Indian J. Vet. Med. Vol. 40, No. 2, 2020 pp. 1-8

Invited Review Article

Looking through blood cell abnormalities as a diagnostic tool for improved disease diagnosis in animals

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Haematology buttresses the clinical diagnostic medicine, as it helps in assessment and tracking of pathologic basis of infectious and non-infectious disease and their existence. Amongst all the non-infectious causes, metabolic disorders greatly influence the variation in blood cell morphology. Haematology seldom provides any etiologic diagnosis; however, they help in monitoring possible response of disease to therapy and close watch on supervening infection in animals, besides also helping in formulation of possible prognosis regarding the future course and outcome of treatment or the outcome of the disease (Ronald *et al*., 2014). Haematology favourably helps in diagnosing morphologic variations with in hematologic system and very occasionally renders complete disease diagnosis on the basis of hemogram. This review focuses on to provide a brief overview of sample (blood) collection, specific features of blood cells and major abnormalities noticed in various circulating blood cells which invariably assists in identifying and making possible innuendo of clinical symptoms/disease conditions to their associated organ's /systems involvement, in addition to the damage inflicted by various common and uncommon aetiologies. This approach has been proved highly indispensable for timely implementation of optimal therapeutic steps for rapid remission /resolution of disease condition in animals.

Sample collection, handling and their appropriate storage

The most preferred sites for collection of blood from large animals is external jugular vein and less commonly (withdrawn from) coccygeal blood vessels. In small animals (like dogs and cats), cephalic vein is favoured and seldom saphenous vein. It is advisable to keep animal fasting overnight to avoid post prandial lipemia, which normally interferes in haemoglobin, plasma protein and fibrinogen estimations (Harvey, 2001). To avoid stress related variations in blood parameters, it is suggested that animal should be kept calm before collection of blood. During collection, blood should be taken directly into vacutainer tube, which invariably reduces platelet clumping and clot formation, thus avoiding misinterpretation. Even a small degree of clot can render the sample unsuitable for appropriate hematologic interpretation. Between ethylene-diaminetetraacetic acid (EDTA) and heparin (the commonly used anticoagulant), it is EDTA which is used preferably for blood collection in mammals. The advantage using EDTA is, it imparts appropriate colouration to leucocytes and cause low clumping of platelets, unlike heparin. Heparin is exclusively used for birds and reptilian blood samples, as EDTA results in haemolysis of their samples (Meyer and Harvey, 1998). An immediate gentle mixing is approved for avoiding small clot formation. The desirable concentration of EDTA salts varies from 1.2 mg-1.5 mg per ml of blood, depending upon the associated salt present in it. Potassium salts is preferred over sodium salts as sodium salts are less miscible in blood (Benjamin, 1997). An inappropriate amount of anticoagulant and mixing can further spoil the entire effort of collection, thus may contribute to incorrect interpretation. The samples should immediately be dispatched to laboratory and investigation should immediately be carried out on receipt of samples. Blood smear(s) preferably made on the spot should rapidly be dried to minimize the morphologic changes. In the event of expected delay in pursuing processing, the samples should immediately be stored at 4^{o}C for an overnight period. Measures should be taken for platelets, as they may undergo disintegration in prolonged storage even at 4^{o}C, so therefore an aliquot of sample should immediately be tested for platelet counts within 4 -5 hrs of collection (Ronald *et al.*, 2014).

Red blood cell morphology, their variations and the interpretations

Morphologically, animal's erythrocytes (red blood cells) are a non-nucleated and are in the shape of biconcave disc which accounts for central pallor of erythrocytes as observed in blood films (Jain, 1993).

This biconcavity is highly pronounced in dogs which normally possess large size dimension of erythrocytes. This features allows their red blood cells to assume any given shape and deformation, while in circulation besides large oxygen carrying capacity owing to larger surface area to volume ratio. A great variation within species of domestic animals exists that helps in their identification during forensic evaluation and also in the laboratory for confirmation. Erythrocytes from goat generally have a flat surface with little central depression; similarly red blood cells of camelid family are thin, elliptical in shape and not biconcave in shape. Unlike mammalian erythrocyte, red blood cells of birds, reptiles and amphibians are nucleated and elliptical in shape. In general, the red blood cells of equine species perform a typical settlement arrangement called *Rouleaux* formation due to the presence of protein called *Rouleaux* promoting factor present in their plasma. This settlement is unique as erythrocyte tends to adhere upon each other like as stack of coins. Unlike equine, (with exception to cat and pigs) the presence of *rouleaux* formation in other species is always associated with inflammatory conditions. They can also be noted during lympho-proliferative disorders, as result of abnormal secretions of one or few immunoglobulins (Jain 1993). Similarly, under certain circumstances, with little difference, red blood cells also get aligned in special cluster arrangements, known as *agglutination* which occurs when immunoglobulin bind on to erythrocyte surface (Meyer and Harvey, 1998). A rare but human handling error also adds up to agglutination of horse blood when collected in inappropriate concentration of heparin (Moore *et al.,* 1987; Monreal *et al.,* 1995).

