UNIVERSITI PUTRA MALAYSIA

A RETROSPECTIVE STUDY ON ANAEMIA IN CATS PRESENTED TO THE UNIVERSITY VETERINARY HOSPITAL, UNIVERSITI PUTRA MALAYSIA FROM THE YEAR 2015

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RAQUEL YONG LI HUI

A project paper submitted to the

Faculty of Veterinary Medicine, Universiti Putra Malaysia

In partial fulfillment of the requirement for the

DEGREE OF DOCTOR OF VETERINARY MEDICINE

Universiti Putra Malaysia,

Serdang, Selangor Darul Ehsan.

MARCH 2016

CERTIFICATION

It is hereby certified that we have read this project paper entitled "A Retrospective Study On Anaemia In Cats Presented To The University Veterinary Hospital, Universiti Putra Malaysia From The Year 2015" by Raquel Yong Li Hui and in our opinion it is satisfactory in terms of scope, quality, and presentation as partial fulfillment of the requirement for the course VPD 4999- Project

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DEDICATIONS

This project is dedicated to the One Almighty God, who created me and made all things possible,

To my family,

Father

Mother

Sisters: Lydia, Fiona and Elaine

& Snowy

And to all my lecturers who have committed themselves towards the noble cause of education

ACKNOWLEDGEMENTS

There are a number of people without whom this thesis might not have been written, and to whom I am greatly indebted.

First and foremost, I would like to thank my Abba Father for being gracious in providing everything and to enable me to study in the field of my interest. I am indeed very blessed to be able to finish this thesis.

My utmost gratitude to my dearest supervisor, Professor Dr. Rasedee Abdullah for his guidance, support, understanding and encouragement throughout this project. Without his persistent help, this thesis writing would not have been possible.

I would also like to acknowledge my co-supervisor, Associate Professor Dr. Gurmeet Kaur Dhaliwal. Despite her tight schedule, she was so willing to share her knowledge and expertise of her field on this project.

Furthermore, special thanks goes to the staff in clinical pathology laboratory, staff of University Veterinary Hospital, UPM who assisted me in collecting the information and data that I needed throughout this project.

To my parents, who have been a source of encouragement and inspiration to me all these years. Thank you so much for supporting me in my determination to find and realize my potential since young; and now in supporting me to pursue my dream to be a veterinarian. Not to forget my dearest sisters, Lydia, Fiona and Elaine for their unconditional love and for being my listener in times of difficulty.

Not to forget my friends, Joanne, Sheryl, Wei Kiat, Heshini, Stephanie, Pei Ni and Kimmy for their encouragement and utmost support. Thank you.

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ABSTRAK

KAJIAN RETROSPEKTIF TERHADAP ANEMIA PADA KUCING YANG DIBAWA KEPADA HOSPITAL VETERINARY UNIVERSITI, UNIVERSITI PUTRA MALAYSIA PADA TAHUN 2015

Jangka hayat eritrosit kucing yang lebih kurang 73 hari adalah lebih singkat berbanding pada anjing yang lebih kurang 120 hari. Justeru, kucing lebih cenderung untuk mengembang anemia berbanding anjing. Malah, anemia adalah keadaan yang paling kerap berlaku pada kucing yang dirujuk kepada Hospital Veterinar University (UVH), Universiti Putra Malaysia (UPM). Kajian pencirian jenis anemia pada kucing yang dirujuk kepada UVH ini belum pernah dilakukan. Justeru, objektif kajian ini adalah untuk menentukan pengelasan dan aetiologi kes anemia felin di UVH, berdasarkan gerak balas sumsum tulang. Rekod klinikal retrospektif untuk tahun 2015 diperolehi dan dianalisis. Terdapat 162 ekor kucing beranemia, berumur di antara 7 bulan hingga 2 tahun, yang daripadanya 90 (55.56 %) adalah bukan jana semula sambil 72 (44.44 %) jana semula. Di kalang kucing ini, 65 (40.12 %) merupa kucing peliharaan dalam rumah, 59 (36.42 %) adalah separa bebas, dan 38 (23.46 %) di luar rumah. Tiga belas (52 %) ekor kucing yang pemvaksinan dan penyahcacingan terkini, mengidap anemia bukan jana semula, sambil 12 (48 %) mengidap anemia jana semula. Di kalang 52 ekor kucing yang diserang ektoparasit, 10 (19 %) mengidap anaemia bukan jana semula dan 42 (81 %) mengidap anemia jana semula. Di kalang kucing yang diserang pinjal pula, 39 (69.2 %) ekor dijangkiti mikoplasma hemotropik. Petanda klinikal paling kerap pada kucing anemia ialah penyahhidratan, pucat,

abdomen kembung, dan jaundis. Penyebab paling kerap untuk anemia pada kucing ialah penyakit berjangkit, kecederaan trauma, dan gangguan metabolisme. Tiga puluh ekor kucing, berumur 3 hingga 6 tahun, yang mengidap anemia diuji untuk jangkitan virus leukemia felin (FeLV) dan virus immunokurangan felin (FIV). Lapan belas (60 %) yang positif untuk FeLV atau FIV atau kedua-duannya sekali mengidap anemia bukan jana semula sambil 6 (20 %) mengidap anemia jana semula. Tidak terdapat sebarang perkaitan ($p>0.05$) antara jantina, pemvaksinan, penyahcacingan, umur, atau pengurusan dengan status janaan semula anemia. Bagaimanapun, ada perkaitan positif tererti ($p<0.05$) antara serangan pinjal, jangkitan FeLV dan FIV dengan anemia jana semula pada kucing.

