			
Pg	3.4	1.7-5.3	4			
AF						

White cell indices on 3 yearlings:

WBC 6.4, range 2.8-10.8
N 18 14-21
L 76 71-83
M 5 3-7
E 2 0-4
B 0.5 0-1

Ref. 41: No. not given
Ref. 88: 7 animals

See also ref. 45.

Survey Results

Test	*Av.*	*Range*	*No.*
PT	14.8	13.5-16.0	4
RVV	8.0	7-9	4
PTT	37	34-40	4
RT	136	66-240	4
KRT	63	49-69	4
TT	9	7-11	4
I	200	124-267	4
II	63	49-69	4
V	137	110-160	4
VII			
VIII		500-1000+	4
IX	310	260-330	4
X	205	200-220	4
XI	54		1
XII	460		1
XIII	+		4
AT			
CR			
TP	5.56	5.4-5.64	4

PF 3 release 42 (1)
PF 3 total 98 (1)

TYLOPODA
CAMELIDAE
Lama pacos
Alpaca

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	14.2	12.3-15.4	4
RBC	12.0	10.8-13.3	4
PCV	35	29-42	4
Retics	0.1	0-0.6	4
MCV	29.8	29-39	4
MCH	11.7	10.6-13.3	4
MCHC	40.2	35.0-43.5	4
MCD	6.51 x 3.14		1
WBC	14.4	9.8-17.5	4
N	79	69-87	4
L	18	9-30	4
M	2	1-4	4
E	1	0-2	4
B	0		4
Plts	290	230-328	3
ESR	0		1
ELT	24h		1
Pg	3.5		1
AF			

Ref. 88

Av.	*Range*
12.2	7.5-16.7
9.5	7.8-10.8
11.8	6.9-15.5
	43-79
	14-27
	0-0.5
	9-33
	0-1.5

7 animals

Survey Results

Test	*Av.*	*Range*	*No.*
PT	16.2	15.0-17.5	2
RVV	9.3	8.5-10.0	2
PTT	39	35-43	2
RT	78	65-90	2
KRT	49	38-59	2
TT	7		2
I	323	190-455	2
II	50		1
V	500		1
VII			
VIII	1000+		2
IX			
X	233	135-330	2
XI	26		1
XII			
XIII	+		1
AT			
CR	78		1
TP	5.7		1

See also ref. 41

TYLOPODA
CAMELIDAE
Lama guanaco
Guanaco

Survey Results

Test	Av.	No.
PT	16	1
RVV	8.5	1
PTT	47	1
RT	88	1
KRT	44	1
TT	8.0	1
I	624	1
II	80	1
V	100	1
VII		
VIII		
IX		
X	120	1
XI	20	1
XII	540	1
XIII	+	1
AT		
CR	57	
TP		

	Ref. 4		Ref. 88	
Test	Av.	Range	Av.	Range
Hb	17.3	13.2-20.5	16.4	14.6-19.2
RBC	15.5	12.1-17.8	10.4	8.9-11.7
PCV	40	31-45		
Retics				
MCV				
MCH				
MCHC				
MCD				
WBC	12.6	8.6-19.0	11.7	6.4-19.2
N	64	57-78		41-93
L	24	16-30		15-27
M	3	2-3.8		0.5-2.5
E	5	3-8		4-16
B		0-0.5		1-2
Plts				
ESR				
ELT				
Pg				
AF				
		3 animals		8 animals

TYLOPODA
CAMELIDAE
Vicugna vicugna
Vicuna

	Survey Results			*Ref. 88*	
Test	*Av.*	*Range*	*No.*	*Av.*	*Range*
Hb	15.5	15.2-15.8	2	12.2	9.8-14.8
RBC	13.0	12.6-13.4	2	10.3	9.4-11.5
PCV	40.5	38-43	2		
Retics	1.1	1.0-1.2	2		
MCV	31.1	30.1-32.1	2		
MCH	11.9	11.7-12.0	2		
MCHC	38.1	36.2-40.0	2		
MCD	7.05 x 3.17	6.99x7.13-3.15x3.2	2		
WBC	8.5	5.8-11.2	2	11.7	6.4-19.2
N	77	70.5-82.5	2		41-54
L	17	11-22	2		11-40
M	5	4-6	2		0-0.5
E	1.5	1-2	2		5-18
B	0		2		
Plts	231	198-265	2		
ESR	0		2		
ELT					
Pg					
AF					

Survey Results

Test	*Av.*	*Range*	*No.*
PT	17.8	17.5-18.0	2
RVV	7.5		2
PTT	47	45-49	2
RT	98	96-100	2
KRT	47	46-48	2
TT	10.75	10.0-11.5	2
I	508		1
II	135		1
V	86		1
VII			
VIII	1000+		1
IX			
X			
XI	76		1
XII	600		1
XIII	+		1
AT			
CR			
TP			

See also ref. 45

TYLOPODA
CAMELIDAE
Camelus bactrianus
Bactrian camel

	Survey Results			*Ref. 38*	*Ref. 41*	*Ref. 42*
Test	*Av.*	*Range*	*No.*	*Av.*	*Av.*	*Av.*
Hb	14.5	11.1-17.6	14		12.7	8.8
RBC	11.7	9.7-12.9	14	10-19	10.45	11.1
PCV	35	29-42	14	40		
Retics	0.1	0-0.6	14			
MCV	27.0	26.0-31.6	14			
MCH	11.9	10.6-13.6	14			
MCHC	43.8	37.2-45.0	14			
MCD	7.45 x 3.81		1	3.5 x 7.2	3.6 x 7.5	
WBC	15.6	8.6-24.4	17			10.8
N	67	50-86	17			69
L	27	10-37	17			11
M	3	0-7	17			3
E	2.5	0-7	17			15
B	0.5	0-1	17			2
Plts	355	220-526	12			
ESR	0		19			
ELT	720+		13			
Pg	4.36	3.05-5.9	9			
AF						
				No. = 12-20	*No. not given*	*24 animals*

Cabot's rings present in some red cells.

For Hb and RBC of Bactrian X Arabian Camels (Nairs) see Ref. 42.

Bactrian camel

Survey results

Test	*Av.*	*Range*	*No.*
PT	20.5	14-26	13
RVV	8.5	5-11	13
PTT	59	42-77	13
RT	101	73-133	13
KRT	73	53-90	13
TT	7.5	5-10	13
I	303	184-454	10
II	30	24-38	9
V	190	120-310	9
VII			
VIII		700-1000+	14
IX	107	60-160	5
X	200	76-300	11
XI	32	20-44	2
XII	575	510-640	2
XIII	+		10
AT	400	300-501	2
CR	54	50-59	3
TP	5.34	4.4-6.4	9

PF3 release 60, range 51-67 (5 animals)
PF3 total 103, range 100-104 (5 animals)
Contact activation index 71
Range 29-84 (9 animals)

TYLOPODA
CAMELIDAE
Camelus dromedarius
Arabian camel

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	10.7	9.1-12.0	6
RBC	9.1	8.0-10.9	6
PCV	36	28-42	6
Retics	0.6	0.2-1.2	3
MCV	39.9	31-46	6
MCH	13.1	10.5-15.7	6
MCHC	32.3	24.4-43.0	6
MCD	7.0 x 3.8	6.92-7.08 x 3.41-4.15	2
WBC	4.1	3.0-4.0	4
N	49	38-65	4
L	42	25-51	4
M	5	1-9	4
E	4	2-4	4
B	0.1	0-0.5	4
Plts	271	263-280	2
ESR	0		4
ELT	1440+		2
Pg			
AG			

Test	*Ref. 38* *Av.*	*Ref. 38* *Range*	*Ref. 39* *Av.*	*Ref. 39* *Range*	*Ref. 95* *Av.*
Hb	13.1	10.6-15.1	15.5	10.6-20.3	13.2
RBC	7.24	6.1-9.3	8.2	3.8-12.6	7.2
PCV	27	20-33			43
Retics					
MCV	37.9	30-47			59.9
MCH	17.4	14.6-21.3			18.3
MCHC	47	41-53			30.7
MCD					
WBC	18.1	10.5-28.3	20.1	12.9-27.2	12.5
N	51	10-60	39	21-56	31
L	40	35-58	46	26-65	63
M	3	1-6	6	0-12	2.4
E	6	2-18	9.5	0-19	2.2
B	0.05	0-0.5		0-1	0.7
Plts					
ESR					
ELT					
Pg					
AG					
	10-20 animals		*95 animals*		*80 animals*

See also refs. 41, 42

Arabian camel

Survey Results

Test	*Av.*	*Range*	*No.*
PT	20.5	20-21	2
RVV	9.0		1
PTT	55	54-56	2
RT	95	85-105	2
KRT	63	58-67	2
TT	13.5	10-17	2
I	270		1
II			
V	1000+		1
VII			
VIII	1000+		1
IX	1000+		1
X	145		1
XI	18		1
XII			
XIII	+		1
AT			
CR			
TP			

Contact activation index 57 (1)

RUMINANTIA
CERVOIDEA
CERVIDAE
Dama dama
Fallow deer

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	14.3	12.2-15.6	3
RBC	10.0	9.0-11.8	3
PCV	46	42-53	3
Retics	0		3
MCV	45.9	44.9-47.0	3
MCH	14.6	14.2-15.2	3
MCHC	31.5	30.0-32.5	3
MCD	4.91	4.77-5.04	3
WBC	2.6	1.7-4.0	3
N	81	67-90	3
L	15	5-29	3
M	3	2-4	3
E	1		3
B	0		3
Plts	362	253-472	2
ESR	0.5	0-1	3
ELT	300		1
Pg			
AF			

Survey Results

Test	*Av.*	*Range*	*No.*
PT	30.6	18-45	3
RVV	10.6	8.0-13.5	3
PTT	47	45-53	3
RT	93	83-101	3
KRT	231	50-420	3
TT	5.2	4.5-6.0	3
I	469	184-743	3
II	58	37-79	2
V	387	125-650	2
VII	60		1
VIII		300-1000+	2
IX	1000+		3
X	158	150-165	2
XI	115	90-140	2
XII	1000+		1
XIII	+		3
AT			
CR	60.5	59-62	2
TP			

Red cells showed complete sickling when exposed to oxygen

PF3 release 77(1)
PF3 total 100 (1)
Contact activation index 80 (1)

RUMINANTIA
CERVOIDEA
CERVIDAE
Axis axis
Spotted deer or chital

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	13.0	12-14	2
RBC	13.4	13.0-13.7	2
PCV	34.5	32-37	2
Retics	0		2
MCV	23.5	22-25	2
MCH	9.75	8.5-10.0	2
MCHC	37.5	37-38	2
MCD			
WBC	5.0	4.9-5.1	2
N	30	27-33	2
L	65	62-68	2
M	2	1-3	2
E	3	2-4	2
B	0		2
Plts	410	370-450	2
ESR	8	3-12	2
ELT	120		1
Pg	3.0		1
AF			

Red cells showed complete sickling when exposed to oxygen

Survey Results

Test	*Av.*	*Range*	*No.*
PT	17.0		1
RVV	8.0		1
PTT	47		1
RT	96		2
KRT	88		1
TT	8.0		1
I			
II	15.5	15-16	2
V	900		1
VII			
VIII	825	650-1000	4
IX	50		2
X	77	60-100	3
XI	1000+		1
XII	600		1
XIII	+		3
AT			
CR			
TP			

PF3 release 85 (1)
PF3 total 115 (1)
Contact activation index 69 (1)

RUMINANTIA
CERVOIDEA
CERVIDAE
Axis porcinus
Hog deer

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	16.8	15.5-18.2	3
RBC	14.3	13.6-15.1	3
PCV	50	46-54	3
Retics	0.2	0-0.4	2
MCV	37.0	35-39	3
MCH	12.7	11.4-14.0	3
MCHC	32.5	28-39	3
MCD			
WBC	3.3	1.2-5.5	3
N	46	40-52	3
L	34	26-42	3
M	4	4-5	3
E	15	11-18	3
B	1	0-2	3
Plts	273	240-305	3
ESR	4.5	0-13	3
ELT	160		1
Pg			
AF			

Survey Results

Test	*Av.*	*No.*
PT	44.0	1
RVV	6.5	1
PTT	25	1
RT	32	1
KRT	40	1
TT	7.0	1
I	187	1
II	52	1
V	1000+	1
VII		
VIII	1000+	1
IX		
X		
XI		
XII	680	1
XIII	+	1
AT	230	1
CR		
TP		

These animals, together with one other hog deer examined, showed complete sickling of red cells on exposure to oxygen.

RUMINANTIA
CERVOIDEA
CERVIDAE
Cervus timorensis
Timor deer

Survey Results

Test	*Av.*	*No.*
Hb	14.5	1
RBC	10.5	1
PCV	41	1
Retics	0.5	1
MCV	40	1
MCH	14.5	1
MCHC	35.0	1
MCD	4.82	1
WBC	7.4	1
N	40	1
L	52	1
M	4	1
E	2	1
B	2	1
Plts	420	1
ESR		
ELT		
Pg		
AF		

Red cells showed complete sickling when exposed to oxygen.

Survey Results

Test	*Av.*	*Range*	*No.*
PT	15.0		1
RVV			
PTT	42		1
RT	70		1
KRT	67		1
TT	7.0	6.0-8.0	2
I			
II			
V	100		1
VII			
VIII	1000+		1
IX	620		1
X	78		1
XI	38		1
XII	270		1
XIII	+		1
AT			
CR			
TP			

RUMINANTIA
CERVOIDEA
CERVIDAE
Cervus nippon
Sika deer

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	16.9	14.1-19.9	6
RBC	13.07	10.0-15.7	6
PCV	45.2	37-54	6
Retics	0		6
MCV	34.9	33.5-37.0	6
MCH	13.0	11.9-14.1	6
MCHC	37.1	36-38	6
MCD			
WBC	3.6	3.4-3.9	6
N	39	12-50	6
L	55	32-79	6
M	2	0-5	6
E	4	0-9	6
B	0		6
Plts	353	308-480	6
ESR	2	0-7	6
ELT			
Pg			
AF			

Red cells of all animals showed sickling trait when exposed to oxygen

Survey Results

Test	*Av.*	*No.*
PT	17.0	1
RVV	7.0	1
PTT	36	1
RT	68	1
KRT	58	1
TT	6.0	1
I	705	1
II		
V		
VII		
VIII	1000+	1
IX		
X	220	1
XI	190	1
XII	1000+	1
XIII	+	1
AT		
CR	50	1
TP	7.4	1

PF3 release 68 (1)
PF3 total 100 (1)
Contact activation index 60 (1)

RUMINANTIA
CERVOIDEA
CERVIDAE
Cervus elephas
Red deer

Test	*Survey Results* Av.	Range	No.	*Ref. 33* Av.	SEM
Hb	15.81	13.6-17.4	6	14.5	± 0.69
RBC	10.8	9.1-12.9	6	9.58	± 0.6
PCV	47.4	42-51	6	46.5	± 0.46
Retics	0		6		
MCV	43.9	41.3-45.0	6	47.5	
MCH	14.6	13.4-15.4	6	15.1	± 0.56
MCHC	33.3	31.5-34.2	6	31.9	± 0.65
MCD	4.49	4.43-4.55	6		
WBC	2.5	0.7-4.5	6	2.95	± 0.11
N	38	29-47	6	50	
L	54.5	40-59	6	35	
M	5	3-8	6	6.6	
E	2	0-6	6	9.1	
B	0.5	0-2	6	0	
Plts	258	164-412	6		
ESR	2		2		
ELT		180-24h	2		
Pg	2.85		1		
AF					

Red cells from these animals plus 2 other red deer examined showed complete sickling when exposed to exygen.

For effect of age on blood count see ref. 33.

