UNIVERSITI PUTRA MALAYSIA

PATTERN OF HAEMATOLOGY AND SERUM BIOCHEMISTRY PARAMETERS IN CATS SUSPECTED OF FELINE INFECTIOUS PERITONITIS PRESENTED TO UNIVERSITY VETERINARY HOSPITAL, UNIVERSITI PUTRA MALAYSIA FROM THE YEAR 2014 TO 2016

JONG CHEE ZUNG

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JONG CHEE ZUNG

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CERTIFICATION

It is hereby certified that we have read this project paper entitled "Pattern of Haematology and Serum Biochemistry Parameters in Cats Suspected of Feline Infectious Peritonitis presented to University Veterinary Hospital, Universiti Putra Malaysia from the year 2014 to 2016", by Jong Chee Zung and in our opinion it is satisfactory in terms of scope, quality, and presentation as partial fulfilment of the requirement for the course VPD 4999 – Final Year Project.

.....

ASSOC. PROF. DR. HAZILAWATI HJ. HAMZAH

D.V.M. (UPM), M.V.Sc. (UPM), PhD (Murdoch)

Head of Department

Department of Veterinary Pathology and Microbiology

Faculty of Veterinary Medicine

Universiti Putra Malaysia

(Supervisor)

.....

ASSOC. PROF. DR. GOH YONG MENG

D.V.M, PhD (UPM)

Head of Department

Department of Veterinary Preclinical Sciences

Faculty of Veterinary Medicine

Universiti Putra Malaysia

(Co-Supervisor)

DEDICATIONS

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

To my beloved family,

Late father, Dr. Jong Kim Hock

Mother, Hu Hock Lai

Sister, Grace Jong

Brother, Daniel Jong

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

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It has indeed been a period of intense learning for me, not only in the scientific arena, but on a personal level. Writing this thesis has had a huge impact on me and I would like to reflect on the people who have directly or indirectly helped me along the way.

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

Abbreviation	Meaning
ALP	Alkaline Phosphatase
ALT	Alanine Aminotransferase
A:G	Albumin to Globulin Ratio
ASH	American Shorthair
BSH	British Shorthair
CI	Confidence Interval
DLH	Domestic Longhair
DSH	Domestic Shorthair
ELISA	Enzyme-linked Immunosorbent Assays
FCoV	Feline Coronavirus
FECV	Feline Enteric Coronavirus
FIP	Feline Infectious Peritonitis
FIPV	Feline Infectious Peritonitis Virus
RBC	Red Blood Cell
OR	Odds Ratio
P	P-value
PCV	Packed Cell Volume
S.D.	Standard Deviation
UPM	Universiti Putra Malaysia
UVH	University Veterinary Hospital
WBC	White Blood Cell

ABSTRAK

Abstrak daripada kertas yang dikemukakan kepada Fakulti Perubatan Veterinar untuk memenuhi sebahagian daripada keperluan Kursus VPD 4999 – Projek Ilmiah Tahun Akhir

CORAK HEMATOLOGI DAN SERUM BIOKIMIA PARAMETER DALAM KUCING YANG DISYAKI RADANG PERITONEUM BERJANGKIT FELIN YANG DIKEMUKAKAN KE HOSPITAL VETERINAR UNIVERSITI, UNIVERSITI PUTRA MALAYSIA DARI TAHUN 2014 HINGGA 2016

Oleh

Jong Chee Zung

2017

Penyelia: Prof. Madya Dr. Hazilawati Hj. Hamzah

Penyelia Bersama: Prof. Madya Dr. Goh Yong Meng

Radang peritoneum berjangkit felin (FIP) adalah penyakit immunopatologi maut yang disebabkan oleh felin koronavirus bermutasi yang dijumpai dalam kedua-dua kucing liar dan jinak. Kini, kajian tempatan pada corak hematologi dan serum biokimia parameter pada kucing FIP adalah amat terhad. Oleh itu, kajian ini dijalankan untuk menentukan corak hematologi dan serum biokimia parameter pada kucing yang