In suspected cases of anaemia or haemorrhages, red blood cell analysis is helpful. *Absolute anaemia* is characterized by decrease in red blood cell numbers, haemoglobin concentrations and packed cell volume. Anaemia in animal is broadly categorized into *regenerative* and *non- regenerative* responses. Intriguingly, this classification can well recognized by looking at cell size and their colourations. In case of regenerative anaemia, the bone marrow respond to a demand for red blood cells by circulating immature cells known as polychromatophils and present in low numbers during normal state in adult animals (Jain, 1993). Polychromatophil cells are very high in young animals and characteristically acquire bluish to reddish blue cytoplasm and typically assume large size than mature red blood cells. Due to their pliable nature, they are very much prone to infolding and out-folding's and appear as *target cells*. In addition to this, the polychromatophils also possess netlike structure which are known as *reticulocytes*, and inherited its nomenclature owing to the presence of reticular ribosomal structures and mitochondria. Other observable cell types/ features noted in regenerative anaemia include nucleated red blood cells, basophilic stippling, Howell-jolly bodies and anisocytosis. Evidence of nucleated red blood cells without polychromasia indicates likelihood of damage in bone marrow (primary or metastatic neoplasia) and also as a case of lead poisoning. Erythrocytes with basophilic stippling contains variable sized blue dots in cytoplasm of red blood cells are basically confirmed as retained RNA, is commonly observed in regenerative response in ruminants and in case of lead poisoning as a result of degradation of RNA (Bessis, 1973). A *Howell-jolly* body, a remnant of nuclear material is seen in red blood cells and arises as a failure of macrophage function is of great concern, especially of splenic macrophage functions, are quite often seen in splenectomised animals (Jain, 1993). During diseased condition, the circulating red blood cells are in constant threat to certain oxidative and degenerative changes which results in cytoplasmic protuberance, that are often retractile and are known as *Heinz bodies*. Formation of *Heinz bodies* have also been affiliated to drug induced oxidative injury. *Heinz bodies* are normally seen in cats. Another cell type, which occurs due to oxidative damages, is *eccentrocyte* where a crescent shaped clear spaced areas are seen at one end of the red blood cells.

Metabolic disorders are also implicated in morphological alteration of red blood cells and one of the common variations is formation of *burr cells*. They are elongated red blood cells with multiple projections called spicules placed at an evenly position. Their presence indicates possible damages to renal system/ renal diseases (Weiss *et al*., 1990). Another membrane affiliated disorder is *acanthocytes*. They are spiculated cells like burr cell, albeit, they are differentiated on the basis of their multiple spurs placed at an irregular position with irregularly blunt to finger like projections. Formation of such alteration is an outcome to the disturbances in the ratio of cholesterol and phospholipids contents of cell membranes (Rebar *et al.,* 1981; Christopher and Lee, 1994). Their presence has been grossly related to liver diseases in large and small animals and also linked as consequence to disseminated intravascular coagulation and glomerulonephritis (Weiss *et al.,* 1993). Apart from

these membranous alterations, changes associated with central zone of pallor implicate red blood cells for poor functional performances. The most common changes are stomatocytes and spherocytes. *Stomatocytes* are cup shaped erythrocytes which has largely been related to inherited metabolic defect. Their presences were also seen following treatment with amphipathic drug, where irregular drug distribution within inner half of lipid bilayer normally results in metabolic defects (Smith et al., 1982). *Spherocytes* on the other hand are initiated after loss of cell membrane and central pallor, which means they lack the biconcavity features and become incompetent to carry requisite amount of oxygen as required by the body. Such cells are frequently noticed in association with *immune mediated hemolytic anaemia* and *snake envenomation* (Marks et al., 1990; Walton et al., 1997). Owing to micro-vascular abnormalities, certain morphological variations are also seen in red blood cells. They are schictocytes (schizocytes) and dacrocytes. *Schictocytes* are formed due to mechanical damage of red blood cells by the fibrin strands present with in micro vascular structure. Similarly *dacrocytes* also originate as a result of fragmentation of red blood cells and myelofibrosis (Jain, 1993).