29 animals

Survey Results

Test	Av.	Range	No.
PT	50	45-55	2
RVV	8.2	8.0-8.5	3
PTT	38	34-42	3
RT	69	68-70	3
KRT	49	48-50	3
TT	6.5	6-8	3
I	514	509-520	3
II	15	12.5-17.5	3
V	385	70-700	2
VII			
VIII	1000+		3
IX	220		1
X	166	58-300	3
XI	1000+		1
XII	1000+		1
XIII	+		3
AT	435		1
CR	67	66-68	2
TP	5.78	5.42-6.15	3

PF3 release 56(1)
PF3 total 103 (1)
Contact activation index 60 (1)

RUMINANTIA
CERVOIDEA
CERVIDAE
Odocoileus virginianus
Whitetailed deer

Test	*Survey Results* *Av.*	*Survey Results* *No.*	*Ref. 36* *Av.*	*Ref. 36* *Range*
Hb	11.0	1	18.6	11.9-24.6
RBC	7.0	1	18.7	10.8-23.0
PCV	33	1		
Retics	0	1		
MCV	46.5	1		
MCH	15.7	1		
MCHC	33.8	1		
MCD	4.57	1		
WBC	3.5	1	5.2	3.7-6.2
N	56	1	34	17-63
L	32	1	60	29-77
M	3	1	3	2-4
E	7	1		0-5
B	2	1		0-3
Plts	460	1		
ESR			17*	3-61
ELT				
Pg				
AF				

Red cells showed sickling tendency on exposure to oxygen

**Westergren method*

For results on Odocoileus hemionus (mule deer) see refs. 34 and 35.

RUMINANTIA
CERVOIDEA
CERVIDAE
Cervus canadensis (Wapiti)
Elaphurus davidianus (Père David's deer)

Wapiti
Survey Results

Test	*Av.*	*Range*	*No.*
Hb	13.3	13.1-13.4	2
RBC	9.4	9.1-9.7	2
PCV	35.5	35-36	2
Retics	0		2
MCV	38.9	38.2-39.6	2
MCH	14.5	14.4-14.6	2
MCHC	37.2	36.3-38.2	2
MCD	5.46	5.37-5.55	2
WBC	4.8	4.5-5.1	2
N	59.5	53-66	2
L	34.5	27-42	2
M	2.5	0-5	2
E	2.5	0-5	2
B	1	0-2	2
Plts	355	250-460	2
ESR	3.5	0-7	2
ELT			
Pg			
AF			

Red cells of 2 out of a total of 12 Wapitis examined showed sickling when exposed to oxygen

Père David's Deer
Survey Results

Test	*Av.*	*Range*	*No.*
Hb	17.2	16.6-19.5	10
RBC	9.5	8-11	10
PCV	47	43-57	10
Retics	0.1	0-1	10
MCV	50.1	43.8-60.2	10
MCH	18.4	15.7-23.5	10
MCHC	36.7	34.0-39.6	10
MCD	5.59	5.49-5.69	2
WBC	4.2	2.3-5.2	10
N	44	28-63	10
L	48	31-66	10
M	3	0-4	10
E	4	2-5	10
B	1	0-3	10
Plts	247	125-386	10
ESR	3	0-5	9
ELT			
Pg			
AF			

Red cells of all animals examined showed sickling when exposed to oxygen

RUMINANTIA
CERVOIDEA
CERVIDAE
Hydropotes inermis
Chinese water deer

Survey Results

Test	*Av.*	*No.*
Hb	**16.2**	**1**
RBC	**10.2**	**1**
PCV	**42**	**1**
Retics	**0.1**	**1**
MCV	**42.0**	**1**
MCH	**16.0**	**1**
MCHC	**38.0**	**1**
MCD		
WBC	**6.4**	**1**
N	**74**	**1**
L	**19**	**1**
M	**6**	**1**
E	**4**	**1**
B	**1**	**1**
Plts	**370**	**1**
ESR	**2**	**1**
ELT		
Pg		
AF		

RUMINANTIA
CERVOIDEA
CERVIDAE
Rangifer tarandus
Reindeer = Caribou

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	17.4	13.8-19.9	10
RBC	9.8	8.6-11.3	10
PCV	47.4	41-56	10
Retics	0.4	0-0.8	10
MCV	47.5	42-55	10
MCH	17.4	15-20	10
MCHC	36.6	33-39	10
MCD	4.87	4.76-4.98	7
WBC	4.7	2.4-7.5	10
N	56.5	38-67	10
L	38	22-52	10
M	2.5	1-9	10
E	2.5	0-6	10
B	0.5	0-2	10
Plts	276	153-440	9
ESR	0.5	0-1	3
ELT	284	229-300	3
Pg			
AF			

No sickling of red cells observed

Ref. 37

Test	*Av.*	*Range*
Hb	14.5	11.5-16.5
RBC	10.8	9.5-11.8
PCV		
Retics		
MCV		
MCH		
MCHC		
MCD		
WBC	4.2	2.3-5.4
N	57	38-50
L	38	26-57
M	3	1-4
E	2	1-3
B	0.8	0-1
Plts		
ESR		
ELT		
Pg		
AF		

7 animals

Survey Results

Test	*Av.*	*Range*	*No.*
PT	23.0	20-27	5
RVV	12.7	10.5-15.0	6
PTT	50	43-54	6
RT	89	52-109	5
KRT	91	57-141	5
TT	7.0	5.5-8.5	7
I	221	193-249	2
II	15		1
V	300		1
VII			
VIII	360	134-800	6
IX			
X	107	80-175	6
XI			
XII			
XIII	+		4
AT			
CR	56	46-64	5
TP	5.78	5.42-6.15	2

RUMINANTIA
GIRAFFOIDEA
GIRAFFIDAE
Giraffa camelopardalis
Giraffe

Survey Results

Test	Av.	Range	No.
Hb	13.3	13-13.4	3
RBC	9.4	8.4-10.1	3
PCV	37.6	37-38	3
Retics	0.1	0-0.2	3
MCV	39.4	35.9-45.5	3
MCH	14.1	13.2-15.9	3
MCHC	34.8	34-36	3
MCD	4.34		1
WBC	4.4	3.5-5.8	3
N	56	47-68	3
L	39	28-48	3
M	3	1-2	3
E	0		3
B	2	0-3	3
Plts	140	129-151	2
ESR	2	1.0-2.5	2
ELT			
Pg			
AF			

Survey Results

Test	Av.	Range	No.
PT			
RVV	13.5		1
PTT	80	73-87	2
RT	108		1
KRT	76		1
TT	9.0		1
I	622		1
II	37		1
V	370		1
VII			
VIII	270		1
IX			
X	115		1
XI	38		1
XII	310		1
XIII	+		1
AT	515		1
CR	61	59-63	2
TP	8.25		1

PF3 release 62 (1)
PF3 total 116 (1)
Contact activation index 63.5
Range 63-64 (2)

RUMINANTIA
BOVOIDEA
ANTILOCAPRIDAE
Antilocapra americana
Pronghorn antelope

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	14.4	14.1-14.6	2
RBC	10.6	10.3-10.8	2
PCV	45.5	45-46	2
Retics			
MCV	41.0	38-44	2
MCH	13.2	12.8-13.6	2
MCHC	31.1	30.2-32.0	2
MCD	5.11	5.05-5.18	2
WBC	3.3	2.5-4.1	2
N	67	65-69	2
L	25	20-31	2
M	6	3-9	2
E	2	1-3	2
B	0		2
Plts			
ESR			
ELT	1080		1
Pg			
AF			

Survey Results

Test	*Av.*	*Range*	*No.*
PT	21.5	20-23	2
RVV			
PTT	36	35-37	2
RT			
KRT			
TT	6.25	6.0-6.5	2
I	301	185-417	2
II			
V			
VII			
VIII			
IX			
X			
XI			
XII			
XIII	+		2
AT			
CR			
TP			

RUMINANTIA
BOVOIDEA
BOVIDAE
BOVINAE
Boselephas tragocamelus
Nilgai

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	13.9	12.0-16.4	3
RBC	7.1	6.0-8.6	3
PCV	41.6	39-45	3
Retics	0		3
MCV	59.0	52.5-65.2	3
MCH	19.4	19-20	3
MCHC	33.1	30.8-37.4	3
MCD	5.04		1
WBC	3.4	2.7-5.7	4
N	70	60-83	3
L	22	8-29	3
M	7	4-11	3
E	1	0-2	3
B	0.5	0-1	3
Plts	387	166-624	3
ESR	24	2-50	3
ELT			
Pg			
AF			

Survey Results

Test	*Av.*	*Range*	*No.*
PT	13.0		1
RVV	10.0		1
PTT	40		1
RT	79		1
KRT	78		1
TT	4.0		1
I	385		1
II			
V			
VII			
VIII			
IX			
X			
XI	69	65-74	2
XII	80		1
XIII			
AT			
CR			
TP			

RUMINANTIA
BOVOIDEA
BOVIDAE
BOVINAE
Tragelephas strepsiceros
Greater kudu

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	18.5	17.9-19.2	2
RBC	9.6	8.4-10.7	2
PCV	51.5	45-58	2
Retics	0		2
MCV	53.6	53.0-54.2	2
MCH	19.5	17.9-21.0	2
MCHC	36.0	33.1-39.0	2
MCD	5.74	5.49-5.99	2
WBC	4.9	4.3-5.5	2
N	50	34-66	2
L	43	30-56	2
M	2.5	2-3	2
E	4	1-7	2
B	0.5	0-1	2
Plts	313	222-404	2
ESR	0		2
ELT	1380		1
Pg	4.6		1
AF			

Survey Results

Test	*Av.*	*Range*	*No.*
PT	25.5	19-32	2
RVV	11.5	9-14	2
PTT	137	125-150	2
RT	232	180-285	2
KRT	205	156-255	2
TT	6.25	5.0-7.5	2
I	279	229-330	2
II	11	10-12	2
V	290	280-300	2
VII			
VIII	130	110-150	2
IX	600		1
X	100		2
XI	<1		2
XII	260	230-290	2
XIII	+		2
AT	290		1
CR			
TP	6.4		1

Note factor XI Activity of less than 1%

PF3 release 57 (1)
PF3 total 121 (1)
Contact activation index 33 (1)

RUMINANTIA
BOVOIDEA
BOVIDAE
BOVINAE
Bos taurus
Domestic cattle

	Ref. 1		Ref. 4		Ref. 5		Ref. 9		Ref. 92	
Test	*Av.*	*SD.*	*Av.*	*Range*	*Av.*	*Range*	*Av.*	*Range*	*Av.*	*Range*
Hb	11.3	1.49	11.0	8-15				8.9-11.0	11.0	8-14
RBC	5.95	0.765	7.0	5-10	6.15	4.8-7.9	6.6	5-8	6.5	5-11
PCV	33.7	4.14	35	24-46					37	33-48
Retics										
MCV	57.1	7.27	52	40-60						
MCH	19.2	2.8								
MCHC	33.7	2.81	33	30-36						
MCD	5.75	0.216								
WBC	7.03	1.96	8.0	4-12	5.5	2.3-10.6	9.2	6-12	9.0	6-12
N	39	10.0	28	15-45	30	13-46	32	20-40	3.0*	2-4
L	51	11.8	58	45-75	54	31-76	55	45-65	5.0*	4-6
M	8	2.7	4	2-7	1.5	0-3	5	3-15	0.5*	0.2-1.5
E	9	11.9	9	2-20	13	4-26	8	3-15	0.5*	0-1.5
B	0		0.5	0-2	0.6	0-1.2	0.6	0-1	0.05*	0-0.1
Plts	350						350			
ESR										
ELT										
Pg										
AF										

81 Ayrshires *21 animals* **WBC x 10^3/c.mm*

See also refs. 2, 3, 6-8, 10-14.

For blood coagulation on domestic cattle see ref. 93.

RUMINANTIA
BOVOIDEA
BOVIDAE
BOVINAE
Bos taurus
Domestic cattle (Ankole)

Test	*Survey Results* *Av.*	*Range*	*No.*	*Ref. 16* *Av.*
Hb	12.5	12-13	2	8.98
RBC	8.6		2	6.2
PCV	33	32-34	2	32.9
Retics	0		2	
MCV	38.2	37.0-39.5	2	53.2
MCH	14.4	13.9-15.0	2	14.6
MCHC	37.8	37.5-38.2	2	27.2
MCD				
WBC	11.1	9.3-12.9	2	11.2
N	57.5	47-68	2	29
L	31	26-36	2	46
M	2.5	2-3	2	6.2
E	7	2-12	2	12.9
B	2	1-3	2	0
Plts	240		1	
ESR	0		2	
ELT				
Pg				
AF				

40 cows

For blood picture of Zebu cattle, see ref. 15.

RUMINANTIA
BOVOIDEA
BOVIDAE
BOVINAE
Taurotragus oryx (Eland)
Bos grunniens (Yak)

Eland
Survey Results

Test	*Av.*	*Range*	*No.*
Hb	12.7	11.0-15.1	7
RBC	7.1	5.6-8.2	7
PCV	36.1	29-44	7
Retics	0.05	0-0.1	7
MCV	51.0	48-55	7
MCH	18.1	17-19	7
MCHC	35.3	34-37	7
MCD	5.63	5.55-5.82	2
WBC	5.7	4.4-8.5	7
N	70	56-82	7
L	23	11-29	7
M	3	1-6	7
E	3	1-5	7
B	1	0-2	7
Plts	287	239-440	7
ESR	4	1-8	4
ELT			
Pg			
AF			

Yak
Survey Results

Test	*Av.*	*Range*	*No.*
Hb	11.2		1
RBC	7.3		1
PCV	37		1
Retics	0		1
MCV	48.8		1
MCH	14.8		1
MCHC	30.4		1
MCD	5.08	5.07-5.09	2
WBC	9.3		1
N	18		1
L	76		1
M	3		1
E	3		1
B	0		1
Plts	336		1
ESR	0		2
ELT			
Pg			
AF			

RUMINANTIA
BOVOIDEA
BOVIDAE
BOVINAE
Bubalus bubalus
Asiatic buffalo

	Ref. 32		*Ref. 87*	*Ref. 97*
Test	*Av.*	*Range*	*Av.*	*Av.*
Hb	13.0	11.0-15.2	12.1	
RBC	6.8		6.9	6.8
PCV	44.3	38-52		
Retics				
MCV				
MCH				
MCHC				
MCD				
WBC	6.7		11.5	10.1
N	36		31.7	36
L	51		61.4	53
M	8		2.2	4
E	5		4.7	7.5
B	0		0	<1
Plts				
ESR	6	2-8		
ELT				
Pg				
AF				

20 animals

See also refs. 30, 31.