Katakunci: anemia, jana semula, bukan jana semula, kucing, aetiologi, Hospital Veterinar Universiti, Universiti Putra Malaysia.

ABSTRACT

An abstract of the paper presented to the Faculty of Veterinary Medicine in partial fulfilment of the course VPD 4999 Project.

A RETROSPECTIVE STUDY ON ANAEMIA IN CATS PRESENTED TO THE UNIVERSITY VETERINARY HOSPITAL, UNIVERSITI PUTRA MALAYSIA FROM THE YEAR 2015.

By

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160588

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The life-span of cat erythrocytes at approximately 73 days is shorter than that of the dog at approximately 120 days. Thus, cats are more prone to develop anaemia than dogs. In fact, anaemia is one the most common condition among cats referred to the University Veterinary Hospital (UVH), Universiti Putra Malaysia (UPM). No study has been done to characterise the type of anaemia in cats referred to UVH. Thus, the objective of this this study is to determine the classification and aetiologies of feline anaemia cases in UVH, with respect to bone marrow response. Retrospective clinical records from year 2015 were obtained and analysed. There were 162 anaemic cats, of various ages, of which 55.56% (n=90) and 44.44% (n=72) had non-regenerative and regenerative anaemia respectively. Among these cats, 65 (40.12%) were kept indoors, 59 (36.42%) were semi-roamers, and 38 (23.46%) were outdoor cats. Of vaccinated and dewormed cats, 13 (52%) cats had non-regenerative anaemia while 12 (48%) had

regenerative anaemia. Among 52 cats infested with fleas, 69.2% were diagnosed with hemotropic mycoplasma. Of the 52 cats, 81 % and 19 % had regenerative anaemia and non-regenerative anaemia respectively. The most common clinical signs observed in anaemic cats were dehydration, pallor, distended abdomen, and jaundice. The most common cause of anaemia in cats were infectious diseases, traumatic injury, and metabolic disorders. Sixty percent (n=18) of cats positive for either FeLV or FIV or both had non-regenerative anaemia while 40% (n=12) had regenerative anaemia. There was no significant ($p>0.05$) association between gender, vaccination, deworming, age, or management and the regenerative status of anaemia. However, there was a significant ($p<0.05$) positive association between flea infestation, FeLV and FIV infections and the regenerative status of anaemia in cats.

Keywords: anaemia, non-regenerative, regenerative, cats, aetiology, University Veterinary Hospital, Universiti Putra Malaysia

1.0 INTRODUCTION

Anaemia is a reduction below normal in the total erythrocyte (RBC) count, packed cell volume (PCV), or hemoglobin (Hb) concentration and a consequent decrease in oxygen-carrying capacity and delivery to tissue (White and Reine, 2009). The condition can develop from loss, destruction, or lack of production of erythrocytes. In anaemia, the first step in defining the pathophysiology of the problem that involves assessment of bone marrow regeneration by determine blood reticulocyte count. Erythrocyte indices, which includes the mean corpuscular volume (MCV), mean corpuscular Hb concentration (MCHC), and erythrocyte morphology are determine to ascertain the cause of anaemia. (Day and Kohn, 2012).

There are two types of anaemia that is regenerative and non-regenerative anaemia. Regenerative anaemia is characterized by reticulocytosis and is typically occurs due to loss (hemorrhage) or destruction (hemolysis) of erythrocytes in the circulation. On the other hand, anaemia without reticulocytosis is referred to as non-regenerative anaemia and typically occurs in diminished erythropoiesis, impaired bone marrow erythrocyte production from whatever cause (Tvedten, 2010). Haemolytic anaemia is frequently associated with oxidative damage to erythrocytes, infectious agents such as *Mycoplasma haemofelis*, neoplasia, and primary immune-mediated syndromes. Non-regenerative anaemia is associated with a number of infectious agents, including feline leukemia virus (FeLV), Felin immunodeficiency virus (FIV), and coronaviruses associated with feline infectious peritonitis (FIP), as well as a variety of non-infectious diseases including neoplasia, renal disease, endocrinopathies such as diabetes mellitus, and bone marrow diseases (Kohn *et al.,*2006).

Most causes of anaemia in cats can be diagnosed by history and physical examination of the patient, complete blood cell count, serum biochemical analyses, coagulation tests, diagnostic imaging and biopsy for neoplasia or other mass lesions such as abscessation, FeLV antigen test, FIV antibody test, polymerase chain reaction (PCR), and bone marrow examination.

Although it has been suggested that in cats, the majority of anaemias are non-regenerative (Tasker, 2006), the classification and aetiologies of anaemia are not well-described. Thus, this study is aimed to determine the classification and aetiologies of feline anaemia in terms of regeneration status. The study also describes the patient's history, signalment and physical examination findings of anaemic cats presented to the UVH, UPM. The information gain in this study will enable clinicians to understand the common causes of anaemia and the typical laboratory findings of cats with anaemia to assist them in the treatment of feline diseases.