Non regenerative anaemia in animals is best detected with following changes like normocytic normochromic red blood cells, macrocytic normochromic or microcytic and hypochromic cells (Kraft and Durr, 2005). Normocytic normochromic cells are frequently associated with chronic inflammatory conditions and also observed in connection with erythropoietin deficiency (renal diseases) and endocrine disorder. Macrocytic normochromic cells are associated with vitamin B_{12}, folic acid and cobalt deficiency (Grunder, 2006), whereas microcytic and hypochromic cells are commonly observed after iron deficiency which arises mostly during chronic bleeding or haemorrhages and especially in pigs viz Piglet anaemia due to low iron in sow milk. Formation of microcytes is also due to copper deficiency associated with less absorption from gut. Also, is linked to macrocytic anaemia and neutropenia, mimicking myelodysplastic syndrome.

Infectious agents of erythrocytes and their interpretations

Domestic animals are very prone to suffer from both haemoprotozoan and hemobacterial diseases. These infectious agents tend to resides in erythrocytes as intracellular pathogen and maintain their life cycle affecting the longevity and structural integrity of red blood cells. They cause mild to severe hemolysis, depending upon the pathogenicity of the organism and susceptibility of host. At several occasions, the presence of such infectious agent inside the red blood cells baffles novice haematologist and results in erroneous interpretation. The most common baffling situation is presence of *Anaplasma* organisms which looks very similar to Howell-jolly bodies (Wanduragala and Ristic, 1993). Although Howell-jolly bodies are seen at the periphery of cells, however their distributions are random and always singular unlike *Anaplasma* organisms which commonly exist as multiple in numbers. Similarly, certain epicellular parasites are difficult to distinguish from stain artifact and found individually or in groups on the edge of red blood cells, which require special staining to differentiate. Both *Haemobartonella* species and *Eperythrozoon* species, the most troubling parasites/organism in detection through general staining process (i.e. Leishman stain) are roughly diagnosed on the basis of their pattern of distribution with in circulating blood. It is believed that *Haemobartonella* firmly attaches it to red blood cells while *Eperythrozoon* occurs as free moving organism in plasma as well as delicate basophilic ring like structure upon or between erythrocytes (Reagan *et al*., 1990). This particular way of differentiation has raised objections especially during the situation when blood smear(s) are prepared in haste with forceful tractions resulting in free form of *Haemobartonella* organism. Furthermore, their distinction might prove unrealistic when they are poorly differentiated from precipitated stain or fixation artifacts. Confusion are also developed when overlying activated platelets resides upon red blood cells as *Babesia* organism, thus careful observation are needed in the beginning to distinguish artifacts from parasites/bacterial organism and to acquire professional prowess over it. Both *Haemobartonella* and *Eperythrozoon* organism are now reclassified as hemobacterial organism under genus *Mycoplasma* (Rikihisa *et al.,* 1997). Other than parasites/bacterial organism, viral inclusions are also seen within red blood cells. They are generally distinguished from artifacts by presence of their smooth glassy appearance. Diff–Quik stain is often considered as preferred stain for identifying viral inclusions (more commonly canine distemper). In contrast to the above situation, some of the haemo-parasites and bacterial organisms are easily identified by their unique appearances. *Babesia* organisms for example are easily differentiated by the presence

of their typical pyriform shaped structure; similarly *Cytauxzoon* organisms are easily identified on the basis of their typical "signet ring" or "safety pin" appearance (Glenn and Stair, 1984).