RUMINANTIA
BOVOIDEA
BOVIDAE
BOVINAE
Bison bonasus
European bison

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	13.6	11.7-15.3	4
RBC	8.0	6.4-9.1	4
PCV	47	41-50	4
Retics	0		2
MCV	59.7	51.5-65.0	4
MCH	17.2	14.9-18.8	4
MCHC	28.7	28-30	4
MCD	5.34	5.25-5.44	4
WBC	6.1	5.0-8.4	4
N	60	50-75	4
L	34	23-44	4
M	5	2-8	4
E	0.5	0-1	4
B	0.5	0-1	4
Plts	253	163-307	3
ESR			
ELT			
Pg			
AF			

RUMINANTIA
BOVOIDEA
BOVIDAE
HIPPOTRAGINAE
Oryx tao (Scimitar-horned oryx)
O. leucoryx (Arabian oryx)

Scimitar-horned oryx

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	15.6	15.3-15.9	3
RBC	9.0	8.0-10.4	3
PCV	42.8	42-44	3
Retics	0		3
MCV	49.1	43.0-52.4	3
MCH	17.6	15.7-19.1	3
MCHC	36	35-37	3
MCD			
WBC	5.8	4.9-7.7	3
N	74	62-82	3
L	23	17-34	3
M	2.5	1-4	3
E	0.5	0-1	3
B	0		3
Plts	295		1
ESR	0.5	0-1	3
ELT			
Pg			
AF			

Arabian oryx

Survey Results

Test	*Av.*	*No.*
Hb	12.5	1
RBC	8.2	1
PCV	43.5	1
Retics	0.5	1
MCV	61.5	1
MCH	18.2	1
MCHC	29.1	1
MCD	5.41	1
WBC	3.6	1
N	77	1
L	18	1
M	5	1
E	0	1
B	0	1
Plts	213	1
ESR	4	1
ELT	24h+	1
Pg		
AF		

RUMINANTIA
BOVOIDEA
BOVIDAE
HIPPOTRAGINAE
Connochaetes gnou **(Brindled gnu)**
C. taurinus **(White-bearded gnu)**

Brindled gnu
Survey Results

Test	*Av.*	*Range*	*No.*
Hb	14.8	12.7-16.2	3
RBC	10.4	9.7-11.2	4
PCV	42	37-47	3
Retics	0		3
MCV	40.1	38-43	3
MCH	13.7	13.2-14.7	3
MCHC	35.1	34-36	3
MCD			
WBC	4.9	3.3-6.3	4
N	48	35-55	4
L	47	41-58	4
M	3	1-5	4
E	2	0-5	4
B	0.5	0-1	4
Plts	512	498-528	2
ESR	0		3
ELT	24h+		2
Pg			
AF			

White-bearded gnu
Survey Results

Test	*Av.*	*Range*	*No.*
Hb	14.8	14.2-15.5	2
RBC	12.6	12.3-12.9	2
PCV	39.5	39-40	2
Retics	0		2
MCV	31.3	31-31.7	2
MCH	11.7	11.5-12.0	2
MCHC	37.4	36.4-38.0	2
MCD	4.41		1
WBC	3.1		1
N	83		1
L	15		1
M	2		1
E	0		1
B	0		1
Plts	398	172-574	3
ESR	0.5		3
ELT			
Pg			
AF			

RUMINANTIA
BOVOIDEA
BOVIDAE
HIPPOTRAGINAE
Damaliscus dorcas
Blesbok

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	16.7	14.6-20.0	12
RBC	10.5	9.6-12.7	12
PCV	46	39-51	12
Retics	rare	0-0.1	12
MCV	43.8	39.3-49.0	12
MCH	15.9	14.3-18.6	12
MCHC	36.3	35-40	12
MCD	4.28	4.18-4.38	3
WBC	4.2	2.7-7.2	12
N	61	31-82	12
L	33.5	15-52	12
M	4	1-10	12
E	1.5	0-4	12
B	0.1	0-1	12
Plts	222	101-550	10
ESR	2	0-6	7
ELT	24h+		4
Pg			
AF			

Survey Results

Test	*Av.*	*Range*	*No.*
PT	16.2	15-18	4
RVV	7.3	7-9	4
PTT	50	44-62	4
RT	109	75-134	4
KRT	79	62-100	4
TT	8.1	7-10	4
I	292	248-318	3
II	25	23-27	2
V		500-1000+	4
VII			
VIII	1000+		4
IX	445	210-800	4
X	120	90-180	4
XI	250		1
XII	98		1
XIII	+		4
AT	306	285-345	3
CR			
TP	6.01	5.43-6.43	3

RUMINANTIA
BOVOIDEA
BOVIDAE
HIPPOTRAGINAE
Kobus ellipsiprymnus
Waterbuck

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	18.2	16.2-19.5	3
RBC	10.1	9.1-11.0	3
PCV	51	49-55	3
Retics	0		3
MCV	50.9	49.0-54.5	3
MCH	18.0	17.5-18.5	3
MCHC	35.3	32.7-37.4	3
MCD			
WBC	5.3	3.9-6.4	3
N	51	34-60	3
L	47	37-64	3
M	1	1-2	3
E	1	0-2	3
B	0	0	3
Plts	288	216-382	3
ESR	0		3
ELT			
Pg			
AF			

RUMINANTIA
BOVOIDEA
BOVIDAE
ANTILOPINAE
Antilope cervicapra
Blackbuck

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	16.6	16.2-17.0	2
RBC	11.3	9.7-12.8	2
PCV	46.5	46-48	2
Retics	1.0		2
MCV	44.6	42.0-47.5	2
MCH	16.3	16.0-16.7	2
MCHC	35.5	35-36	2
MCD	4.75	4.72-4.78	2
WBC	9.3	8.3-10.3	2
N	69	59-78	2
L	29	18-41	2
M	1	0-2	2
E	0.5	0-1	2
B	0.5	0-1	2
Plts	459	458-460	2
ESR	5	0-10	4
ELT	630	240-1010	3
Pg	6.3		1
AF			

Survey Results

Test	*Av.*	*Range*	*No.*
PT	13.5	12-15	2
RVV	7.5	7-8	2
PTT	55	54-56	2
RT	74	73-75	2
KRT	54	53-55	2
TT	7.0	6-8	2
I	351		1
II			
V	300		1
VII			
VIII	1000+		4
IX	125	100-150	2
X	95		1
XI	75		1
XII	223	200-245	2
XIII	+		4
AT			
CR			
TP	6.5	5.9-7.3	2

RUMINANTIA
BOVOIDEA
BOVIDAE
CAPRINAE
Saiga tatarica
Saiga antelope

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	15.1	13.6-18.9	4
RBC	9.3	8.7-10.1	4
PCV	55	51-56	4
Retics			
MCV	58.9	54-64	4
MCH	16.3	13.6-20.0	4
MCHC	28.1	24.5-36.5	4
MCD	5.28	5.24-5.34	4
WBC	5.2	3.5-8.6	4
N	64	56-79	4
L	31.6	14-40	4
M	3.7	1-7	4
E	0.3	0-0.5	4
B	0.2	0-0.5	4
Plts	331		1
ESR	2.5		1
ELT	1440+		1
Pg			
AF			

Survey Results

Test	*Av.*	*Range*	*No.*
PT	17.0		1
RVV	11.0		1
PTT	55	51-60	2
RT	75	56-94	2
KRT	40		1
TT	5.0	4-6	2
I	768	763-773	2
II	12		1
V	1000+		1
VII			
VIII	450		1
IX	270		1
X	56		1
XI			
XII			
XIII	+		2
AT			
CR			
TP	5.9	5.1-6.7	6

PF3 release 77 (1)
PF3 total 152 (1)
Contact activation index 77 (1)

RUMINANTIA
BOVOIDEA
BOVIDAE
CAPRINAE
Ovis canadensis (Bighorn sheep)
Capra falconeri (Markhor)

Bighorn sheep
Survey Results

Test	*Av.*	*Range*	*No.*
Hb	17.5	15.1-19.9	2
RBC	11.8	10.2-13.4	2
PCV	47.5	43-52	2
Retics	0		2
MCV	40.6	38.8-42.5	2
MCH	14.8		2
MCHC	36.7	35.2-38.2	2
MCD			
WBC	19.4	19.2-19.6	2
N	86.5	86-87	2
L	13	12-14	2
M	0.5	0-1	2
E	0		2
B	0		2
Plts	246		1
ESR	0		2
ELT			
Pg			
AF			

Markhor
Survey Results

Test	*Av.*	*No.*
Hb	12.2	1
RBC	16.9	1
PCV	31	1
Retics	0	1
MCV	18.3	1
MCH	7.2	1
MCHC	39.3	1
MCD		
WBC	15.9	1
N	77	1
L	22	1
M	1	1
E	0	1
B	0	1
Plts	380	1
ESR	0	1
ELT		
Pg		
AF		

RUMINANTIA
BOVOIDEA
BOVIDAE
CAPRINAE
Ovibos moschatus
Musk ox

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	13.5	12-15	2
RBC	9.4	7.8-10.9	2
PCV	36	33-39	2
Retics	0		2
MCV	39.1	35.7-42.4	2
MCH	14.5	13.7-15.4	2
MCHC	37.6	36.4-38.9	2
MCD	4.54	4.51-4.57	2
WBC	9.3	7.9-10.6	2
N	41.5	39-44	2
L	50.5	46-55	2
M	2	0-4	2
E	5	4-6	2
B	1	0-2	2
Plts	301		1
ESR	6		1
ELT			
Pg			
AF			

RUMINANTIA
BOVOIDEA
BOVIDAE
CAPRINAE
Capra ibex
Ibex

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	9.6	9-12	9
RBC	12.9	9.2-21.4	9
PCV	46	30-64	9
Retics	0		3
MCV	36.2	30-43	9
MCH	8.9	5.0-10.8	9
MCHC	24.4	16.8-32.2	9
MCD	4.24	4.01-4.44	9
WBC	3.8	0.6-9.0	9
N	61	50-82	9
L	33	10-46	9
M	5	1-12	9
E	1	0-2	9
B	0		9
Plts	262	226-299	2
ESR	0		1
ELT	1440+		1
Pg	1.67		1
AF			

Survey Results

Test	*Av.*	*Range*	*No.*
PT	16.0		1
RVV	9.0		1
PTT	26		1
RT	51		1
KRT	64		1
TT	7.0		1
I	525		1
II	21	20-22	2
V	320	140-500	2
VII			
VIII	1000+		2
IX	550	400-700	2
X	53	50-56	2
XI			
XII	640		1
XIII	+		1
AT	260		1
CR			
TP	6.9	5.7-7.8	8

RUMINANTIA
BOVOIDEA
BOVIDAE
CAPRINAE
Capra hircus
Goat

	Survey Results			*Ref. 4*		*Ref. 92*		*Ref. 96*
Test	*Av.*	*Range*	*No.*	*Av.*	*Range*	*Av.*	*Range*	*Av.*
Hb	10.8	9.0-12.9	10	11.0	8-14	11.0	8-14	9.2
RBC	15.8	11.9-19.4	10	13.0	8-18	15.0	13-18	16.6
PCV	34	30-41	10	28	19-38	34	29-38	32.8
Retics	0		10					
MCV	21.5	19.2-23.5	10	23.0	15-30			
MCH	6.9	5.8-7.8	10					
MCHC	32.1	30.0-34.8	10	38.0	35-42			
MCD	3.12		1					
WBC	9.9	9.4-10.4	10	9.0	4-13	9.0	5-13	16.6
N	49	25-75	10	36	30-48	3.0*	2-4	
L	49	25-74	10	56	50-70	6.0*	2-10	
M	1	0-3	10	2.5	0-4	0.5*	0-0.7	
E	1	0-4	10	5	1-8	0.2*	0-1	
B	0		10	0.5	0-3	0.05*	0-0.5	
Plts	420	180-620	10					
ESR	0		10					1.2*
ELT	24h+		10					
Pg								
AF								

No. not given
$* X10^3/c.mm$

** in 12 hrs.*

Goat

Survey Results				Ref. 101		Ref. 99	
Test	*Av.*	*Range*	*No.*	*Av.*	*Range*	*Av.*	*± SD*
PT	20.5	19-22	2	12.6			
RVV	8.0		2				
PTT	49	48-50	2	41		60	± 0.1
RT	108	90-126	2	85			
KRT	74	60-88	2				
TT	7.5		1				
I	497	448-547	2	462			
II	62	41-83	2	32.8			
V	420		1				
VII							
VIII	1000+		2				
IX							
X							
XI	41	35-52	3				
XII	680		1				
XIII	+		2	+			
AT							
CR							
TP							

RUMINANTIA
BOVOIDEA
BOVIDAE
CAPRINAE
Ovis aries
Domestic sheep

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	12.9	10.0-16.6	20
RBC	10.3	8.2-12.4	20
PCV	36.3	30-40	20
Retics	0.1	0-0.4	20
MCV	34.3	29.8-38.0	20
MCH	12.7	10.6-14.6	20
MCHC	34.2	31-41	20
MCD	4.65	4.25-4.9	20
WBC	5.0	2.9-7.4	20
N	43	18-73	20
L	43	23-70	20
M	6	2-10	20
E	9	2-21	20
B	0		20
Plts	284	109-579	20
ESR	0.5	0-1	20
ELT	1440+		19
Pg	1.5	0.9-2.5	6
AF			

	Ref. 4		*Ref. 17*		*Ref. 92*	
Test	*Av.*	*Range*	*Av.*	*Range*	*Av.*	*Range*
Hb	12.0	8-16			11.0	8-14
RBC	12.0	8-16	11.5	6.2-15.5	11.0	8-14
PCV	38	24-50			34	29-38
Retics	0					
MCV	33	23-48				
MCH	10.7	9-12				
MCHC	33	31-38				
MCD	4.5	3.2-6.0				
WBC	8.0	4-12	9.2	1.1-17.5	8.0	5-11
N	30	10-50	24	11-47	3.0*	1.5-4.5
L	62	40-75	68	41-83	5.0*	4-6
M	2.5	0-6	2.5	0-13	0.5*	0.1-0.7
E	5	0-10	5	0-15	0.2*	0-0.5
B	0.5	0-3	0.5	0-3	0.05*	0-0.1
Plts	400	250-750				
ESR						
ELT						
Pg						
AF						
	No. not given		*100 Scottish hill sheep*		*No. not given* * $\times 10^3$/c.mm	

See also refs. 18-21

Domestic sheep

Survey Results

Test	*Av.*	*Range*	*No.*
PT	13.9	10-20	6
RVV	8.4	7.0-12.5	10
PTT	45	30-64	10
RT	98	70-150	10
KRT	83	72-112	9
TT	11.7	8.0-23.0	7
I	297	190-429	30
II	26	16-34	6
V		450-1000+	6
VII			
VIII	1000+		30
IX			
X	105	45-150	6
XI	15		1
XII	290		1
XIII	+		10
AT	238	203-275	4
CR			
TP	6.15	5.73-6.66	5

PF3 release 57(1)
Contact activation index 53
Range 25-69 (8 animals)

Test	*Ref. 61* *Av.*	*Ref. 61* *Range*	*Ref. 94* *Av.*
PT	14.7	12.5-16.5	11.4
RVV			
PTT			
RT			
KRT	117	67-162	
TT			
I	291	132-456	140
II	21.4	10-40	15
V	417	160-800	200
VII			
VIII	809	450-1650	1000
IX	210	82-350	100
X	32	13-72	6
XI	36	7-80	
XII			600
XIII			
AT			
CR			
TP			
	25 sheep		*1 animal*

RUMINANTIA
BOVOIDEA
BOVIDAE
CAPRINAE
Ovis musimon
Mouflon

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	15.8	14.1-17.4	17
RBC	14.2	11.6-20.4	17
PCV	45.2	40-49	32
Retics	0.3	0-1.4	32
MCV	31.8	22-37	17
MCH	11.1	10.2-13.0	17
MCHC	34.5	33.0-37.4	17
MCD	4.35	4.34-4.36	2
WBC	6.9	3.9-9.2	32
N	37	15-48	32
L	57	49-80	32
M	2	1-4	32
E	3	1-8	32
B	1	0-2	32
Plts	650	492-884	32
ESR	0		14
ELT	1440+		32
Pg			
AF			

Survey Results

Test	*Av.*	*Range*	*No.*
PT	15.7	14-18	11
RVV	8.7	8-10	11
PTT	48	42-62	12
RT	96	86-1i2	12
KRT	91	86-98	12
TT	7.6	7-9	12
I	180	113-288	34
II	34		1
V			
VII	27		1
VIII	1000+		1
IX			
X	90		1
XI			
XII			
XIII			
AT			
CR			
TP	5.0		1

RUMINANTIA
BOVOIDEA
BOVIDAE
CAPRINAE
Ovis tragelaphus
Barbary sheep

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	13.4	12.4-13.9	6
RBC	17.7	15.3-19.2	6
PCV	53	49-55	6
Retics	0		4
MCV	29.2	27.9-31.0	6
MCH	7.6	6.5-9.1	6
MCHC	26.8	22.2-33.6	6
MCD	3.4	3.23-3.63	6
WBC	3.9	3.4-5.0	6
N	52	28-67	6
L	38	26-59	6
M	8	6-13	6
E	2	0-3	6
B	1	0-3	6
Plts	286	266-306	4
ESR			
ELT	1440+		3
Pg	7.6		1
AF			

Survey Results

Test	*Av.*	*Range*	*No.*
PT	45	33-52	3
RVV	10.3	10-11	3
PTT	47	46-49	3
RT	76	70-90	3
KRT	61	49-70	3
TT	9.0	6-11	3
I	313	292-343	3
II	21		1
V	700		1
VII			
VIII	1000+		2
IX	1000+		1
X	35		1
XI	22		1
XII	407	190-640	2
XIII	+		3
AT			
CR			
TP	6.4	5.0-7.0	6

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Chapter 6

OTHER MAMMALIAN ORDERS

This chapter includes results from animals of several zoological orders, presented without detailed comments because of the small number of individuals and species which have been examined. The information is included mainly for general interest and for comparative purposes. It may also serve to give some indication of the haematological pattern to be expected in less easily accessible related animals as, on the whole, the blood picture follows zoological classification. Unusual features of special interest have also been pointed out.