2.0 LITERATURE REVIEW

2.1 Erythrocyte Physiology

Understanding the erythrocyte physiology is essential to the approach to treating anaemic patients. Depending on the life-span in a particular species, approximately 1% of circulating erythrocytes are produced and replaced daily. The process of erythropoiesis dependent on the hormone erythropoietin produced primarily by the kidneys (Donnelly, 2001). Erythropoietin synthesis and production is stimulated by renal hypoxia that occurs within minutes to hours. Erythropoietin production will reach maximum within 24 hours after the onset of hypoxia (Car, 2000). Erythropoietin acts on primarily on the bone marrow to stimulate the proliferation and maturation of erythroid progenitor cells (Feldman, 1993). Besides promoting erythropoiesis, erythropoietin also facilitates hemoglobin production and stimulates release of erythrocytes and reticulocytes into the circulation. Erythrocytes production time upon erythropoietin stimulation average 4 days. Some factors such as p15E component of the feline leukemia virus (FeLV) inhibit erythropoiesis thus resulting in non-regenerative anaemia (Day and Kohn, 2012).

In healthy adult cats, erythropoiesis occurs in the bone marrow of the axial skeleton (White and Reine, 2009). In cases of prolonged anaemia or bone marrow dysfunction, erythropoiesis can also occur in extramedullary sites such as the spleen, liver, and lymph nodes. However, the extramedullary may not be as effective as medullary erythropoiesis. In cases of severe anaemia, the bone marrow can increase its erythrocyte production by 6- to 8-fold in an effort to maintain a normal circulating erythrocyte count (Feldman, 1993).

2.2 Erythrocyte Morphology and Life Cycle

Feline erythrocytes are smaller, approximately 5 to 6 μm in diameter and lack the prominent central pallor seen in canine erythrocytes (Figure 1). The haemoglobin of cats is more susceptible to oxidant injury than in other species because the haemoglobin contains eight oxidisable sulfhydryl groups. For this reason, low numbers (<10%) of small Heinz bodies may be seen on erythrocytes of healthy cats (Hamilton and Edelstein, 1972). In addition, blood smears of cats may show a moderate rouleaux formation and Howell-Jolly bodies (Figure 2), and this appearance is normal (Rebar *et al*., 2001). Normally the feline erythrocyte will circulate for approximately 73 days (Ettinger and Feldman, 2009) before breaking down and recycled by the mononuclear phagocyte system of the liver, spleen and bone marrow (Weiser, 1994).

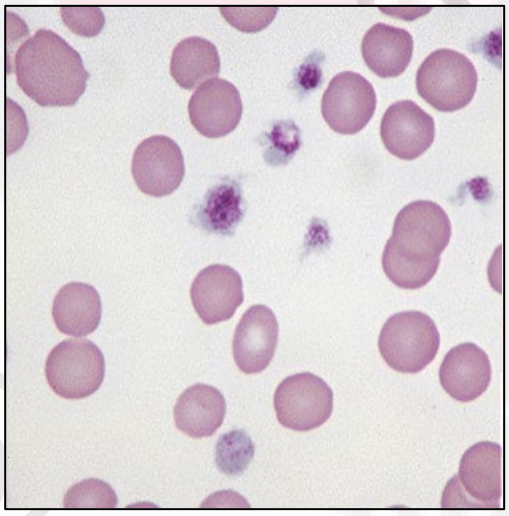

Figure 1: Normal erythrocytes of a cat showing absence of central pallor.
Source: *www.eclinepath.com*

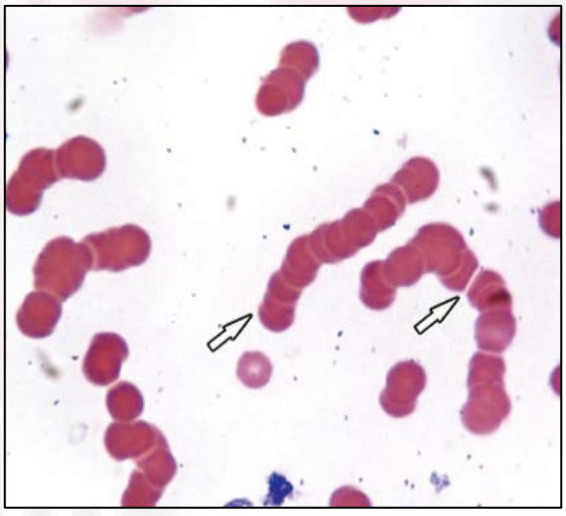

Figure 2: Photomicrograph of a cytologic preparation of blood from a healthy cat showing rouleaux (*arrows*).
Source: *Conpendiumvet.com*

2.3 Clinical Signs of Anaemia

Normally when a cat is anaemic, the clinical signs reflect reduced tissue oxygenation and the associated physiological adjustments. One of the clinical signs associated with an anaemic patient is the pale mucous membrane colour. Mucous membrane pallor provides a rough guide to the degree of anaemia; however, it can be can be deceptive in cats. Tachycardia and poor tolerance of stress reflect increase in sympathetic tone. Cardiac auscultation may reveal a soft systolic murmur due to increased blood turbulence and/or gallop sounds. Normally during severe anaemia, tachypnoea and dyspnoea would be seen due to oxygen deficiency during exercise or when stressed. The ability of the cat to tolerate severe anaemia (Knottenbelt and Mackin, 1998) is due the unique erythrocyte physiology and its adaptation in response to reduced tissue oxygenation.