White blood cell morphology, their variations and the interpretations

White blood cells are mainly responsible for extending immunity against infection and are synthesized in bone marrow, besides lymphoid tissue where lymphocytes are exclusively produced at a regulated fashion. Different sub types of white blood cells are present and they are neutrophils, eosinophils, basophils, lymphocytes and monocytes. Amongst all, it is neutrophils which predominantly travel in general circulation to keep surveillance against infection and their numbers vary with the change in flow of blood meaning increase in numbers towards endothelial surface occurs during infection when flow of velocity recedes and becomes normal in reparative stage, when blood flow velocity increases (Web and Latimer, 2011). In an exception to this, ruminants carry lymphocytes as predominant white blood cells in the circulation. Briefly, neutrophils are identified on the basis of their nuclear lobulation pattern. Few distinct deviating features of neutrophils helps in identification of species like pinker cytoplasm appears in bovines as compared to other species. In horses, nuclear segments are not as distinct as noted in canines and bovines (Reagan *et al.,* 2009). Another class of neutrophils i.e. *band cells* is at times seen in normal animals and more commonly during acute infection are distinguished on the basis of their nuclear morphology i.e. band shaped nuclei, in which nuclear membranes maintains parallel dimension with constant width. A common change which normally noted in animals during inflammation is increased presence of band neutrophils commonly known as *left shift* and their presence signifies forceful expulsion of immature cells into circulation by superimposing infections/toxicities and the bone marrow becomes fatigued to hold them up for their optimal maturation which is prerequisite to their release in the circulation. Similar to band cells, their classification is also based upon hypo-segmentation of nuclei, another condition exists in dogs, cats and horses which is referred to as *Pelger Huet* anomaly, is characterized by hypo-segmentation due to a defect in the process of segmentation of nuclei of mature neutrophils that results in false left shift (Latimer *et al.,* 1987). They are generally differentiated from band cells by the presence of dense nuclear chromatin materials. In the event of toxicity, three (3) important features persists i.e. increased basophilia, foaminess and presence of *Dohle bodies* in the cytoplasm which determines the degree of toxic impact to the cells. *Dohle bodies* appeared as irregularly shaped small blue gray particles in the cytoplasm and are the outcome to disruption of lamellae of rough endoplasmic reticulum following toxicity that results in abnormal accumulation of ribosomal RNA leading to increased basophilia (Bessis, 1973). Interestingly, horses and cats bear these bodies quite commonly during inflammation and are normally not considered for a severe sign of toxicity. One of the common reasons for the toxic changes in neutrophils is *endotoxaemia*. Another important morphologic change that is seen in toxic cells is toxic granulation characterized by multiple small purple granules in the cytoplasm of cells. Unlike hypo-segmentation, hyper segmentation of nuclei is also reported and they occurs mainly due to vitamin B_{12} deficiency and also during stress, in which the underlying circulatory glucocorticoid levels interferes with endothelial margination and the cells remain in circulation for longer than normal (Reagan *et al.,* 2009). *Right shift*, the ratio of immature to mature *neutrophils* is considered with reduced count or lack of «young neutrophils" (metamyelocytes, and band neutrophils) in blood smear, associated with the presence of "giant neutrophils. However along while assessing the conditions, the status of Absolute and Relative Neutrophilia be considered in association with Total Leukocyte count; where *Absolute neutrophil count* (ANC) is a measure of the number of *neutrophil* granulocytes present in the blood i.e. the real number of WBCs (that are neutrophils) present in blood and *Relative Neutrophilia* where number of neutrophils exceed the normal range within limits.

Lymphocytes, the second most white blood cells of circulation appears round in contour and slightly smaller than neutrophils bears round to oval nuclei with slight indentation. A small amount of light blue cytoplasm is generally present in them. Some animals possess medium to large sized lymphocytes and are mostly seen in ruminants. During antigenic stimulation, the lymphocytes in circulation assume nuclear and cytoplasmic abnormalities which includes increased amount of cytoplasm with prominent peri-nuclear zone, along with multiple nuclear indentations. Increase in the number of such cells is generally indicative of lymphoproliferative disorders (Peterson and Couto, 1994). Apart from this, the presence of

immature lymphocytes with one or more nucleoli in high numbers also suggests for lymphoproliferative disorders. In case of lymphoproliferative disorders, the lymphoid and myeloid cell undergoes abnormal clonal proliferation. When their proliferation occurs in bone marrow, these cells find their way into general circulation and become leukaemia. Finding an abnormality in the peripheral blood is often the first indication for leukaemia (Hodgkins *et al.,* 1980). Lymphocytic leukemia are more frequently observed in dogs and cats as compared to horses and cattle. Two types of lymphocytic leukemia are observed in animals i.e. acute and chronic. Out of these two, the acute leukemia is poorly differentiating and comprises of lymphoblast, while in chronic leukemia; small to medium sized lymphocytes are present in very high numbers. Lymphosarcoma, a lymphoproliferative disorder, in which neoplastic proliferation starts initially in primary sites i.e. lymph nodes and tissue other than bone marrow can also affect bone marrow to exhibit leukemic phase of lymphosarcoma. Due to greater incidence of lymphosarcoma, immature lymphoblast in circulation would not be uncommon to see. A rare lymphoproliferative disorders observed in canine is large granular lymphocytic leukaemia, in which the cells carries large sized purple cytoplasmic granules also referred to as *mononuclear cell leukaemia*. In addition to this, proliferation of plasma cells in bone marrow and their widespread circulatory presence mainly suggest plasma cell myeloma and such proliferations are not normally seen in inflammatory diseases.