Order: MONOTREMATA

Blood counts on a small series of echidnas (spiny anteaters) have been included because of the primitive nature of these mammals. The red cells are disc-shaped and biconcave and do not contain nuclei although a small number of Howell Jolly bodies are present [1]. The findings on one Bruijn's echidna are remarkable for the high mean red cell volume and, although this animal appeared clinically normal at the time of obtaining the blood sample, the possibility that it was suffering from macrocytic anaemia should be excluded before speculating on the significance of this finding. In each of the three species of echidna examined the white count is relatively high. Apart from an increased neutrophil nuclear lobe count there are no remarkable features about the white cells. The platelets are large and, on stained films appear either as very elongated, spindle-shaped structures with a tendency to intertwine together or as normal platelets with spreading and aggregating activity. The possibility that two types of haemostatic cells are present in these animals, one type perhaps forming a link between the spindle-shaped thrombocytes of non-mammalian vertebrates and regular mammalian platelets is of great interest and requires further study.

Blood coagulation in echidnas has been reported as being comparatively rapid [2] and this has been confirmed by limited tests on one Australian echidna in the present survey.

MONOTREMATA

TACHYGLOSSIDAE

Tachyglossus setosus (Tasmanian echidna) *and T. aculeatus* (Australian echidna)

Tasmanian echidna
Survey Results

Test	*Av.*	*No.*
Hb	11.2	1
RBC	5.9	1
PCV	35	1
Retics	0	1
MCV	59	1
MCH	20	1
MCHC	33	1
MCD		
WBC	14.9	1
N	64	1
L	34	1
M	1	1
E	1	1
B	0	1
Plts	215	1
ESR	4.5	1
ELT		
Pg		
AF		

Australian echidna
Survey Results

Test	*Av.*	*Range*	*No.*
Hb	11.5	11.1-11.8	2
RBC	5.25	5.1-5.4	2
PCV	32.3	30-34.5	2
Retics	0		2
MCV	60.8	58.3-63.4	2
MCH	21.55	21.5-21.6	2
MCHC	35.6	34.2-37.0	2
MCD			
WBC	16.75	16.7-16.8	2
N	55.5	54-57	2
L	42	40-44	2
M	2.5	2-3	2
E	0		2
B	0		2
Plts	235	234-236	2
ESR	10		1
ELT			
Pg			
AF			

A few red cells in each species contain Howell Jolly bodies.

For blood coagulation of echidna, see ref. 2.

MONOTREMATA
TACHYGLOSSIDAE
Zaglossus bruijni
Bruijn's echidna

Survey Results

Test	*Av.*	*No.*
Hb	10.6	1
RBC	1.5	1
PCV	29	1
Retics	0.2	1
MCV	198	1
MCH	72	1
MCHC	36.5	1
MCD	8.3	1
WBC	14.0	1
N	54	1
L	39	1
M	2	1
E	5	1
B	0	1
Plts	195	1
ESR		
ELT	24h	1
Pg		
AF		

A small proportion of the red cells contain Howell Jolly bodies.

Survey Results

Test	*Av.*	*No.*
PT	44	1
RVV		
PTT	30	1
RT		
KRT	32.5	1
TT		
I	206	1
II	37	1
V	760	1
VII		
VIII	1000+	1
IX		
X	15	1
XI		
XII		
XIII		
AT		
CR		
TP		

Order: MARSUPIALIA

Some information on the haematology of marsupials is available from the literature [3-7]. This does not always support the finding in the present survey of high haemoglobins and packed cell volumes in many animals of this order [4, 6]. The red cells often contain Howell Jolly bodies and occasionally nucleated red cells are found in the peripheral blood of normal animals. Reticulocytes are common. The white count of Bennet's Wallaby is low with the neutrophil as the predominant cell in adult animals. The neutrophyl/lymphocyte ratio is reversed in immature animals. Neutrophil nuclei are hyperlobulated compared with man [5].

Results on a few animals suggest that the platelet count may be below the normal human range. These animals however have an active coagulation mechanism [6, 8] with rapid generation of intrinsic prothrombin activator associated with high levels of fibrinogen and factors V and VIII. The prothrombin time with human tissue factor is prolonged [6, 8] and assayed levels of factors II and X are very low. It should be restated that these findings may be explained by lack of reactivity in mixed clotting systems, although, in marsupials, unlike other mammals in which factors II, VII and X react poorly with nonspecific tissue factor, a proportional prolongation of the clotting time with Russell's viper venom is also found. This may indicate a true comparative deficiency of factor II and/or X although no bleeding tendency is present.

The fibrinolytic mechanism of the few marsupials in which it has been tested is moderately active, and plasminogen is activated by human urokinase and by streptokinase if 'proactivator' is provided.

MARSUPIALIA
PHALANGEROIDEA
MACROPODIDAE
Protemnodon rufogrisea
Bennet's wallaby

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	17.5	14-20	15
RBC	5.8	4.6-6.9	15
PCV	52	43-58	15
Retics	3.6	0-8	15
MCV	90.3	83-98	15
MCH	32.9	27-35	15
MCHC	34.1	30-38	15
MCD	7.37	7.34-7.40	2
WBC	4.5	2.4-6.6	15
N	59	31-74	15
L	37	19-65	15
M	2	0-7	15
E	1.5	0-4	15
B	0.5	0-1	15
Plts	210	118-302	15
ESR	4	0-12	6
ELT	240		1
Pg			
AF			

Survey Results

Test	*Av.*	*No.*
PT	80	1
RVV	29	1
PTT	37	1
RT	71	1
KRT	47	1
TT	6.0	1
I	1270	1
II	< 1	1
V		
VII		
VIII	1000+	1
IX	100	1
X	<1	1
XI		
XII		
XIII	+	1
AT		
CR		
TP	5.60	1

Howell Jolly bodies present in a small proportion of the red cells. Occasional nucleated red cells seen.

Neutrophil/lymphocyte ratio reversed in 3 immature (6 month old) animals examined.

Note low factor II and X activity.

For coagulation studies in marsupials, see ref. 8.

MARSUPIALIA
PHALANGEROIDEA
MACROPODIDAE
Macropus agilis x M. ualabatus
Agile x swamp wallaby

Survey Results

Test	Av.	No.
Hb	17.9	1
RBC	6.8	1
PCV	60	1
Retics	0.6	1
MCV	88.5	1
MCH	26.4	1
MCHC	29.3	1
MCD		
WBC	3.4	1
N	25	1
L	66	1
M	9	1
E	0	1
B	0	1
Plts	245	1
ESR		
ELT	240	1
Pg		
AF		

Survey Results

Test	Av.	No.
PT	68	1
RVV	27	1
PTT	37	1
RT	77	1
KRT	68	1
TT	6.0	1
I	343	1
II	12	1
V	1000+	1
VII		
VIII	1000+	1
IX	22	1
X	0	1
XI		
XII		
XIII	+	1
AT		
CR		
TP	4.05	1

Some red cells contained Howell Jolly bodies.

Note low factor II activity and no detectable factor X.

MARSUPIALIA
PHALANGEROIDEA
MACROPODIDAE
Dendrolagus goodfellowi
Goodfellow's tree kangaroo

Survey Results

Test	*Av.*	*No.*
Hb	17.5	1
RBC	6.1	1
PCV	50	1
Retics	0.5	1
MCV	81.4	1
MCH	28.5	1
MCHC	35.0	1
MCD		
WBC	6.8	1
N	59	1
L	23	1
M	14	1
E	4	1
B	0	1
Plts		
ESR	0	1
ELT		
Pg		
AF		

Survey Results

Test	*Av.*	*No.*
PT	80	1
RVV	32	1
PTT	53	1
RT	85	1
KRT		
TT	7.0	1
I	762	1
II	33	1
V	860	1
VII		
VIII		
IX		
X	1.5	1
XI		
XII		
XIII	+	1
AT		
CR		
TP		

Red cells occasionally contain Howell Jolly bodies.

Note low factor X activity.

MARSUPIALIA
PHALANGEROIDEA
MACROPODIDAE
Setonix brachyurus
Quokka

Survey Results

Test	*Av.*	*No.*
Hb	15.6	1
RBC	7.3	1
PCV	45	1
Retics	0	1
MCV	61.5	1
MCH	21.3	1
MCHC	34.4	1
MCD		
WBC	13.0	1
N	86	1
L	12	1
M	1	1
E	1	1
B	0	1
Plts	427	1
ESR	12	1
ELT	960	1
Pg	6.5	1
AF		

Survey Results

Test	*Av.*	*No.*
PT	30	1
RVV	21	1
PTT	35	1
RT	118	1
KRT	25	1
TT	6.0	1
I	1020	1
II		
V		
VII		
VIII		
IX		
X		
XI		
XII		
XIII	+	1
AT		
CR		
TP		

MARSUPIALIA
PHALANGEROIDEA
VOMBATIDAE
Vombatus ursinus
Common wombat

Survey Results

Test	*Av.*	*No.*
Hb	13.5	1
RBC	5.8	1
PCV	43	1
Retics	0.4	1
MCV	74.0	1
MCH	23.3	1
MCHC	31.0	1
MCD	5.49	1
WBC	8.8	1
N	10	1
L	76	1
M	13	1
E	1	1
B	0	1
Plts	148	1
ESR	8	1
ELT		
Pg		
AF		

Survey Results

Test	*Av.*	*No.*
PT	20	1
RVV	14.5	1
PTT	39	1
RT	65	1
KRT	26	1
TT	19	1
I	590	1
II		
V	1000+	1
VII		
VIII		
IX		
X		
XI		
XII		
XIII	+	1
AT		
CR		
TP	6.15	1

Order: EDENTATA

Results of a blood count on one clinically normal animal of the species *Myrmecophaga tridactyla* (giant anteater) have been included because of the rarity of opportunity in obtaining data of this species. The large MCV in this animal confirms the report of Gulliver [88].

The blood coagulation and fibrinolytic mechanisms of Edentates has not been studied, but plasminogen of the giant anteater is activated by urokinase and by streptokinase in the presence of human 'proactivator'.

EDENTATA
MYRMECOPHAGIDAE
Myrmecophaga tridactyla
Giant ant-eater

Survey Results

Test	*Av.*	*No.*
Hb	13.5	1
RBC	3.0	1
PCV	50	1
Retics	0.4	1
MCV	162.0	1
MCH	49.0	1
MCHC	30.3	1
MCD	8.24	1
WBC	7.1	1
N	67	1
L	24	1
M	6	1
E	2	1
B	1	1
Plts		
ESR		
ELT		
Pg		
AF		

See also frontispiece.

Order: LAGOMORPHA

The only species of this order for which haematological data is available is the domestic rabbit *(Oryctolagus cuniculus)* [9-13, 87]. Rabbit blood is unusual in that the cells comparable to neutrophils have uncharacteristic staining properties and are known as pseudoeosinophils or amphophils. These cells, which comprise 30-60% of the total white cells, have polymorphous nuclei and cytoplasm which stains diffusely pink with Romanowski stains, apparently as a result of the fusion or aggregation of many small acidophilic granules, with a variable number of larger eosinophilic granules superimposed on the pink background [14]. These cells are easily distinguished from true eosinophils which have larger, more regular spherical granules. Similar cells are found in some rodents.

The rabbit is also unique amongst laboratory animals in the relatively large numbers of basophils present in the circulating blood. The blood count of this species varies slightly with age and breed and diurnal variation in the white count has also been reported [14]. Reticulocytes and polychromatic red cells are common.

Rabbit platelets have been studied extensively. The total count is often greater than 4×10^6 per c.mm. Platelets are rapidly aggregated by ADP [38, 40, 59, 60] and collagen [38] but not by adrenaline or 5-hydroxytryptamine [38, 40]. ADP-induced aggregation is inhibited by adenosine [38]. The plasma of rabbits has a higher ability than that of man to inactivate ADP [38].

The blood coagulation mechanism of rabbits has also been studied in some detail. The extrinsic pathway of prothrombin conversion is activated rapidly by human tissue factor and rabbit brain thromboplastin reacts well with human plasma [15]. This fact is utilised in the commercial production of thromboplastins made from rabbit brain used mainly in laboratory tests for the control of anticoagulant therapy in man. Intrinsic thromboplastin generation is rapid in New Zealand white rabbits but slower in a few lop-ears which have been tested. This difference may be a function of factor VIII activity which is higher in New Zealand whites than in lop-ears.

The euglobulin lysis time is variable in rabbits [54], possibly as a result of individual differences in response to the stress associated with handling. Fibrinolytic inhibitors are more active in rabbit than in human blood [62]. Rabbit plasminogen is activated by human urokinase and by streptokinase without addition of proactivator. Many of the original experiments on lysis of intravascular thrombi by streptokinase were carried out on this species [16].

LAGOMORPHA
LEPORIDAE
Oryctolagus cuniculus
Domestic rabbit (New Zealand White)

	Survey Results			*Ref. 11*		*Ref. 12*		*Ref. 13*	
Test	*Av.*	*Range*	*No.*	*Av.*	*Range*	*Av.*	*Range/SD*	*Av.*	*± SD*
Hb	11.2	9.6-13.1	20					11.8	± 0.55
RBC	5.1	4.5-5.8	20	5.6	4.5-7.0	5.9	± 7.8	5.4	± 0.55
PCV	36.5	31-41	20						
Retics	2.6	0.8-5.0	20					2.62	± 1.22
MCV	72.2	61.9-82.2	20						
MCH	22.3	18.0-27.2	20						
MCHC	30.2	27.8-31.8	20						
MCD	6.30	6.06-6.59	10	5.7	5-8				
WBC	6.4	3.1-9.2	20	7.9	4-13	10.7	5.8-15.5	7.07	± 1.88
N	49.5*	38-66	20	43*		39*	± 10.8	37.8*	± 13.88
L	38	26-51	20	42		56	± 13.3	53	± 14
M	8.5	4-16	20	9		1.5	± 1.4		
E	1.5	0-3	20	2		1.1	± 0.8		
B	2.5	1-6	20	4		3.6	± 2.1		
Plts	386	230-690	20	540	200-1000			743	± 218
ESR	0.75	0-1.5	20						
ELT		170-24h+	10						
Pg									
AF									

**Pseudoeosinophils*

See also refs. 9 & 10, 20, 87.