The severity of clinical signs in anaemic cats is related more closely to the chronicity than to the degree of anaemia. Chronic anaemia such as severe haemolytic anaemia is better tolerated than acute anaemia (Knottenbelt and Mackin, 1998). Normally, because of their tolerance to anaemia, clinical signs may not become apparent in cats with chronic anaemia until the haematocrit is as low as 10 to 15 L/L (Ettinger and Feldman, 2009).

2.4 Regenerative Anaemia

Regenerative anaemia cannot be seen immediately following haemorrhage. Anaemia may seem to be non-regenerative during the early phases of blood loss, before a peripheral reticulocyte response take place. Immediately following hemorrhage, the

haematocrit may be normal, reflecting a loss of erythrocytes and plasma in equal proportions. However, a shift of water from the interstitial to the intravascular space ensues within 12 to 24 hours and this results in decrease in the haematocrit and the total protein level. At this point, the erythrocytes most likely appear normal in morphology, and anaemia is normocytic and normochromic. As hypoxia stimulates the release of erythropoietin, reticulocytes are formed and released from the bone marrow. At this point, anaemia becomes regenerative after 4 to 5 days following acute blood loss.

Regenerative anaemia also usually develops after intra- and extravascular haemolysis. Haemolytic anaemia is frequently associated with oxidative damage to erythrocytes, infectious agents, neoplasia, and primary immune-mediated syndromes (Kohn *et al*., 2006). Three species of hemotropic Mycoplasmas are known to infect cats worldwide; *Mycoplasma haemofelis, Candidatus Mycoplasma haemofelis* and *Candidatus Mycoplasma haemominutum*. According to Sykes, 2010, *M. haemofelis* is the most pathogenic species and causes haemolytic anaemia in immunocompetent cats.

2.5 Non-regenerative Anaemia

The inability of the bone marrow to respond appropriately to a peripheral deficiency in erythrocytes results in non-regenerative anaemia. There are many causes of non-regenerative anaemia, including primary diseases of the bone marrow and systemic diseases that have secondary effects on the bone marrow. The prognosis of non-regenerative anaemia is variable: some anaemia are reversible, whereas others may be chronic or fatal (White and Reine, 2009).

Non-regenerative anaemia is associated with a number of infectious agents, including feline leukemia virus (FeLV), feline immunodeficiency virus (FIV), and coronaviruses associated with feline infectious peritonitis (FIP), as well as a variety of non-infectious diseases including neoplasia, renal disease, endocrinopathies such as diabetes mellitus, and bone marrow diseases (Kohn *et al*., 2006).

3.0 MATERIALS AND METHODS

3.1 Data Collection

A retrospective study was performed on the records available at the Haematology and Clinical Biochemistry Laboratory, Faculty of Veterinary Medicine, Universiti Putra Malaysia (UPM). The records for January to December of 2015 examined for cases of feline anaemia. The hematology results were obtained and the erythrocyte parameters; erythrocyte count, haemoglobin concentration, packed cell volume (PCV), mean corpuscular haemoglobin concentration (MCHC), mean corpuscular volume (MCV), and reticulocyte count were recorded. Anaemic patients were identified and categorised as regenerative or non-regenerative anaemia based on the reticulocyte index (RI) that was calculated based on the following formula:

$$\text{Reticulocyte Index (\%)} = \frac{\text{Reticulocyte count}_{\text{patient}}\,(\%) \times \text{PCV}_{\text{patient}}(\text{L/L})}{0.35\ (\text{average PCV for cats})}$$

Case numbers of these anaemic cats were obtained from the haematology records at the Haematology and Clinical Biochemistry Laboratory, Faculty of

Veterinary Medicine, UPM. The medical records of the identified case were obtained from the UVH, UPM.

3.2 Data recording

Medical records obtained were signalment (age, breed, gender), common clinical signs (e.g., inappetence, weakness, vomiting, diarrhoea) and physical examination findings (e.g., presence of flea, pallor, jaundice, pyrexia, abdominal pain and traumatic injury). Haematological data at presentation were recorded and reticulocyte index (RI) were calculated to classify the anaemia as either regenerative of non-regenerative. Other test done to include for feline immunodeficiency virus (FIV), feline leukaemia virus (FeLV), Haemoplasma infection, final diagnosis, and aetiology of anaemia were also recorded.

3.3 Case classifications

The case records were reviewed to classify the anaemia according to aetiology, which is either bone marrow (BM) disorder, haemorrhage or haemolysis. If more than one aetiology is suspected, the most probable cause was recorded. Non-regenerative anaemia were further subdivided into primary BM disease or secondary suppression of BM activity because of neoplasia such as mammary gland tumour and lymphoma and renal insufficiency such as acute or chronic kidney disease, infectious-inflammatory or other causes of BM suppression.

The DAMNITV (Garosi, 2004) classification system based on the definitive diagnosis was used (Rizzo *et al.,* 2007). Each case was also classified separately

according to the degenerative, anomalous (hereditary coagulopathy), metabolic (chronic kidney disease, acute kidney injury, diabetes mellitus), neoplastic (lymphoma, mammary gland tumour, carcinoma), infectious (FIP, FeLV, FIV, haemoplasma infection), idiopathic, inflammatory, immune-mediated (IMHA), toxic, traumatic caused (road traffic accident, dog attack, high rise syndrome) or vascular disease (Congestive heart failure).