Another neoplastic disorder which arises from bone marrow is myeloproliferative disorders. *Myeloproliferative disorders* involve cells of granulocytic, monocytic, erythrocytic and megakaryocytic lineages (Latimer, 1995). They are broadly categorized into *myelodysplastic syndrome, acute myeloid leukaemia* and *chronic myeloid leukemia*. Myelodysplasia is almost a pre-leukemic stage, in which there exists a high possibility of cellular transformation into cancerous form. Animals with myelodysplastic syndrome carry abnormalities in maturation of one or more myeloid lineage cell types. Sometime in case of myelodysplasia, low numbers of immature blast cells are seen in general circulation. Myelodysplasia of cells of erythropoeitic cell lineage is known as *dyserythropeisis*. There are few important features of cells which classify them as dyserythropoietic cells like megaloblastic cells with immature nuclear appearance with uncondensed nuclear chromatin. Evidences of bluish granular materials in cytoplasm as an excess of iron materials and macrocytosis are the other two, which helps in diagnosing this condition. Myelodysplasia of granulocytic cells is known as *dysgranulopoiesis*. The diagnosis of this condition is quite challenging and majority of its feature carries resemblance to overlapping features of toxic neutrophils. One interesting change that essentially helps in their diagnosis is presence of abnormal granule shapes or decreased numbers of granules. Acute myeloblastic leukaemia also known as acute granulocytic leukaemia typically possesses high numbers of myeloblast (promyelocytes) and their differentiation from lymphoproliferative disorders becomes extremely difficult and in those cases they requires special enzyme cyto-chemical staining or immuno-phenotyping for their accurate classification. Similarly acute monocytic leukaemia is recognized by high numbers of monocytic precursors; however they are very difficult to be distinguished from acute myeloblastic leukaemia and acute lymphocytic leukaemia. Identifying some rare leukemic disorders like erythroleukemia are further challenging, as they bear leukemic cells of both red and white cell lineages (Weiser, 1995). They are difficult to be differentiated from non- neoplastic process i.e. leukoerythroblastic response, which typically includes mature erythrocytic and leucocytic precursors unlike to erythroleukemia where disproportionate numbers of early erythrocytic and leucocytic precursors prevails, without significant numbers of polychromatophils. Most of these cells are usually metarubricytes and rubricytes with occasional numbers of rubriblasts/prorubricytes. Neoplastic conditions of well differentiated cell series are also very high and they get easily diagnosed by their wide presence in the circulation without inflammatory changes. Although, not a true leukaemia, at times high numbers of mast cells are also present in circulation without any association to inflammatory diseases and in those cases it is assumed as neoplastic condition and is termed as *mastocytemia*.

Infectious agents of white blood cells and their interpretations

Unlike to the case of red blood cell, the white blood cells clearly display the presence of infectious agent. Due to contrasting background of their cytoplasm which is usually lighter in shade, the infectious agents are easily spotted, as they possess distinctive dark outline/contour of their morphology. Several classes

of pathogen(s) attempt to reside in these cells to evade host's immunological attack and thereby maintain their reproductive and somatic stages of life cycle (Harvey, 2001). The most frequent infectious agents noticed in white blood cells are protozoan parasites. Morulae of *Ehrlichia* species is a good example. They are mainly seen in acute stage of infection. They are easily diagnosed on the basis of tightly packed basophilic clusters of organism within the cytoplasm of monocytes and neutrophils. Similarly during *Hepatozoon* infection, the organism appeared as large oblong refractile structures within the cytoplasm of circulating neutrophils. The nucleus of gamonts usually stains poorly with routine blood stain and the organism frequently gets entangled with nucleus of neutrophils. Viral inclusions are observed in the cytoplasm of neutrophils as red inclusion when stained with Diff-Quik stain but are very difficult to be visualized in Wright or Giemsa stained blood films. Bacteria are seldom numerous enough to be seen in blood films, and blood stain easily gets contaminated with bacteria, so therefore it is important to observe phagocytosed bacteria within cells prior to diagnosis of bacteraemia is made. *Mycobacterium* organisms appear as unstained rods within the cytoplasm and sometimes *Histoplasma* organism in neutrophils.