Domestic rabbit

	New Zealand whites Survey Results			Lop-ears Survey Results			Ref. 17	Ref. 18
Test	*Av.*	*Range*	*No.*	*Av.*	*Range*	*No.*	*Av.*	*Av.*
PT	15.5	9-25	12	14.2	11-26	7		
RVV	9.3	7.5-10.0	8					
PTT	53	32-90	26	73	66-95	12		
RT	104	85-155	11	117	110-125	2	116	
KRT	42	30-55	10	96	80-120	12		
TT	8.3	5-11	14	8.0	7.5-8.5	2		
I	317	247-462	11				320	143
II	30	19-70	5					95
V		500-1000+	9					2000
VII								315
VIII	1000+		7	130	110-160	4		300
IX	220	100-520	24					100
X	480	350-620	5					
XI								143
XII	430		2					
XIII	+		5	+		4		
AT	312	260-365	2					
CR	37		1					
TP	5.74	4.96-6.62	5	3.55	3.2-3.85	3		

Contact activation index 65
Range 51-77 (5 animals)

No = 6 *No = 3*

Order: RODENTIA

The order Rodentia is divided into three suborders, the Sciuromorpha (squirrels, marmots, chipmunks), the Myomorpha (rats and mice) and the Hystricomorpha (porcupines, cavies, agoutis etc.). Rodents are world-wide in distribution and highly successful with regard to numbers of species and individuals. They are highly adaptable and thus inhabit a wide variety of different environments; this variety is reflected to some extent in their haematology.

Rats, mice, guinea pigs and hamsters are widely used as laboratory animals and there exists a large and diffuse literature on their haematology [9-11, 18-32, 66, 87]. These species have not been studied in great detail in the present survey; results on a small number of animals have been included for the sake of general interest but it should be emphasised that their haematological parameters can be influenced by time and site of obtaining the blood sample, age, sex, anaesthetic or handling techniques, temperature, stress [65] and also varies in different strains [14, 23]. Some differences have even been reported in rats of the same strain obtained from different suppliers [29]. Thus, reported normal values cannot take the place of experimental controls.

The red cells of rats, mice and hamsters have relatively short half-lives [14] and polychromatic cells, reticulocytes and cells containing Howell Jolly bodies are common. Reticulocytes often occur in clumps on stained films. The neutrophils of laboratory rodents also warrant some comment. The nucleus is often without the definite lobulation usually seen and horse-shoe, sausage-shaped or ring (doughnut) forms are present. This finding is applicable only to myomorph rodents; hystricomorphs have neutrophils with nuclei which are hyperlobulated compared with man. In guinea pigs, like rabbits, the neutrophil is replaced by the pseudoeosinophil or amphophil. These cells, which are easily distinguished from true eosinophils, have a number of spherical acidophilic granules in their cytoplasm, usually less distinctive than those seen in rabbit pseudoeosinophils, and smaller and less numerous than those of true eosinophils. In the present survey, similar cells have been found in all other hystricomorph rodents examined, the most extreme example of eosinophilic granulation occurring in the Capybara. Guinea pig lymphocytes are of interest for the occurrence in a variable number of large lymphocytes of Kurloff bodies. These stain diffusely red or appear vacuole-like with reddish granulation [87]. They are rare in immature animals and are apparently influenced by sex hormones [58]. These inclusions have not yet been observed in other rodent species.

In the present survey blood counts have also been carried out on a few less commonly available rodents. The hystricomorphs tested are notable for the apparent wide species variation found, particularly in the size and number of red cells. The Capybara, which is the largest living rodent, also apparently has the largest red cells of animals in this group. A sickling tendency has been observed in animals of this species, the mechanism of which has not yet been investigated.

Experimental studies on platelet behaviour and blood coagulation in rats and guinea pigs provide some basic information about the haemostatic mechanism of rodents. Platelets are numerous in rodents, reported counts sometimes being greater than 1×10^6 per c.mm of blood [14]. Rat platelets are moderately adhesive on glass surfaces [34, 36] and rat and guinea pig platelets are aggregated rapidly and completely by ADP [36-39]. Unlike human platelets, aggregation does not occur with adrenaline [38, 39], and the ADP reaction is not inhibited by adenosine [36, 39]. The breakdown of ADP by rat and guinea pig plasma is more rapid than in man [37-41]. An inherited platelet storage pool disease, characterised by a mild haemorrhagic diathesis, has been described in Fawn-hooded rats [45].

Data obtained in the present survey together with information from other authors suggests that the clotting mechanism is active in rodents and that levels of clotting factors are equal to or greater than those of man. [42-45] Extrinsic prothrombin activation with human brain extract is rapid in rats, mice, hamsters and some hystricomorphs but prolonged in guinea pigs and porcupines. The whole blood clotting time [46, 47] but not the prothrombin time [48] is shortened by stress in rats and in this species exericse and adrenaline injection produce no measurable increase in factor VIII activity [49]. The clotting time of hibernating hamsters [50] and ground squirrels [63] is prolonged and a correlation between clotting time and population density has been reported in the vole, *Microtus californicus.* [51].

Rodents are particularly susceptible to the action of coumarin and indanedione drugs which accumulate in the tissues and cause severe depression of the vitamin K-dependent clotting factors. This has led to the use of warfarin as a rat poison.

The blood fibrinolytic mechanism is active in those rodents in which it has been examined [52-57], particularly in the guinea pig [56]. The measurable level of circulating plasminogen activator is highly dependent on the method used [52]. Plasminogen of rodents is activated directly by human urokinase but requires the addition of human proactivator for activation by streptokinase.

RODENTIA
SCIUROMORPHA
SCIUROIDEA
SCIURIDAE
Sciurus sp.
Tree squirrel

Survey Results

Test	*Av.*	*No.*
Hb	12.2	1
RBC	4.4	1
PCV	40	1
Retics	0.6	1
MCV	91.5	1
MCH	27.5	1
MCHC	29.8	1
MCD		
WBC	2.2	1
N	32	1
L	65	1
M	3	1
E	0	1
B	0	1
Plts	372	1
ESR	1	1
ELT		
Pg		
AF		

RODENTIA
MYOMORPHA
MUROIDEA
CRICETIDAE
Lemmus sp.
Lemming

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	15.1		1
RBC	10.5		1
PCV	39		1
Retics			
MCV	37.1		1
MCH	14.4		1
MCHC	39.6		1
MCD			
WBC	8.9		1
N	62	54-79	3
L	35.5	20-42	3
M	1	1-2	3
E	1.5	1-2	3
B	0		3
Plts			
ESR			
ELT			
Pg			
AF			

RODENTIA
MYOMORPHA
MUROIDEA
CRICETIDAE
Mesocricetus auratus
Golden hamster

	Survey Results			*Ref. 9*	*Ref. 10*	*Ref. 24*		*Ref. 25*	
Test	*Av.*	*Range*	*No.*	*Range*	*Av.*	*Av.*	*± SD*	*Av.*	*± SD*
Hb	16.2	14.9-18.0	10	15-20	17.4	17.6	± 1	15.5	± 4.1
RBC	7.7	7.1-8.5	10	5.0-9.2	7.2	7.5	± 0.5	7.1	± 1.7
PCV	49	44-51	10	47.4	46.2		41-53		
Retics	1.7	1.0-2.4	10						
MCV	62.4	59-67	10						
MCH	21.0	19.8-23.0	10						
MCHC	33.3	31.2-34.9	10						
MCD	5.77	5.57-6.04	10	6.2-7.0					
WBC	6.7	4.9-9.8	10	8.5-10.0	7.6-8.4	8.56	± 1.54	5.24	± 1.2
N	26.4	20-40	10	16-29	28	29	± 11	20	± 6
L	61.4	53-70	10	68-81	62	67.9	± 11.9	61	± 7.5
M	9.5	5-17	10	0-25	2	2.4		3	± 0.5
E	2.7	1-6	10	0.7-2.8	1	0.7		1.8	± 0.2
B	0		10	0	1	0		0	
Plts	370	329-451	10					902	± 50
ESR	0		10						
ELT		8-20h	4						
Pg									
AF									

See also ref. 87.

Golden hamster

Survey Results

Test	Av.	No.
PT	13.0	1
RVV	9.5	1
PTT	85	1
RT	103	1
KRT	39	1
TT	17.0	1
I		
II		
V		
VII		
VIII		
IX		
X		
XI		
XII		
XIII		
AT		
CR		
TP		

For blood coagulation in hamsters, see refs. 25 & 50.

RODENTIA
MYOMORPHA
MUROIDEA
CRICETIDAE
Gerbillus unguiculatus
Gerbil

Survey Results

Test	Av.	No.
Hb		
RBC	4.0	1
PCV		
Retics		
MCV		
MCH		
MCHC		
MCD		
WBC	8.0	1
N	57	1
L	42	1
M	0	1
E	0.5	1
B	0.5	1
Plts		
ESR		
ELT		
Pg		
AF		

	Ref. 30		*Ref. 30*	
Test	Av.	Range	Av.	Range
Hb	15.9	15.2-16.8	15.0	14.4-15.6
RBC	8.85*	7.9-10.0		
PCV	49.2	46-52	46.8	44-48
Retics				
MCV	54.5*	46-60		
MCH	17.5*	16.1-19.4		
MCHC	32.1*	30.6-33.3		
MCD				
WBC	13.5	6.5-21.6	8.7	7.5-10.9
N	13.9	2-23	23.4	7-41
L	84.8	73-97	74.8	58-92
M	0.3*	0-3		
E	1.2*	0-4		
B	0.05*	0-1		
Plts				
ESR				
ELT				
Pg				
AF				
	Males		*Females*	

** Males & females*

No. = 20

RODENTIA
MYOMORPHA
MUROIDEA
CRICETIDAE
Ondatra sp.
Muskrat

Ref. 33

Test	*Av.*	*Range*
Hb	**13.6**	**6.6-19.8**
RBC	**6.4**	**4.3-8.0**
PCV	**50**	**24-68**
Retics		
MCV	**80**	**65-119**
MCH		
MCHC		
MCD		
WBC	**7.5**	**3.3-25.0**
N	**70**	**33-93**
L	**25**	**5-46**
M	**2.8**	**0-10**
E	**0.6**	**0-2.5**
B	**1.66**	**0-15**
Plts		
ESR		
ELT		
Pg		
AF		

No. = 71

RODENTIA
MYOMORPHA
MUROIDEA
MURIDAE
Rattus norvegicus
Norway rat

	Survey Results			*Ref. 9*		*Ref. 11*		*Ref. 21*
Test	*Av.*	*Range*	*No.*	*Av.*	*Range*	*Av.*	*Range*	*Av.*
Hb	13.6	12.4-14.7	10	14.0	10.8-17.5			14.3
RBC	6.8	6.1-7.8	10	8.5	7.4-9.6	8.5		8.8
PCV	41.7	40-43	10	45	35-51			
Retics	3.9	1.2-6.2	10					
MCV	61.8	53-69	10					
MCH	20.1	17.6-22.2	10					
MCHC	32.2	29.7-33.9	10					
MCD	6.52	6.38-6.71	10	6. 34		6.3	5.8-6.8	
WBC	6.6	4.5-11.0	10	15.0	6.4-26.2	11.6	8-15	15.5
N	20	13-36	10	30	12-46	27	15-40	24
L	71	54-83	10	67	53-83	68	50-80	68
M	8	4-12	10	5	1-7	5.3	2-7	6
E	1	0-3	10	2	0-3.4	2	0-4	2
B	0		10	0.1	0-1	0.8	0-1.5	0.01
Plts	459	393-561	10					
ESR	0.1	0-0.5	10		0.7-1.8			
ELT		120-1200	6					
Pg								
AF								

Wistar strain (Survey Results)

1036 rats (Ref. 21)

See also refs. 10, 14, 20, 29, 31, 87.

Norway rat

Survey Results

Test	*Av.*	*Range*	*No.*
PT	14.0	11.5-15.0	12
RVV	8.4	7-10	12
PTT	42	30-50	12
RT	84	70-90	12
KRT	38	31-50	12
TT	9.6	8.5-11.0	12
I			
II	92	76-99	7
V	370	155-600	7
VII			
VIII	450	300-1000	10
IX			
X	170	120-200	7
XI	122	120-125	2
XII	420	370-460	2
XIII			
AT			
CR			
TP	6.26		1

PF3 release 70, range 66-74 (2 animals)
PF3 total 124, range 119-129 (2 animals)

For fibrinolysis in rats, see ref. 52.

RODENTIA
MYOMORPHA
MUROIDEA
MURIDAE
Mus musculus
House mouse (albino)

Survey Results

Test	Av.	Range	No.
Hb	15.0	13-16	10
RBC	9.0	7.1-10.0	10
PCV	47.4	44-52	10
Retics	4.2	1-11	10
MCV	52.9	48-62	10
MCH	16.7	14.9-19.6	10
MCHC	31.2	29-33	10
MCD	5.41	5.12-5.66	10
WBC	7.8	4.0-12.8	10
N	17	6-29	10
L	77	68-90	10
M	5	1-7	10
E	1	0-2	10
B	0		10
Plts	443	358-583	10
ESR	0		10
ELT	600+		6
Pg			
AF			

Test	Ref. 9 Av.	Ref. 9 Range	Ref. 10 Av.	Ref. 31 Av.	Ref. 31 Range
Hb	15.0	12-17	14.5	15.0	10-20
RBC	9.2	5.5-13.9	9.2	9.0	7-11
PCV			42	40	35-45
Retics					
MCV					
MCH					
MCHC					
MCD					
WBC	14.0	7-32	7-8	8.0	4-12
N	20.6	8-58	25.8	2.0*	0.5-4
L	66.6	36-90	64.7	6.0*	3-9
M	5.7	0.7-14	7	1.0*	0-5
E	2.6	0-15	2	0.05*	0-0.5
B	rare	0-0.5	0.5	1.0*	0-3
Plts					
ESR					
ELT					
Pg					
AF					

* $X10^3/c.mm$

See also refs. 11. 14, 23, 87.

House mouse

	Survey Results			*Ref. 43*	
Test	*Av.*	*Range*	*No.*	*Av.*	*Range*
PT	11.0	10-15	12	13.0	11.5-16.5
RVV	6.5	6.0-7.5	12		
PTT	53	47-59	12	25.2	18.5-33.4
RT					
KRT	32	27-38	7		
TT	7.6	6.0-9.0	12	7.9	6.9-10.5
I				231	44-339
II				47	29-73
V				538	360-688
VII					
VIII	900		1		
IX				46	23-80
X				148	57-256
XI				63	38-96
XII				86	60-136
XIII	+		1		
AT					
CR					
TP	4.94	4.39-5.49	2		

See also ref. 44.

MYOMORPHA
MUROIDEA
MURIDAE
Praomys natalensis
Multimammate mouse

	Ref. 66		*Ref. 66*	
Test	*Av.*	*SD/range*	*Av.*	*SD/range*
Hb	13.83	± 9.4	12.91	± 0.92
RBC	7.89	± 0.41	7.3	± 0.58
PCV	42	± 3.4	38.8	± 3.0
Retics	1.8	0.2-4.2	2.17	0.2-6.8
MCV	53.07	± 3.2	53.45	± 3.36
MCH	17.5	± 9.4	17.74	± 1.19
MCHC	33.02	± 1.29	33.3	± 0.98
MCD				
WBC	7.55	5.4-10.6	7.53	2.8-13.0
N	22.8	8-46	18.4	4-35
L	73.2	48-89	76	57-93
M	2.7	0-7	1.9	0-5
E	1.3	0-5	1.7	0-9
B	0		0	
Plts	368	217-750	289	208-445
ESR				
ELT				
Pg				
AF				
	23 males		*32 females*	

RODENTIA
HYSTRICOMORPHA
CAVOIDEA
HYDROCHOERIDAE
Hydrochoerus hydrochaeris
Capybara

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	10.6	10.2-11.1	2
RBC	3.15	3.1-3.2	2
PCV	35.5	33-37	2
Retics			
MCV	113.5	102-125	2
MCH	33.8	31.6-36.0	2
MCHC	30.5	30-31	2
MCD	9.9		1
WBC	7.0	6.1-7.9	2
N	62	55-69	2
L	34.5	25-44	2
M	3	1-5	2
E	0		2
B	0.5	0-1	2
Plts	213	129-294	2
ESR	29	24-34	2
ELT			
Pg			
AF			

Neutrophils have markedly eosinophilic granules
Red cells show a tendency to form sickles.