3.4 Statistical analysis

All data were tabulated in the Microsoft Excel spreadsheet and transferred to SPSS spreadsheet for further analyses such as frequency, medians and modes (where applicable). Additional tests for association were done by using the Chi-square (Pearson Chi-square test) on selected data. Statistical significance is recorded at $p<0.05$ and associated confidence intervals were calculated and recorded. All statistical analyses were conducted using the IBM SPSS (Statistical Program for Social Science) software version 21.0. Selected factors used in the determination of association were age, breed, sex, neuter status, vaccination and deworming status, FeLV and FIV and presence of ectoparasites.

4.0 RESULTS

4.1 Cases

Data retrieval identified 162 cats with anaemia in the year 2015.

4.2 Descriptive data

4.2.1 Descriptive data for haematological parameters

Descriptive data for haematological parameters were shown in Table 1. Out of 162 anaemic cats, 72 (44.44%) were regenerative while 90 (55.56%) cats were non-regenerative.

Table 1: Haematological parameters of feline anaemia cases (n=162)

Parameters (Units)	Mean (± Sd)	Reference Range
PCV (L/L)	0.19 (±0.03)	0.24-0.45
MCHC (g/L)	358.91 (± 39.39)	300-360
MCV (fL)	43.24 (±8.51)	39-55
Reticulocyte (/100 RBC)	6.2747 (± 9.27)	0.5-1.5

*Calculated Reticulocyte Production Index (RPI) classified 90/162 (55.56%) cats as non-regenerative, 72/162 (44.44%) cats as regenerative.
PCV = Packed cell volume
MCHC = Mean corpuscular haemoglobin concentration
MCV = Mean corpuscular volume
RBC = Erythrocyte

4.2.2 Descriptive data of patient signalment and history

This study comprises of 61 female cats and 101 male cats. Out of the 61 female cats, 37 (60.66%) cats had non-regenerative anaemia while 24 (39.34%) cats had regenerative anaemia. Whereas of the 101 male cats, 53 (52.48%) cats had non-regenerative anaemia while 48 (47.52%) cats had regenerative anaemia.

Table 2:Feline anaemia according to bone marrow response and gender (n=162).

			Gender (%)		Total (%)
			female	male	
Anaemia Type	NRA	Count	37.0	53.0	90.0
		Expected Count	33.9	56.1	90.0
	RA	Count	24.0	48.0	72.0
		Expected Count	27.1	44.9	72.0
Total		Count	61.0	101.0	162.0
		Expected Count	61.0	101.0	162.0

NRA = non-regenerative anaemia; RA = regenerative anaemia

Table 3: Feline anaemia according to bone marrow response and management (n=162)

			Management			Total
			Indoor	Outdoor	Semi-Roamer	
Anaemia Type	NRA	Count	37.0	18.0	35.0	90.0
		Expected Count	36.1	21.1	32.8	90.0
	RA	Count	28.0	20.0	24.0	72.0
		Expected Count	28.9	16.9	26.2	72.0
Total		Count	65.0	38.0	59.0	162.0
		Expected Count	65.0	38.0	59.0	162.0

NRA = non-regenerative anaemia; RA = regenerative anaemia

From table 3, of the total 162, 65 (40.12%) anaemic cats that were kept indoor, 59 (36.42%) semi-roamers, 38 (23.46%) kept outdoor. Among indoor cats, 37 (56.92%) cats had non-regenerative while 28 (44.08%) cats had regenerative anaemia. Among semi-roamers, 35 (59.32%) cats had non-regenerative and 24 (40.68%) cats regenerative anaemia. On the other hand, 20 (52.63%) outdoor cats suffered from regenerative and 18 (47.37%) cats non-regenerative anaemia.

Table 4:Feline anaemia according to vaccination and deworming status (n=162).

			Vaccination/Deworming		Total
			Not current	Current	
Anaemia Type	NRA	Count	78.0	12.0	90.0
		Expected Count	76.1	13.9	90.0
	RA	Count	59.0	13.0	72.0
		Expected Count	60.9	11.1	72.0
Total		Count	137.0	25.0	162.0
		Expected Count	137.0	25.0	162.0

NRA = non-regenerative anaemia; RA = regenerative anaemia

From Table 4, there were 137 (84.57%) anaemic cats with vaccination and deworming status not current and 25 (15.43%) anaemic cats current. Among cats with not current vaccination and dewormin, 78 (56.93%) cats had non-regenerative and 59 (44.07%) regenerative anaemia. Thirteen (52%) anaemic cats with current vaccination and deworming had non-regenerative and 12 (48%) had regenerative anaemia.