Platelet morphology, their variations and the interpretations

Platelets are anuclear cytoplasmic fragments of megakaryocytes. They mostly appear as light blue with many small reddish purple granules when visualized using routine blood stains. Their size varies with species, and cat's platelet appears larger than any other domestic animals (Boudreaux and Ebbe, 1998). Their platelets further get activated during blood sample collection and handling and results in degranulation. The total numbers of platelets is influenced by the amount of production, consumption, sequestration and loss (Russell, 2010). Increased platelet count is indicated during severe haemorrhages or increased bleeding tendency, which includes epistaxis, hematuria, hematemesis and hyphema in addition to echymosis and petechiae. Thromocytosis during physiological stress is due to epinephrine induced spleenic contraction. Increased thrombopoeisis is seen with inherited megakaryocytes disorders (Stokol, 2010). Platelets with large diameter are called as *macroplatelets* are rarely seen in normal animals, except in cats, while their presence in thrombocytopenic animals suggests myelodysplastic or myeloproliferative disorders (Harvey, 1981). They can also be seen in non-thrombocytopenic animals that have recently recovered from thrombocytopenia. An activated platelet may have thin cytoplasmic projections from spherical cell body and their cytoplasmic granules may get crushed by their own cytoplasmic microtubules or microfilaments. Due to this, their cytoplasmic disintegrated granules generally take a central positioning similar to nucleus and are mistakenly considered as nucleus. Their numbers get increased during inflammation, neoplasia, iron deficiency or in chronic blood loss. Hypogranularity may also arise in case of platelet activation, and also can be seen in myeloproliferative disorders (Cain *et al*., 1986). Decreased cell (platelet) count is observed during excessive blood loss, thrombocytopenic purpura due to their consumption, while decreased synthesis leading to low cell count is seen in myelopthisic or hypo plastic changes due to toxins and destruction due to neoplasia, infection or drugs.

Infectious agents of platelets and their interpretations

Platelets are generally less affected with intracellular organism or parasites, however *Ehrlichia platys* typically affect platelets of dogs and their morula appear as tightly packed basophilic clusters within cytoplasm of cell and is mostly seen in dogs (Harvey, 1998). Other than parasitic infections, some bacterial and viral infections are also affecting the platelets number and they are salmonellosis, Bovine viral diarrhoea virus infection (Rebhun *et al.,* 1989).

Miscellaneous cells and parasites of blood

Apart from all the above discussed cells and their abnormalities, some naturally occurring cells also contribute in shedding information on physiological and pathological status of body. For example, megakaryocytes, which are multilobulated, platelet producing giant cells, are mostly seen during examination of blood buffy coat smears and their increased numbers are seen in cases of high and continued platelet production (Roszel *et al.,* 1965). On the other hand, dwarf megakaryocytes are smaller than the normal one and have decreased nuclear ploidy with pronounced cytoplasmic granules. They are commonly noticed in myeloproliferative disorders of bone marrow smears and not commonly in blood smears.

There are parasites or other infectious agent which are not directly associated with blood cells. For example microfilarial organism like *Dirofilaria* and *Dipetalonema* species in dogs, *Setaria* species in cattle and horses, *Trypanosoma* species in cattle and dog (Urquhart *et al.,* 1996). Unlike these parasites, some of the bacterial organisms are indirectly associated with red blood cells and they do not utilize them for their cyclic progression. A species of *Borrelia* i.e. *Borrelia burgdorferi* has been observed in red blood cells of dogs (Breitschwerdt *et al*., 1994).

Conclusion

It was concluded that in haematology, blood cell examination carries significant diagnostic importance, as by looking simply at the morphologic structure or their affiliated changes, an experienced pathologist can ascertain some diseased conditions or can relate them to an underlying cause, which is/are clinically oblivion to a clinician. This review endeavours to bring in brief methods of sample collection and their storage, in addition to exclusive details on various red blood cell morphology, their distortions/deviations from normal with distinctive findings from all domestic animals. This will not only improve the diagnostic ability, but shall also enhance cognitive power to undertake decision on the prospects of treatment already followed or to be followed in future. Attempts to demarcate clearly certain artefactual content from more challenging parasitic infections have also been discussed, so that novice haematologist should find them easy while beginning their shot.

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