RODENTIA
HYSTRICOMORPHA
CAVOIDEA
CAVIIDAE
Cavia porcellus
Domestic guineapig

Test	Survey Results Av.	Range	No.	Ref. 9 Av.	Range	Ref. 11 Av.	Range	Ref. 26 Av.	Range
Hb	13.0	11.5-15.4	10	14.7	13-16				
RBC	5.0	4.7-5.9	10	5.64	3.4-8.8	5.8	4.5-6.8	5.0	4.6-5.4
PCV	41.3	36-48	10	42	37-47				
Retics	1.4	0.2-3.2	10						
MCV	79.1	73-86	10						
MCH	24.9	23.4-27.5	10						
MCHC	31.0	29.8-32.5	10						
MCD	6.87	6.73-7.09	10			7.5	7.2-7.8		
WBC	13.3	10.0-19.5	10	9.0	3.2-15.0	10.7	6-20	9.1	5-15
N	55.2	40-71	10		18-60	41.8	30-50	32	16-44
L	35.0	19-51	10		55-80	45.3	35-55	64	55-81
M	9.2	5-15	10		1-2	8.4	1-20	3.1	0-7
E	0.1	0-1	10		1-5	4.8	2-15	0.6	0-3
B	0.5	0-1	10		0-3	0.77	0-2	0.2	0-2
Plts	250	182-308	10						
ESR	2.8	0-7	10						
ELT	144	37-225	7						
Pg									
AF									

Lymphocytes sometimes contain Kurloff bodies
Neutrophils have eosinophilic granules

For haematology, see also refs. 10, 19, 27, 28, 31, 87.

Domestic guineapig

Survey Results

Test	*Av.*	*Range*	*No.*
PT	26.5	24-29	10
RVV	14	10-17	10
PTT	41	33-48	10
RT	76	60-87	10
KRT	30	23-35	10
TT	8.5	7-12	10
I	528	483-605	10
II	33.5	26-44	10
V	330	150-500	10
VII			
VIII	1000+		5
IX	100	45-150	10
X	60		1
XI	325	240-410	2
XII	420	370-460	3
XIII	+		5
AT			
CR	63		1
TP	4.38	3.6-4.9	4

Contact activation index 31
Range 29-32 (2 animals)

RODENTIA
HYSTRICOMORPHA
HYSTRICOIDEA
HYSTRICIDAE
Atherus sp.
Brush-tailed porcupine

Survey Results

Test	*Av.*	*No.*
Hb	12.0	1
RBC	3.6	1
PCV	44	1
Retics	1.0	1
MCV	122	1
MCH	33.5	1
MCHC	27.0	1
MCD		
WBC	12.5	1
N	31	1
L	52	1
M	4	1
E	12	1
B	1	1
Plts	192	1
ESR	6	1
ELT	275	1
Pg		
AF		

Neutrophils contain eosinophilic granules

Survey Results

Test	*Av.*	*Range*	*No.*
PT	26	16-34	3
RVV	11.0	10.5-12.5	3
PTT	40	35-50	3
RT	59	44-85	3
KRT	37	35-39	2
TT	7.0	6.5-8.0	3
I	525	410-640	2
II	15		1
V	590	280-900	2
VII			
VIII	380		1
IX			
X	87	85-90	3
XI			
XII	170		1
XIII	+		2
AT	415	380-450	2
CR			
TP	5.95	5.65-6.25	2

Contact activation index 61 (1)

RODENTIA
HYSTRICOMORPHA
OCTODONTOIDEA
CTENOMYIDAE
Ctenomys mendocinus
Tucotuco

Survey Results

Test	*Av.*	*Range*	*No.*
PT			
RVV	8.0	7-9	2
PTT	34	33-35	2
RT	56	54-58	2
KRT	53	50-56	2
TT	5.5	5-6	2
I			
II			
V			
VII			
VIII	1000+		1
IX			
X	250		1
XI			
XII			
XIII			
AT			
CR			
TP	6.25		1

RODENTIA
HYSTRICOMORPHA
OCTODONTOIDEA
CAPROMYIDAE
Myocaster coypus
Coypu

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	13.9	13.1-14.9	3
RBC	4.1	3.9-4.2	3
PCV	48	42-58	3
Retics	1.8		1
MCV	117.0	104-142	3
MCH	34.0	32-36	3
MCHC	29.0	23-32	3
MCD	7.44		1
WBC	9.2	5.2-11.3	3
N	54	47-61	3
L	34	28-45	3
M	8	6-10	3
E	4	2-9	3
B	0		3
Plts	282	240-325	3
ESR			
ELT			
Pg			
AF			

Neutrophils contain eosinophilic granules

Survey Results

Test	*Av.*	*Range*	*No.*
PT	13.25	13.0-13.5	2
RVV	6.0		1
PTT	51	47-55	2
RT	60		1
KRT	27		1
TT	6.5	6.0-7.0	2
I			
II	46		1
V	100		1
VII			
VIII			
IX			
X	20		1
XI			
XII			
XIII			
AT			
CR			
TP			

RODENTIA
HYSTRICOMORPHA
CHINCHILLIDAE
Lagostomus maximus
Plains viscacha

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	12.9	12.4-13.5	2
RBC	4.6	4.4-4.8	2
PCV	39.5	36-43	2
Retics	0		2
MCV	84.5	80-89	2
MCH	28.5	28.1-28.2	2
MCHC	32.7	31.4-34.0	2
MCD			
WBC	11.0	7.6-14.4	2
N	55	33-72	2
L	43	24-63	2
M	2	1-3	2
E	2	1-3	2
B	0		2
Plts	255	147-364	2
ESR	3		1
ELT	160		1
Pg	7.45		1
AF			

Neutrophils contain eosinophilic granules

Survey Results

Test	*Av.*	*Range*	*No.*
PT	12.5	12-13	2
RVV	8.0		1
PTT	53	52-54	2
RT	81	70-92	2
KRT	38	36-40	2
TT	7.0	6-8	2
I	865	805-952	2
II			
V			
VII			
VIII	120		1
IX			
X	170	140-200	2
XI			
XII	140		1
XIII	+		2
AT			
CR	60		1
TP	6.55	5.7-7.4	2

PF3 release 58 (1)
PF3 total 89 (1)
Contact activation index 39 (1)

For haematology of the chinchilla, see ref. 32

Order: CETACEA

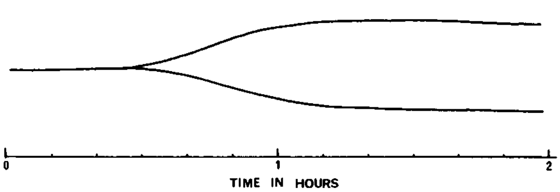
The haematology of small cetaceans has been studied to some extent in relation to the use of these mammals in research into the physiology of diving [68-76]. Like seals, dolphins and whales have a relatively high haemoglobin level and packed cell volume. The total red count is low and the mean cell volume large. The relationship between the mean red cell volume and diameter suggests that the cells have a greater average thickness than is normally found, possibly giving rise to a prolongation of the rate of oxygen diffusion out of the cells which may be advantageous during diving. Occasionally, Howell Jolly bodies and nucleated red cells are present in the peripheral blood of the bottle-nosed dolphin *(Tursiops truncatus)* and the reticulocyte count is high. Intraerythrocytic bodies resembling Heinz bodies have also been found in significant numbers in this species. Red cell rouleau formation is pronounced and the sedimentation rate is rapid.

The total white cell count is within the normal human range with neutrophils as the predominant cell type. In acclimatised captive dolphins the eosinophil count is high in the absence of detectable parasitic infection or allergy. In the bottle-nosed dolphins a low eosinophil count has proved to be a useful indication of stress. The total platelet count is often below the normal human range.

The blood coagulation mechanism of cetaceans is of great interest because those species which have been tested have no demonstrable factor XII activity [75]. Thus the whole blood clotting time, thrombelastograph pattern (Figure 6.1) and other tests depending on intrinsic prothrombin activation are prolonged and are not affected by contact with activating surfaces. The extrinsic pathway of prothrombin activation is well developed and other clotting factors are present in expected amounts. It has been suggested that lack of factor XII may protect these diving mammals from diffuse intravascular coagulation which has been shown to be a major factor in severe cases of decompression sickness in man [77], possibly triggered by activation of factor XII by acidosis. Although the blood pH of resting and diving cetaceans is within the normal mammalian range, a significant decrease occurs as diving is completed. As with humans with congenital factor XII deficiency, cetaceans apparently do not suffer from a haemorrhagic tendency.

In man, factor XII in its activated form has been shown to function as an activator of plasminogen. The finding that fibrinolytic activity can be demonstrated in cetaceans by the euglobulin lysis test confirms that an alternative pathway of plasminogen activation exists.

Figure 6.1. Thrombelastograph tracing on the bottle-nosed dolphin.



CETACEA
ODONTOCETI
DELPHINOIDEA
DELPHINIDAE
Phocoenoides dalli
Dall's porpoise

	Ref. 74		*Ref. 68*	
Test	*Av.*	*± SD*	*Av.*	*Range*
Hb	19.7	± 1.8		
RBC	5.5	± 0.6	7.48	
PCV	53	± 4	55.6	53.4-57.9
Retics				
MCV	96.3		74.3	
MCH	35.8			
MCHC	37.1			
MCD	6.9	± 1		
WBC	5.5	± 1.9		
N	49	± 19		
L	43	± 17		
M	4	± 2		
E	5	± 3		
B	0			
	11 tests on one animal		*No. = 1-2*	

See also ref. 69.

CETACEA
ODONTOCETI
DELPHINOIDEA
DELPHINIDAE
Tursiops truncatus
Bottlenose dolphin

	Survey Results			*Ref. 74*		*Ref. 74*		*Ref. 75*
Test	*Av.*	*Range*	*No.*	*Av.*	*± SD*	*Av.*	*± SD*	*Av.*
Hb	14.5	11.5-16.4	4	15.2	± 1.5	14.4	± 1.4	14.6
RBC	3.7	3.4-4.1	5	4.14	± 0.5	3.98	± 0.4	3.35
PCV	39	31-45	5	45	± 4	43	± 4	38.8
Retics	3.2	1.9-5.0	5					
MCV	103	91-110	5	108.6	±	108.3	±	115.8
MCH	38.5	34-41	4	36.7		36.2		43.5
MCHC	37.2	30-42	4	33.7		33.5		37.6
MCD	6.99	6.78-7.11	4	7.1	± 0.2	7.2	± 0.2	
WBC	7.5	6.0-8.6	5	10.7	± 4.9	9.8	± 3.1	9.0
N	64	52-80	5	61	± 13	61	± 31	52
L	22	9-38	5	22	± 10	20	± 11	28
M	3	1-10	5	3	± 3	2	± 2	2
E	11	0-22	5	13	± 9	15	± 9	23
B	0		5	0		0		0-3
Plts	132	97-180	4					139
ESR	32	13-47	4					
ELT	410	120-600	6					
Pg	5.3		2					6.27-7.02
AF								
				130-180 tests on 10 males		*155-165 tests on 11 females*		*3 animals*

See also ref. 69.

Bottle-nosed dolphin

Survey Results

Test	*Av.*	*Range*	*No.*
PT	14.4	14.0-14.8	2
RVV	11.9	11.8-12.0	2
PTT	193	171-225	6
RT	360		2
KRT	470	270-770	6
TT	8.0	4-11	6
I	385	370-400	2
II	78	65-88	6
V	100		2
VII			
VIII	1000+		2
IX	425	400-450	2
X	104	80-130	6
XI	77.5	75-80	2
XII	<1		6
XIII	+		2
AT			
CR			
TP			

Note factor XII levels of less than 1%.

Ref. 75

Test	*Av.*	*Range*
PT	16.2	13.7-18.6
RVV	12.0	11.6-12.4
PTT	302	240-427
RT		
KRT		
TT	10.0	9.0-10.5
I	331	279-360
II	88	54-110
V	169	125-238
VII	31.6	6.8-63
VIII	468	338-650
IX	130	107-142
X	48	26-72
XI	74	70-81
XII	0	
XIII	100+	
AT	147	143-150

No. = 3

CETACEA
ODONTOCETI
DELPHINOIDEA
DELPHINIDAE
Phocaena phocaena
Harbour porpoise

Ref. 68

Test	*Av.*	*Range*
Hb		14.8-20.0
RBC	5.0	4.5-5.5
PCV		45-55
Retics		
MCV	100	
MCH	35	
MCHC	35	
MCD		
WBC	8.0	4-12
N		40-75
L		20-50
M		0-3
E		0-1
B		
Plts		
ESR		
ELT		
Pg		
AF		

No. = 10

CETACEA
ODONTOCETI
DELPHINOIDEA
DELPHINIDAE
Globicephala scammoni (Pacific pilot whale) *and G. melaena* (North Atlantic pilot whale)

	Pacific pilot whale *Ref. 74*		**N. Atlantic pilot whale** *Ref. 71*	
Test	*Av.*	*± SD*	*Av.*	*± SD*
Hb	16.5	± 1.9	15.8	± 1.2
RBC	3.9	± 0.4	3.71	± 3.8
PCV	46	± 4	45	± 3.5
Retics				
MCV	117.9		123	8.8
MCH	42.3		42.7	± 2.7
MCHC	35.8		35.0	± 0.9
MCD	6.8	± 0.1		
WBC	11.5	± 1.6	11.5	± 3.2
N	72	± 10	72.4	
L	19	± 6	18.8	± 6.2
M	3	± 2	2.6	± 1.5
E	5	± 4	7	± 9.2
B			< 1	
	9 - 13 tests on 2 animals		*No. = 6*	

CETACEA
ODONTOCETI
DELPHINOIDEA
DELPHINIDAE
Orcinus orca
Killer whale

	Ref. 74		*Ref. 75*	
Test	*Av.*	*± SD*	*Av.*	*Range*
Hb	16.2	± 0.9	16.1	15.0-16.8
RBC	4.0	± 0.3	3.8	3.7-3.9
PCV	45	± 0.6	43	40-45
Retics				
MCV	112.5		113.1	
MCH	40.5		42.3	
MCHC	36.0		37.4	
MCD	6.8	± 0.1		
WBC	10.4	± 3.8	6.1	5.4-7.3
N	81	± 12	59	49-65
L	15	± 10	28	24-35
M	3	± 1	3.6	1-6
E	2	± 1	6	4-7
B	0		0	
Plts			256	219-310
ESR				
ELT				
Pg				6.4-6.5
AF				

6 tests on 2 males *No = 3*

	Ref. 75	
Test	*Av.*	*Range*
PT	15.6	14.8-16.3
RVV	13.1	12.6-13.8
PTT	216	144-290
RT		
KRT		
TT	10.1	9.9-10.4
I	466	399-584
II	80	76-84
V	232	113-375
VII	24	22-28
VIII	293	267-343
IX	91	64-107
X	18	14-20
XI	148	56-314
XII	0	
XIII	100 +	
AT	125	112-140
CT*	33	18-47
CTS**	34	25-45

No = 3

**Clotting time in glass tubes.*
***Clotting time in siliconed tubes.*

CETACEA
ODONTOCETI
DELPHINOIDEA
DELPHINIDAE
Lagenorhynchus obliquidens
Pacific white-sided dolphin

	Ref. 74		*Ref. 74*		*Ref. 69*	
Test	*Av.*	± *SD*	*Av.*	± *SD*	*Av.*	*Range*
Hb	17.8	± 1.6	19.8	± 1.9		
RBC	5.31	± 0.5	5.83	± 0.5	5.9	5.6-6.2
PCV	50	± 5	54	± 3	48.9	47.3-49.9
Retics						
MCV	94.1		92.6		82.8	
MCH	33.5		33.9			
MCHC	35.6		36.6			
MCD	6.6	± 0.2	6.9	± 0.1		
WBC	7.9	± 2.3	5.5	± 1.9		
N	43	± 15	48	± 19		
L	29	± 14	43	± 17		
M	5	± 3	4	± 2		
E	21	± 11	5	± 3		
B						
Plts						
ESR						
ELT						
Pg						
AF						
	31-46 tests on 3 males		*21-33 tests on 2 females*		*No. = 3*	

CETACEA
ODONTOCETI
PLATANISTOIDEA
PLATANISTIDAE
Inia geoffrensis
Geoffroy's dolphin

	Ref. 74		*Ref. 74*	
Test	*Av.*	*±SD*	*Av.*	*±SD*
Hb	**14.4**	**± 1.4**	**13.3**	**± 0.3**
RBC	**3.9**	**± 0.5**	**3.8**	**± 0.3**
PCV	**42**	**± 0.3**	**40**	**± 0.4**
Retics				
MCV	**107.6**		**105.2**	
MCH	**36.9**		**35.0**	
MCHC	**34.2**		**33.2**	
MCD	**6.9**	**± 0.2**	**6.8**	**± 0.1**
WBC	**14.6**	**± 3.1**	**12.2**	**± 2.1**
N	**70**	**± 16**	**70**	**± 14**
L	**21**	**± 8**	**20**	**± 8**
M	**4**	**± 3**	**3**	**± 3**
E	**5**	**± 4**	**4**	**± 3**
B	**0**			
	18-20 tests on 5 males		*4 tests on 3 females*	

Order: PINNIPEDIA

The small amount of information available from the literature on the haematology of seals and sea lions suggests that, like Cetaceans, these diving mammals have comparatively high levels of haemoglobin and that packed cell volumes and mean red cell volumes are also high [76, 78-82]. Red cell absolute values indicate an increased mean red cell average thickness compared with terrestrial mammals but similar to Cetaceans. The total white count is equivalent to that of man with neutrophils as the predominant cell type. Basophils are rare.