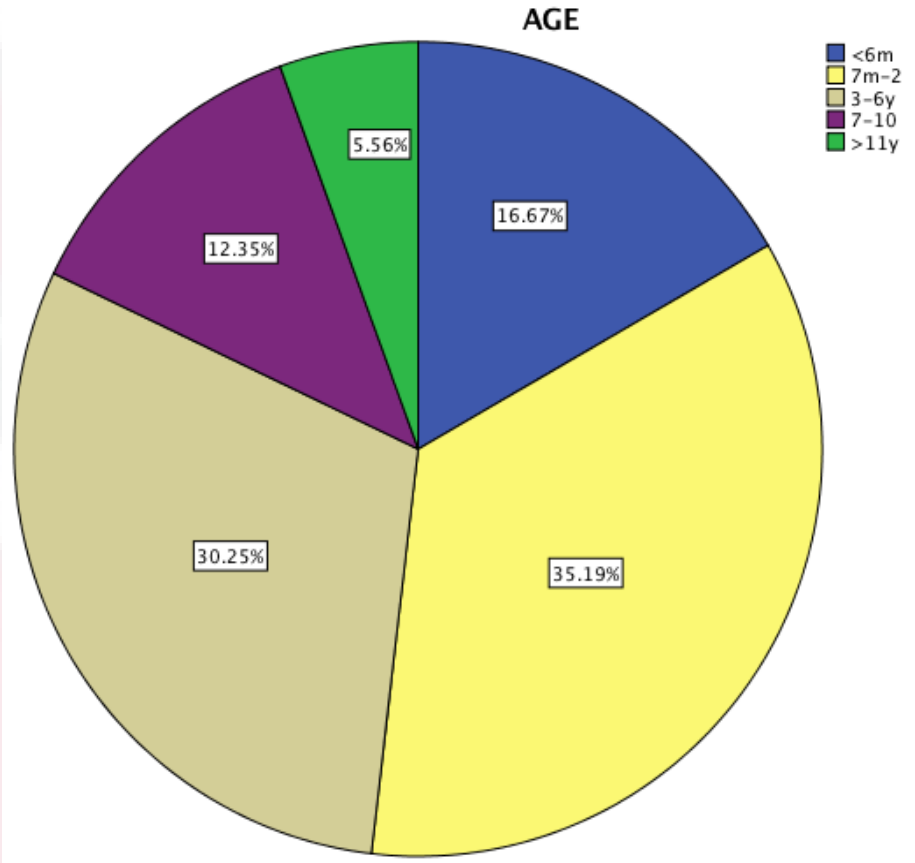

Figure 3: Distribution of anaemic cats according to age group.

The AAFP-AAHA Feline Life Stage Guidelines defines cats according to 5 age groups; <6 month, 7 months to 2 years, 3 to 6 years, 7 to 10 years, and > 11 years. In this study, among the 162 anaemic cats, the highest frequency are cats age 7 months to 2 years while the lowest were cats aged >11 years (Figure 3).

Table 5: Type of anaemia according to bone marrow response (n=162)

Age	Anaemia Type		Total
	Non-regenerative	Regenerative	
< 6 month	16 (59%)	11 (41%)	27
7 month – 2 years	33 (59%)	24 (41%)	57
3 to 6 years	24 (49%)	25 (51%)	49
7 to 10 years	10 (50%)	10 (50%)	20
>11 years	7 (78%)	2 (22%)	9
Total	90 (56%)	72 (44%)	162

The frequency is % of total animal of the respective age group.

Among anaemic cats, those of the >11 year age group had the highest frequency (78%) of non-regenerative anaemia. The other age groups showed approximately equal distribution between non-regenerative and regenerative anaemia (Table 5).

4.2.3 Descriptive data of patient clinical signs and physical examination

Table 6: Bone marrow response to anaemia in cat with ectoparasite infestation (n=52)

	Bone Marrow response	Ectoparasitim Positive
Anaemia_Type	NRA	10
	RA	42
Total		52

NRA = Non-regenerative anaemia; RA = Regenerative anaemia.

52 cats were infested with ectoparasites. Among cats with ectoparasitism 10 had non-regenerative while 42 regenerative anaemia.

Table 7: Clinical signs in cats with anaemia

Clinical Sign	Cats with sign	Frequency	
		Non-regenerative anaemia	Regenerative anaemia
Dehydration	55	41 (74.55%)	14 (25.45%)
Pallor	44	22 (50%)	22 (50%)
Distended abdomen	33	29 (87.88%)	4 (12.12%)
Jaundice	25	4 (16%)	21 (84%)
Anorexia	18	12 (66.67%)	6 (33.33%)
Weak	18	13 (72.22%)	5 (27.78%)
Respiratory signs	18	11 (61.11%)	7 (38.89%)
Vomiting	17	12 (70.59%)	5 (29.41%)
Diarrhoea	9	6 (66.67%)	3 (33.33%)
Pyrexia	8	7 (87.5%)	1 (12.5%)
Polyuria, polydipsia	7	7 (100%)	0
Inappetance	6	2 (33.33%)	4 (66.67%)
Hematuria	4	0	4 (100%)
Hematochezia	4	0	4 (100%)
Total	266	166	100

The most common clinical signs in anaemic cats were dehydration, pallor, distended abodomen, and jaundice. Cats with non-regenerative anaemia mostly showed distended abdomen and dehydration while regenerative anaemia mostly jaundice and pallor.

4.2.4 Descriptive data of patient diagnostic investigation

4.2.4.1 Hemotropic mycoplasma

The frequency of anaemic cats with flea infestation and diagnosed/suspected with hemotropic mycoplasma infection was 36 (69.2%).

4.2.4.2 Feline leukemia and feline immune deficiency virus

Twenty-four cats with anaemia were tested for either FeLV or FIV infection or both (Table 8).

Table 8: Anaemic cats with and without FeLV and FIV infection

	Bone marrow response	Infection				Total
		FeLV +ve	FIV +ve	FeLV & FIV +ve	FeLV & FIV –ve	
Anaemia Type	NRA	6	7	5	0	18
	RA	1	1	4	6	12
Total		7	8	9	6	30

NRA = Non-regenerative anaemia; RA = Regenerative anaemia; FeLV = feline leukemia virus; FIV = Feline immune deficiency virus; +ve = positive; -ve = negative

4.2.2.3 Aetiology

Aetiology of anaemia development was classified as a based on DAMNITV classification (Table 9). The most common cause of anaemia in cats were infectious diseases, traumatic injury and metabolic disorders. Non-regenerative anaemia is most frequently caused by infectious disease, followed in order by metabolic disorder and neoplasia while the most common cause of regenerative anaemia were traumatic injury and infectious diseases. All neoplasias were characterized by non-regenerative anaemia.

Table 9: Bone marrow response in feline anaemia according to aetiology

Aetiology	Number of cats	Non-regenerative anaemia	Regenerative anaemia
Infectious disease	74	49 (66.2%)	25 (33.8%)
Traumatic injury	35	5 (14.3%)	30 (85.7%)
Metabolic disorder	19	16 (84.2%)	3 (15.8%)
Neoplasia	11	11 (100.0%)	0 (0.0%)
Idiopathic disease	8	1 (12.5%)	7 (87.5%)
Inflammatory disease	6	3 (50.0%)	3 (50.0%)
Immune-mediated disease	3	1 (33.3%)	2 (66.7%)
Toxicity	3	2 (66.7%)	1 (33.3%)

Table 10: Association between gender and regenerative status of anaemia in cats.

	Value	df	Asymptotic Significance (2-sided)	Exact Significance (2-sided)	Exact Significance (1-sided)
Pearson Chi-Square	1.031[a]	1	0.310	-	-
Continuity Correction[b]	0.726	1	0.394	-	-
Likelihood Ratio	1.035	1	0.309	-	-
Fisher's Exact Test	-	-	-	0.332	0.197
N of Valid Cases	162	-	-	-	-

[a]0 cells (0.0%) have expected count less than 5. The minimum expected count is 27.11.
[b]Computed only for a 2x2 table.; No significant relationship between the gender and regenerative status of anaemia in cats; df = degree of freedom.

Table 11: Association between vaccination and deworming and regenerative status of anaemia in cats.

	Value	df	Asymptotic Significance (2-sided)	Exact Significance (2-sided)	Exact Significance (1-sided)
Pearson Chi-Square	0.683[a]	1	0.408	-	-
Continuity Correction[b]	0.370	1	0.543	-	-
Likelihood Ratio	0.679	1	0.410	-	-
Fisher's Exact Test	-	-	-	0.512	0.271
N of Valid Cases	162	-	-	-	-

[a]0 cells (0.0%) have expected count less than 5. The minimum expected count is 11.11.
[b]Computed only for a 2x2 table; No significant relationship between vaccination and deworming and regenerative status of anaemia in cats; df = degree of freedom.

Table 12: Association between management status and regenerative status of anaemia in cats.

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	1.420[a]	2	0.492
Likelihood Ratio	1.414	2	0.493
N of Valid Cases	162	-	-

[a]0 cells (0.0%) have expected count less than 5. The minimum expected count is 16.89; No significant relationship between management status and regenerative status of anaemia in cats; df = degree of freedom.

Table 13: Association of between flea infestation and regenerative status anaemia in cats.

	Value	df	Asymptotic Significance (2-sided)	Exact Significance (2-sided)	Exact Significance (1-sided)
Pearson Chi-Square	40.925[a]	1	0.000	-	-
Continuity Correction[b]	38.787	1	0.000	-	-
Likelihood Ratio	42.753	1	0.000	-	-
Fisher's Exact Test	-	-	-	0.000	0.000
N of Valid Cases	162	-	-	-	-

[a]0 cells (0.0%) have expected count less than 5. The minimum expected count is 23.11.
[b]Computed only for a 2x2 table; There is significant relationship between flea infestation and regenerative status of anaemia in cats; df = degree of freedom.

Table 14: Association between age and regenerative status of anaemia in cats.

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	3.184[a]	4	.527
Likelihood Ratio	3.317	4	.506
N of Valid Cases	162		

[a]1cell (10.0%) have expected count less than 5. The minimum expected count is 4.00. No significant relationship between age and regenerative status of anaemia in cats; df = degree of freedom.

Table 15: Association between FeLV and FIV infections and regenerative anaemia in cats.

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	13.523[a]	3	.004
Likelihood Ratio	16.245	3	.001
N of Valid Cases	30	-	-

[a]1cell (10.0%) have expected count less than 5. The minimum expected count is 4.00. FeLV = Feline leukemia virus; FIV = Feline immunodeficiency virus; There is significant relationship between FeLV and FIV infections and regenerative status of anaemia in cats; df = degree of freedom.

5.0 DISCUSSION

This study describes the patient signalment, clinical signs, physical examination findings, haematological data and causes of anaemia in 162 anaemic cats that were presented to University Veterinary Hospital, University Putra Malaysia.

Based on the reticulocyte index (RI), there were more cats with non-regenerative than regenerative anaemic. In this population, anemia due to bone marrow abnormalities was more common compared to those due to haermorrhage and

haemolysis. From the results, a large percentage of cats has secondary suppression of BM activity due to infectious mainly caused by feline infectious peritonitis (FIP), feline leukemia virus (FeLV), feline immunodeficiency virus (FIV), and haemotropic *Mycoplasma* infection. Analysis of specific diseases within BM group and the effect on prognosis and survivability of the cat was not performed because of the small groups and difficulty in obtaining retrospective definitive diagnoses for the cases that fits the DAMNITV classification system (Weiss, 2006).