The blood clotting mechanism has been studied in detail in only one Baikal seal *(Pusa sibirica)* and one Californian sea lion *(Zalophus californianus)*. In these animals both the intrinsic and extrinsic pathways of prothrombin activation are well developed. A rapid whole blood clotting time has been reported in adult elephant seals *(Mirounga leonina)* [81]. Thus there is no evidence for factor XII deficiency as found in cetaceans. Fibrinlytic activity can be demonstrated by the euglobulin lysis test and in the Californian sea lion the plasminogen level is high. Plasminogen is activated directly by human urokinase and by streptokinase without addition of human serum.

PINNIPEDIA
PHOCIDAE
Pagophilus greenlandicus (Harp seal)
Halichoerus grypus (Grey seal)
Leptonychotes weddelli (Weddell seal)

Harp seal
Ref. 79

Test	*Av.*	*Range*
Hb	25.2	21.8-25.2
RBC	4.57	4.09-5.07
PCV	59.2	53.5-65.2
Retics		
MCV	130.5	119-142
MCH	55.4	49.6-61.3
MCHC	42.3	40.6-43.8
MCD		
WBC	7.8	5.3-10.1
N		
L		
M		
E		
B		
Plts		
ESR		
ELT		
Pg		
AF		

No = 15
Influence of age also discussed

Grey seal
Survey Results

Test	*Av.*	*No.*
Hb	19.5	1
RBC	4.9	1
PCV	52	1
Retics	0.8	1
MCV	106	1
MCH	40	1
MCHC	37	1
MCD	7.55	1
WBC	6.0	1
N	48	1
L	49	1
M	2	1
E	0	1
B	1	1

Weddell seal
Ref. 82

Test	*Av.*	*Range*
Hb	23.7	22.5-25.0
RBC	3.73	3.62-3.85
PCV	59	54-65
Retics		
MCV	168	167-169
MCH	63.5	62-65
MCHC	37.8	37.2-38.5
MCD		
WBC		
N		
L		
M		
E		
B		

No = 2 - 9

PINNIPEDIA
PHOCIDAE
Phoca vitulina
Common seal

	Survey Results			*Ref. 76*		*Ref. 80*	
Test	*Av.*	*Range*	*No.*	*Av.*	*±SD*	*Av.*	*Range*
Hb	16.6	13.7-19.3	7	19.2	±1.3	17.6	13.0-22.3
RBC	4.5	3.9-4.9	7	5.45	±0.7	6.7	4.7-8.5
PCV	52.5	45-66	7	52	±6	55.7	48-59
Retics	1.0	0.5-2.0	7				
MCV	107.6	92-118	7	95.4		83.1	
MCH	35.2	27-39	7	35.2		26.2	
MCHC	31.4	30.5-33.6	7	36.9		31.6	
MCD	7.52		1	6.4	±0.3		
WBC	4.4		2	8.0	±1.0	4.5	2.8-6.2
N	60	48-72	4	60	±20		
L	32	16-49	4	33	±22		
M	8	2-12	4	4	± 2		
E	0.5	0-2	4	1	± 1		
B	0						
Plts							
ESR							
ELT							
Pg							
AF							

Occasional nucleated red cell found.

N = 2-6

2-3 animals

PINNIPEDIA
PHOCIDAE
Mirounga leonina (Southern elephant seal)
and M. angustirostris (Northern elephant seal)

	Mirounga leonina Ref. 81		Ref. 81		Ref. 81.		*M. angustirostris* Ref. 76	
Test	*Av.*	*Range*	*Av.*	*Range*	*Av.*	*Range*	*Av.*	*± SD*
Hb	15.77	12.3-19.2	16.23	12.6-18.2			25.0	± 1.0
RBC	3.13	2.12-4.7	3.06	1.98-4.57	3.21	2.7-3.72	5.55	± 0.26
PCV					66	61-71	63.5	± 4.9
Retics								
MCV					205		114	
MCH	50.3		53.0				45.0	
MCHC							39.3	
MCD							7.6	± 0
WBC	15.2	10.1-25.2	14.2	6.8-24.5	15.2	12.5-20.7	9.6	± 1.85
N							55	± 11
L							38	± 14
M							3	± 1
E							4	± 1
B							0	
	14-20 male pups		*12-16 female pups*		*2-5 adults*		*No = 2-3*	

PINNIPEDIA
PHOCIDAE
Pusa sibirica
Baikal seal

Survey Results

Test	*Av.*	*Range*	*No.*
Hb	18.0		1
RBC	5.5	5.3-5.6	2
PCV	66.5		1
Retics	4.0		1
MCV	122	121-123	2
MCH	47.5	46-49	2
MCHC	38.0	36-40	2
MCD			
WBC	5.6	3.4-7.8	2
N	67		1
L	20		1
M	13		1
E	0		1
B	0		1
Plts			
ESR			
ELT	330		
Pg			
AF			

Survey Results

Test	*Av.*	*No.*
PT	12.5	1
RVV	8.0	1
PTT	76	1
RT	81	1
KRT	72	1
TT	7.0	1
I	486	1
II	190	1
V	450	1
VII		
VIII		
IX		
X	130	1
XI		
XII		
XIII	+	1
AT		
CR		
TT	8.55	1

PINNIPEDIA
OTARIIDAE
Zalophus californianus
Californian sealion

Test	Survey Results Av.	Survey Results No.	Ref. 76 Av.	Ref. 76 ± SD	Test	Survey Results Av.	Survey Results No.
Hb			15.0	± 2.1	PT	14.5	1
RBC			4.38	± 0.7	RVV	7.0	1
PCV			45	± 5	PTT	63	1
Retics					RT		
MCV			102.7		KRT		
MCH					TT	11	1
MCHC					I	392	1
MCD			7.1	± 0.2	II	60	1
WBC			9.2	± 1.5	V	900	1
N			58	± 7	VII		
L			28	± 10	VIII		
M			4	± 2	IX		
E			4	± 4	X	150	1
B					XI		
Plts	456	1			XII		
ESR					XIII		
ELT	600	1			AT		
Pg	5.8	1			CR	68	1
AF					TP	6.78	1

No. = 8 (Ref. 76)

PF3 release 63 (1)
PF3 total 86 (1)
Contact activation index 85 (1)

Order: PROBOSCIDEA

Some information on the haematology of elephants is available from the literature. The red cells of these animals are larger than those of most other mammals [84, 85]. This finding, which has been confirmed in the present survey, has led to the suggestion that there is a direct relationship between the overall size of an animal and the size of its red cells. However, this suggestion is not supported by MCV and MCD measurements in small mammals and is undermined by the fact that the largest known red cells are found in amphibians (Chapter 1). Correlated with the large size of red cells in elephants, the total red cell count is low. The haemoglobin level, packed cell volume, red cell diameter and average thickness are within the expected ranges. Adult African elephants apparently have higher red count, PCV, MCV and MCHC than juveniles of the species and higher red cell indices than Indian elephants. Reticulocytes are rare in both species. The red cells show a marked tendency for rouleaux formation and the ESR is high in overtly normal animals.

The total white count is higher in juveniles than in adults and in all groups except adult African elephants lymphocytes outnumber neutrophils. Basophils are rare. Elephant blood is notable for the presence of a significant number of morphologically unusual white cells, the origin of which has not yet been determined. These cells have distinctive bilobed nuclei, the two halves of which are connected by a very thin strand, often almost invisible so that the cells appear binucleated. The cytoplasm has staining characteristics intermediate between lymphocytes and monocytes. These cells are present in both African and Indian elephants of all ages and no significant change in their numbers associated with clinical abnormalities has yet been found.

The platelets of elephants are small and numerous. No studies on their reactivity have been carried out. Blood coagulation is apparently more rapid in Indian than in African elephants. Fibrinolytic activity as measured by the euglobulin lysis test is absent, the clots showing no signs of lysis after incubation for 72 hours at 37°C. Plasminogen can be demonstrated by activation with human urokinase and by streptokinase in the presence of human serum.

PROBOSCIDEA
ELEPHANTIDAE
Elephas maximus
Indian elephant

	Adults Survey Results			*Juveniles* Survey Results			*Ref. 84*	
Test	*Av.*	*Range*	*No.*	*Av.*	*Range*	*No.*	*Av.*	*Range*
Hb	13.6	11.8-17.1	5	14.5	11.6-16.8	3	13.4	12.0-15.5
RBC	3.3	2.9-3.6	5	3.5	3.2-4.7	3	2.8	1.98-4.01
PCV	41	36-47	5	40.5	36-44	3	38.2	30.0-43.3
Retics	0.1	0-0.4	5	0.15	0-0.5	3		
MCV	125	112-136	5	117	114-121	3		
MCH	41	36-46	5	50	36-45	3		
MCHC	32.5	30-34	5	35	32-38	3		
MCD	9.16	8.5-9.7	3					
WBC	11.4	10.2-14.1	5	20.6	19-22	3	10.16	6.4-14.0
N	22	19-27	5	19	14-28	3	36	22-50
L	45	31-53	5	51	40-62	3	52	40-60
M	4	0-7	5	1	0-2	3	2.1	0-5
E	3	0-4	5	1	0-2	3		
*	24	15-36	5	27	24-31	3		
Plts	540	290-815	5	677	300-1000	3		
ESR	36	31-41	5	40		1	36	25-49
ELT	72h+		5	72h+		2		
Pg								
AF								

**Unidentified cells with bilobed nuclei*

13 adults

For influence of age, sex and pregnancy on the blood picture, see ref. 86.

Indian elephant

Survey Results

Test	*Av.*	*Range*	*No.*
PT	13.5	12-15	2
RVV	7.5	6.0-8.5	3
PTT	49	40-67	3
RT	104	60-145	3
KRT	45	33-53	3
TT	7.5	7.0-8.5	3
I	876	730-1013	3
II	150		1
V	270	160-450	3
VII			
VIII	1000+		3
IX	280	73-700	3
X	205	110-300	2
XI			
XII			
XIII	+		3
AT			
CR			
TP	8.18	8.15-8.21	2

PF3 release 72(1)
PF3 total 75(1)
Contact activation index 87(1)

PROBOSCIDEA
ELEPHANTIDAE
Loxodonta africana
African elephant

	Adults Survey Results			*Juveniles Survey Results*			*Ref. 83*		*Ref. 85*	
Test	*Av.*	*Range*	*No.*	*Av.*	*Range*	*No.*	*Av.*	*Range*	*Av.*	*Range*
Hb	17.2	16-18	3	14.7	10.9-17.5	7	15.1	13.6-16.5	14.5	11.5-18.0
RBC	3.8	3.6-4.0	3	3.7	3.2-4.4	7	3.68	3.2-4.7	5.02	4.2-6.6
PCV	48.5	45-52	3	43	38-49	7			48	44-51
Retics	0		3	0		7				
MCV	128	120-137	3	117	98-124	7			97	71-121
MCH	45.4	43.8-48.0	3	39	33-43	7	41.0	37-44	29	23-36
MCHC	35.0	32-39	3	33.6	28-38	7			30	26-37
MCD	9.06	8.88-9.24	3							
WBC	9.0	7.8-10.8	3	17.5	16-24	7			10.4	6.8-14.3
N	50	23-68	3	25	15-34	7	26	17-37	38	27-54
L	31	23-47	3	50	30-60	7	46	40-55	58.2	44-69
M	6	2-8	3	2	1-4	7	0.1	0-1	1.5	0-4
E	0		3	2	0-7	7	2	1-6	2.4	0-6
*	13	10-19	3	21*	14-34	7	25*	17-33		
Plts	455	320-600	3	490	300-600	7				
ESR	21	12-29	3	28	6-48	7			29	19-40
ELT	72h+		3	72h+		4				
Pg										
AF										

**Unidentified cells with bilobed nuclei*

Ref. 83: 10 elephants in natural habitat

Ref. 85: 11 adults

African elephant

Survey Results

Test	*Av.*	*Range*	*No.*
PT	15.3	14.0-16.5	2
RVV	8.5	8.0-9.0	3
PTT	81	72-94	3
RT	138	100-216	3
KRT	47	40-54	3
TT	8.6	5-10	3
I	641	630-661	3
II			
V	450		1
VII			
VIII	1000+		3
IX	500		1
X	170		1
XI			
XII			
XIII	+		3
AT			
CR			
TP			

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APPENDIX

METHODOLOGY

Methods of obtaining blood samples
All the results presented have been obtained from study of venous, arterial or heart blood. Peripheral blood has not been used. The use of anaesthetic or tranquillizing drugs is a prerequisite before bleeding many animals. The most usual drugs are listed in Table 1.

TABLE 1

ANAESTHETIC AND TRANQUILLIZING DRUGS

ANIMAL	DRUGS
Non-human primates	Phencyclidine, Thiopentone Na, Ketamine
Carnivores	Phencyclidine, Ketamine
Artiodactyls	Xylazine, Ketamine, Etorphine
Perissodactyls	Etorphine
Marsupials	Etorphine, Ketamine
Rodents and rabbits	Pentobarbitone Na

Blood samples were obtained by puncture of a suitable blood vessel using disposable plastic syringes and disposable hypodermic needles. The size of needle and syring was selected according to the site and size of the vessel to be punctured. The most usual routes of sampling are listed in Table 7.2.

TABLE 2

MOST USUAL ROUTE OF BLOOD SAMPLING

ANIMAL	BLOOD VESSEL
Non-human primates	Femoral or jugular vein
Carnivores	Jugular or cephalic vein
Artiodactyls	Jugular vein
Perissodactyls	Jugular vein or post-auricular vein in rhinoceroses
Marsupials	Saphenous or jugular vein
Proboscideans	Post auricular vein
Rabbits, rodents	Heart.

Apparatus
Disposable plastic tubes were used for collection and storage of blood samples. New glass tubes were used for clotting and fibrinolytic tests.

Blood counts
Unless otherwise stated, standard haematological techniques described by Dacie and Lewis [1] were used.

Blood sample
Blood was collected into plastic tubes containing the dipotassium salt of ethylenediamine tetra-acetic acid (EDTA) at a concentration of 1-2 mg of the dry salt per ml of blood. Blood films were prepared from blood directly from the syringe or as soon as possible from the EDTA sample. They were dried rapidly in air and stained with Leishman stain.

Red and white cell counts
At the beginning of the survey, blood cells were counted visually using an improved Neubauer counting chamber. Latterly cells have been counted using a Coulter Electronic Particle Counter, model F. Dilutions were prepared in particle-free Eagles solution (Isoton, Coulter Electronics Ltd.). For white cell counts a standard dilution of 1 in 500 was used and the red cells haemolysed by addition of 2% saponin. Red cells were counted at a dilution giving a machine count of 3-8 x 10^6. Optimum settings for attenuation, aperture and threshold controls were determined for each species. These are listed in Table 3. Counts were corrected for coincidence using the chart supplied by Coulter Electronics Ltd.

Haemoglobin concentration
This was measured by the cyanmethaemoglobin method. .Standards were obtained from Diagnostic Reagents, Thame, Oxford.

Packed cell volume
The microhaematocrit technique was used. Centrifugation was standardised at 10,000 for 5 minutes.

Reticulocyte count
Equal volumes of blood and 1% new methylene blue in citrate saline were mixed in a small glass tube and incubated at 37°C for 20 minutes. Films were prepared on clean glass slides and examined microscopically without fixation or counterstaining. The number of reticulocytes in 1000 red cells was counted and results recorded as percentage. This method was also useful for observation and enumeration of Heinz bodies.

Erythrocyte sedimentation rate
The method of Wintrobe was used. Sedimentation was recorded after one hour at room temperature.

Stained blood films
Air-dried films prepared from native or, occasionally, EDTA blood were stained with Leishman stain. They were examined for the presence of blood parasites, unusual forms of red cells and platelets, the presence of excessive rouleaux etc. For the differential white cell count, 200 white cells were examined.

Platelet counts
Platelet counts were carried out by phase contrast microscopy using 1% ammonium oxalate as diluent.

COAGULATION AND PLATELET FUNCTION TESTS

Blood sample
The standards set out by Hardisty and Ingram [2] were followed in order to minimise the

effects of sampling and storage techniques on the results obtained. Unless otherwise stated, blood was collected into a disposable plastic syringe containing 1 part of 3.8% trisodium citrate to 9 parts of blood. The sample was transferred to a clean plastic tube at 4°C. Further manipulations were carried out without delay.

Platelet Poor Plasma (PPP)
This was prepared by centrifugation at 4°C for 10 minutes at 6000 rpm. The PPP was separated using a disposable plastic pasteur pipette, taking care to avoid the white cell and platelet layer. The euglobulin lysis test and contact activation test were set up at once. The remaining PPP was distributed in small aliquots in plastic tubes and stored at −35°C. A freshly thawed aliquot was used for each subsequent test.

Platelet Rich Plasma (PRP)
Citrated blood was centrifuged at 800 rpm for 10 minutes at room temperature. For animals with small red cells some modifications of this regime was necessary. The PRP was separated by means of a plastic pipette and tested at once.

One-Stage Prothrombin Time
Unless otherwise specified, a saline extract of human brain was used [2]. This was preserved by addition of 0.5% phenol and standardised using normal human plasma. The laboratory reagent was compared with British Comparative Thromboplastin [3].

Clotting time with Russell's Viper Venom (RVV)
Russell's Viper Venom (Stypven, Burroughs Wellcome Ltd.) was reconstituted with 0.25% ovolecithin in veronal buffer, pH 7.35. Once prepared the reagent could be stored at 4°C for one week without loss of activity. Volumes each of 0.1 ml of test plasma and RVV reagent were mixed in a clean glass tube and incubated at 37°C for 30 seconds. A stop-watch was started on addition of 0.1 ml 0.025 M $CaCl_2$ and the clotting time recorded.

Partial Thromboplastin Time
Cephalin was prepared from acetone extracted human brain by the method of Bell and Alton [4], and standardised using normal human plasma. The test was carried out by the method of Rodman, Barrow and Graham [5].

Recalcification Time
This test was carried out as described by Biggs and Macfarlane [6].

Kaolin Clotting Time
Light kaolin 1% in Owren's buffer was used. The test was carried out according to Hardisty and Ingram [2].

Thrombin Time
Bovine thrombin (Leo Laboratories Ltd.) was used at a concentration of 50 NIH units/ml saline.

Fibrinogen (Factor I)
Fibrinogen was measured as clottable protein by a modification of the method of Ratnoff and Menzie [7]. The results, corrected for initial dilution by citrate, were expressed in mg/100 ml of plasma.

Contact Activation Test

The activity of factors XI and XII was measured by the contact activation test of Margolis [8] as modified by Biggs and McFarlane [6]. The ability of contacted plasma to shorten the partial thromboplastin time of non-contacted plasma of the same animal was recorded. The results were calculated from the following formula:

$$\text{Activation index} = 100 - \frac{\text{CT of contacted plasma}}{\text{CT of non-contacted plasma}} \times 100$$

Platelet Factor 3 (PF3) Activity

The total and available PF3 was measured by a modification of the method of Hardisty and Hutton [9]. From freshly collected citrated blood, PRP and PPP were prepared. Platelet counts were carried out and, by dilution with a calculated volume of PPP, the number of platelets in the PRP was adjusted to 300 x 10^3/c.mm. The following mixtures were prepared:

i)	Test PRP	0.1 ml	ii)	Test PPP	0.1 ml
	Human PPP	0.1 ml		Human PPP	0.1 ml
	Saline	0.1 ml		Cephalin	0.1 ml

Each mixture was treated with kaolin (0.2 ml. of 5 mg/ml suspension in Owren's buffer, pH 7.35) for 20 minutes at 37°C, mixing frequently to resuspend the kaolin. After exactly 20 minutes, 0.2 ml of prewarmed 0.025 M $CaCl_2$ was added to each tube and the clotting time recorded.

To determine the total PF3 present, the test was repeated on standardised PRP in which the platelets had been disrupted by several times immersing the tube alternately in liquid N_2 and water at 37°C.

PF3 activity was calculated from the formula:

$$\text{PF3 activity} = \frac{\text{CT with cephalin}}{\text{CT of PRP}} \times 100$$

Platelet Aggregation

By dilution with homologous PPP, the platelet count of freshly collected PRP was adjusted to 375-400 x 10^3 per c.mm. Aggregation on addition of adenosine diphosphate (ADP) was measured by continuous recording of changes in optical density by the method of Born [23].

Plasma ADP-inhibitor

This was estimated by the method of Hawkey and Symons [19].

Clot Retraction

Platelet rich plasma, 1 ml was mixed with 0.2 ml 0.1 M $CaCl_2$ in a pyrex test tube, internal bore 8 mm, previously heated to red heat in a bunsen flame. After two hours at 37°C the length of the retracted clot and height of liquid in the tube were measured. Percentage retraction was calculated from the formula.

$$\text{Clot retraction \%} = 100 - \frac{\text{Length of clot}}{\text{height of serum}} \times 100$$

Antithrombin Activity
The ability of PPP to neutralise the effect of bovine thrombin (Leo Pharmaceutical Co.) was measured by the method of Astrup & Darling [10] as modified by Biggs & MacFarlane [6].

Factor XIII
A non-quantitative test for factor XIII was carried out by exposing a standard clot prepared by reclacification of citrated plasma to the action of 5M urea. Failure of the clot to dissolve indicates that fibrin-i, which requires the presence of factor XIII for its formation, is present [11].

Clotting Factor Assays
Calibration curves. The activity of factors II, V, VIII, IX, X, XI and XII have been expressed with reference to calibration curves prepared from human plasma. In each case the curve was prepared from a pool of plasma collected from 10 normal humans or from a single donor known from previous tests to have 100% of the factor in question. Values of greater than 100% were obtained by extrapolating the curve and checked by dilution of the test sample. Expression of the results of factor VII assays is discussed later.

Factor II (Prothrombin)
The absolute level of prothrombin was measured by a modification of the method of Pechet [12] and by the Taipan venom method of Denson [13]. In the first method, standardised human brain extract was used as a source of thromboplastin and in order to mask the species specificity between this reagent and heterologous factors VII and X, these factors were supplied by the inclusion of incubated normal human serum in the test mixture. Because surprisingly low levels of factor II were found in some animals in spite of this precaution, many estimations were carried out in parallel using Taipan venom. This venom converts prothrombin directly to thrombin and should react equally well with prothrombin of all mammals. Results obtained with this method were similar to those from the conventional method, suggesting that the low levels of factor II activity found in many species may be a true representation of physiological levels.

Factor V
Factor V activity was assayed by the method of Stefanini [14] using incubated, oxalated human plasma as a source of factor V – free substrate [15], and standardised human brain extract as thromboplastin.

Factor VII
Factor VII activity was measured by the method of Dische [16]. For primates, human brain extract was used as a source of thromboplastin and factor VII-free plasma was obtained from a patient with congenital factor VII deficiency. This plasma contained less than 1% of factor VII. For carnivore assays factor VII-free substrate was prepared as follows. Four *Putorius furo* (ferrets) were given intramuscular injections of 60mg Warfarin Na. This exceptionally high dose was found to be necessary in order to obtain the required effect. Blood samples were collected from these animals 24 and 36 hours after the injection and animals with prothrombin times of greater than 60 seconds (control 12 seconds) were exsanguinated and the citrated plasma pooled. Assays of factors II, V and X on this plasma gave values of greater than 80% in each case. It was therefore concluded that this plasma was deficient in factor VII. With this plasma carnivore brain extract was used as a source of thromboplastin. Because of the difficulty in obtaining species specific substrate

plasma, factor VII assays have not yet been attempted on other groups of animals.

Factors VIII and IX

These factors were assayed by the one-stage method of Hardisty & Macpherson [17] using human brain cephalin [4] as a source of platelet substitute and substrate plasma from a severe human haemophiliac or patient with Christmas disease as appropriate.

Factor X

Factor X was assayed by the method of Denson [18]. Russell's viper venom (RVV) which is used as a source fo thromboplastin in this test reacts equally well with clotting factors of most other mammals [19]. The influence of the depressed reaction between RVV and monkey plasma [19] on this assay does not influence the result since factors II and V are bovine in origin.

Factors XI and XII

The activity of these factors was assayed by the one-stage method described by Denson [20] using human brain cephalin as a source of platelet substitute and substrate plasma from human individuals specifically deficient in the factor to be measured.

FIBRINOLYTIC TESTS

Euglobulin lysis time

This test was set up on freshly prepared PPP within 30 minutes of obtaining the blood sample. Plasma 0.1 ml was added to 0.4 ml ice cold distilled water and the pH adjusted to pH 5.3 by addition of 0.1% acetic acid. The euglobulin precipitate was obtained by centrifugation at 4°C for 10 minutes at 6000 rpm and redissolved in 0.3 ml phosphate buffer, pH 7.3. Thrombin 0.1 ml of a solution containing 50 NIH units/ml was added and the tube placed in a waterbath at 37°C. The contents were examined after 1 minute to ensure that clotting had occurred and thereafter at intervals for lysis. The lysis time was the interval between addition of thrombin and complete dissolution of the clot. Clots were discarded after 24 hours in most cases.

Plasminogen Assay

Plasminogen was measured by the caseinolytic method of Alkjaersig, Fletcher and Sherry [21]. Activation was achieved by human urokinase.

Antifibrinolysins

These were measured by the method of Blix. [22].

TABLE 3

SETTINGS FOR COULTER ELECTRONIC PARTICLE COUNTER, MODEL F, USING 100μ APERTURE TUBE

	Red Cells			White Cells		
	B	D	T	B	D	T
PRIMATES						
Ring-tailed Lemur	.5	16	15	1	32	15
Thick-tailed Bushbaby	.35	16	15	7	32	15
Owl Monkey	.5	16	15	1	32	10
Capuchin Monkey	.5	16	15	1	16	20
Squirrel Monkey	.5	16	15	1	16	20
Woolly Monkey	.5	16	15	1	32	10
Rhesus Monkey	.5	16	15			
Barbary Ape	.5	16	15	1	32	15
Mangabeys	.5	16	15	1	32	10
Patas Monkey	.35	16	15	1	16	20
Mona Monkey	.5	16	15	1	32	15
Vervet Monkey	.5	16	15	1	32	10
Baboons	.5	16	15	1	32	15
Gibbons	.5	16	15	1	32	15
Orang Utan	.5	16	15	1	32	10
Chimpanzee	.5	16	15	1	32	15
Mountain Gorilla	.5	16	15	1	32	10
Man	.5	16	15	1	16	20
CARNIVORES						
Timber Wolf	.5	16	15	1	16	20
Domestic Dog	.5	16	15	1	16	20
Bushdog	.5	16	15	1	16	20
Arctic Fox	.5	16	15	2	16	10
Bat-eared Fox	.35	16	15	1	16	15
Spectacled Bear	.35	16	10	1	32	10
Coati	.5	8	15	1	16	20
Giant Panda	.35	16	10	1	32	12
Stoat	.35	16	10	1	32	10
Tayra	.5	8	15	1	16	20
Palm civet	.35	16	10	1	16	15
Hyaena	.5	16	10	1	16	10
Lion	.35	16	15	1	32	15
Leopard	.35	16	15	1	32	15
Wild Cat	.35	16	10	1	16	15
Tiger	.35	16	15	1	32	15
Cheetah	.35	16	10	1	32	15
Jaguar	.35	16	10	1	32	15
Golden Cat	.35	16	10	1	16	20
Domestic Cat	.35	16	15	1	16	20
Leopard Cat	.35	16	10	1	16	20
ARTIODACTYLS						
Bush Pig	.5	16	10	1	16	20
Collared Peccary	.5	16	10	1	32	10
Alpaca	.35	8	10	1	16	15
Bactrian Camel	.35	8	10	1	16	15
Axis Deer	.35	16	10	1	32	10
Hog Deer	.35	16	10	1	32	15
Wapiti	.35	16	10	1	32	15
Pere Davids Deer	.35	16	15	1	32	15
Swamp Deer	.35	16	10			
Moose	.35	16	10	1	16	10
Reindeer	.35	16	15	1	16	10
Chinese Water Deer	.35	16	10			

ARTIODACTYLS (Cont.)	B	D	T	B	D	T
Kudu	.35	16	15	1	16	15
Eland	.35	16	10	1	16	15
Nilgai	.5	16	10	1	32	10
Anoa	.35	16	10	1	16	15
Gnu	.35	16	15	1	16	10
Bison	.35	16	15	1	16	10
Yak	.35	16	10	1	16	15
Blackbuck	.5	8	15	1	16	10
Musk Ox	.35	8	15	7	32	15
Goat	.35	8	10	1	16	15
Ibex	.35	8	10	1	16	15
Sheep	.35	8	15	1	16	10
Mouflon	.35	8	15	1	16	15
Barbary Sheep	.35	8	15	1	16	10
PERISSODACTYLS						
Domestic Horse	.35	16	10	1	32	15
Wild Horse	.35	16	10	1	16	15
Zebra	.35	16	10	1	16	15
White Rhinoceros	.35	16	10	1	16	15
Tapir	.5	16	10	1	32	10
RODENTS						
Hamster	.5	16	10	1	16	15
Lemming	.5	16	10	1	16	15
Gerbil	.35	16	10	7	32	10
Spiny Mice	.35	16	15			
Viscacha	.5	16	15	1	16	15
Chinchilla	.5	10	15	1	16	15
Capybara	.5	16	20	1	32	20
Coypu	.5	16	10	1	32	10
Guineapig	.5	16	15	1	16	20
OTHERS						
Common Seal	.5	16	15	1	16	20
Elephants	.5	16	15	1	16	15
Sealion	.707	16	10	1	32	15
Rabbit	.5	16	20	1	32	20
Kangaroos	.5	16	15	1	32	15
Wallabies	.5	16	15	1	32	15
Dolphins	.707	16	10	1	32	15

B = Attenuation
D = Aperture
T = Threshold

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