The clinical signs associated with anaemia in the cat population in this study were vague and non-specific. Clinical signs mostly associated with anaemia were dehydration, followed by pallor, traumatic injury (fracture, external wound), flea infestation, distended abdomen, jaundice, weak, respiratory signs, anorexia, vomiting, presence of mass, diarrhoea, pyrexia, inappetance, hematochezia, and hematuria. However, the clinical signs that are apparent in patients with regenerative anaemia were hematuria, hematochezia, presence of traumatic injury, flea infestation and pallor. When compared to patients with regenerative anaemia, which were mainly due to traumatic, immune-mediated and idiopathic caused, there is an association between haematuria and haematochezia and traumatic injury (White and Reine, 2009). Pale mucous membrane in anaemia is the result of tissue hypoperfusion. Prolonged capillary refill time is the fastest indicator of poor perfusion (Slatter, 2003).

Heavy infestation of fleas would cause haemorrhagic anaemia (Day and Kohn, 2012). In addition, fleas infestation would contribute to feline haemoplasma infection such as *Mycoplasma haemofelis* causing haemolytic anaemia (Kewish *et al*.,

2004) and in our study, this is consistent with the aetiology of regenerative anaemia due to infectious agents.

On the other hand, cats with non-regenerative anaemia cats showed pyrexia, dehydration, jaundice, and vomiting. Based on the physical examination, more non-regenerative anaemia patients have distended abdomen, masses, and respiratory signs. These clinical signs were consistent with the aetiology of non-regenerative anaemia that includes neoplasia, metabolic disorder, vascular diseases, infections, and toxicity.

Dehydration occurs when circulating fluid levels is lower than normal that could be due to either reduced water intake or increased fluid loss. Reduced water intake is normally seen in inappetant sick cats. Various diseases such as kidney disorder/renal insufficiency, diabetes mellitus, renal lymphoma, vomiting, hyperthyroidism would also cause dehydration in cats. Jaundice could be consistent with haemolysis but in our study, only 16% cats with regenerative anaemia had jaundice. A similar finding was reported earlier (Kohn *et al*., 2006). In another study (Sherding, 2000), jaundice were apparent in cases of feline infectious peritonitis. In wet form peritonitis, peritoneal inflammation may involve the gastrointestinal tract causing vomiting and diarrhoea, hepatobiliary system, and the pancreas. In this study, only 14.4% of cats with non-regenerative anaemia had distended abdomen, which is consistent with infectious peritonitis.

The DAMNITV system is currently used for the classification of anaemia, which is based on aetiology (Garosi, 2004). The causes of regenerative anaemia include trauma, immune-mediated, and idiopathic causes. Aetiology of anaemia development

is important because it is associated significantly with survival to discharge as cats. Non-regenerative anaemia can be caused by neoplasia, metabolic, vascular, infectious disease, and toxicity. Cats with regenerative anaemia were more likely to survive than those with non-regenerative anaemia. However, the survival period vary among groups of cats (Korman *et al*., 2013). According Barrs *et al*., (2009), cats with regenerative anaemia caused by haemolysis were more likely to survive. On the other hand, cats with non-regenerative anaemia are less likely to survive (Stokol and Blue, 1999). Those with feline infectious peritonitis are less likely to survive because of the poor prognosis. The median survival period of cats with feline infectious peritonitis is approximately 9 days (Ritz *et al*., 2007).

From the results, most FeLV- and/or FIV-positive cats had non-regenerative anaemia. This study also shows that there is significant relation between the positive test for FeLV and FIV and regenerative status of anaemia. According to White and Reine (2009), FeLV can induce non-regenerative anaemia in cats by causing bone marrow suppression, myelodysplastic syndromes, lymphoma or leukemia, or secondary immune-mediated hemolytic anaemia (Stone and Freden 1990). Cats with FIV infection typically has non-regenerative anaemia. This is consistent with an earlier report (White *et al*., 2011).

The results also showed statistically significant relationship between the fleas infestation and regenerative anaemia in the cats. Fleas are widely thought to transmit *Mycoplasma haemofelis*, which causes infectious anaemia (Woods *et al*., 2005). *Mycoplasma haemofelis* is a gram-negative, epicellular erythrocyte parasites. The anemia associated with *Mycoplasma* infection occurs via direct erythrocyte damage

through the immune-mediated mechanism. During acute infections, the anaemia may appear non-regenerative, as seen in this study. In most cases, the anemia is regenerative when clinical signs began to appear (White and Reine, 2009).

This study had several limitations. This study did not include the survival time of the animal or survival to discharge possibility of the patient. The other limitation is determination of the DAMNITV categories. Subcategorisation anaemia according to is very subjective and some cases they fall into multiple categories. In addition, classification of anaemia into a broader aetiological classes are subject to erroneous classification. Additional analysis to confirm cause of disease, prognosis, and survivability was not performed in this study. This contributes to the difficulty fitting the anaemia cases according to the DAMNITV classification systems.

6.0 CONCLUSION

The patient signalment, clinical signs and physical examination are often vague and non-specific for the feline anaemia cases. However, there is a significant relationship between flea infestation and regenerative anaemia in cats. There was also significant relationship between cat positive for FeLV- and/or FIV and regenerative anaemia. The most common aetiology for non-regenerative anaemia in cats were neoplasia, metabolic, and infectious diseases, while for regenerative anaemia, they are trauma, and infectious disease.

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