disyaki FIP yang dikemukakan ke UVH, UPM dan juga untuk membuat perbandingan pada parameter tersebut antara FIP jenis basah dan FIP jenis keing. Rekod perubatan kucing yang disyaki FIP dengan sejarah dan latar belakang serta jumpaan klinikal dari tahun 2014 hingga 2016 telah dikaji dan kriteria kemasukan tunggal adalah kucing yang diuji antibodi terhadap FCoV dengan menggunakan *dot-ELISA, Biogal's Immunocomb® Feline Coronavirus Antibody Test Kit* dan mempunyai sederhana hingga tinggi positif FCoV titer antibodi (S3-S6). Data pesakit (umur, jantina dan baka), keputusan hematologi dan serum biokimia telah diperoleh. Antara 132 kucing yang disyaki FIP, 81.1% mempunyai hiperproteinemia, 88.6% mempunyai hiperglobulinemia, 97.7% mempunyai nisbah A:G $\leqslant$ 0.8 dan 46.2% mempunyai hipoalbuminemia dalam keputusan serum biokimia manakala 47.8% mempunyai neutrofilia dengan peralihan kiri, 44.7% mempunyai limfopenia, 41.7% mempunyai monositosis, 55.3% mempunyai eosinopenia, dan 31.8% mempunyai anemia yang tidak jana semula. Parameter seperti kiraan limfosit (P = 0.002), kiraan eosinofil (P = 0.009), jumlah protein (P = 0.000), albumin (P = 0.000), globulin (P = 0.041), ALT (P = 0.016), ALP (P = 0.025) dan creatinine (P = 0.047) didapati berbeza dangan nyata sekali antara FIP jenis kering dan FIP jenis basah.

Kata Kunci: Radang peritoneum berjangkit felin, hiperproteinemia, hyperglobulinemia

ABSTRACT

An abstract of the project paper presented to the Faculty of Veterinary Medicine, UPM in partial fulfilment for the course of VPD 4999- Final Year Project

PATTERN OF HAEMATOLOGY AND SERUM BIOCHEMISTRY PARAMETERS IN CATS SUSPECTED OF FELINE INFECTIOUS PERITONITIS PRESENTED TO UNIVERSITY VETERINARY HOSPITAL, UNIVERSITI PUTRA MALAYSIA FROM THE YEAR 2014 TO 2016

By

Jong Chee Zung

2017

Supervisor: Assoc. Prof. Dr. Hazilawati Hj. Hamzah

Co-supervisor: Assoc. Prof. Dr. Goh Yong Meng

Feline Infectious Peritonitis (FIP) is a lethal immunopathological disease caused by mutated feline enteric coronavirus found in both wild and domesticated cats. There are limited local studies on the pattern of haematological and serum biochemical parameters in FIP cats. Thus, this study was conducted to determine the pattern of haematological and serum biochemical parameters in suspected FIP cats presented to UVH, UPM and also to compare these parameters between dry form and wet form FIP. Medical records of cats suspected of FIP with compatible history and clinical signs

admitted to UVH from year 2014 to 2016 were reviewed and the sole inclusion criterion was cats tested for FCoV antibody using dot-ELISA, Biogal's Immunocomb® Feline Coronavirus Antibody Test Kit with medium to high positive FCoV antibody titre (S3-S6). Data on signalment (age, sex and breed), haematology and serum biochemistry results were obtained. Among the 132 suspected FIP cats, 81.1% had hyperproteinaemia, 88.6% had hyperglobulinaemia, 97.7% had A:G ratio ≤ 0.8 and 46.2% had hypoalbuminaemia, 47.8% had neutrophilia with left shift, 44.7% had lymphopaenia, 41.7% had monocytosis, 55.3% had eosinopaenia, and 31.8% had nonregenerative anaemia. Parameters such as lymphocyte count (P=0.002), eosinophil count (P=0.009), total protein (P=0.000), albumin (P=0.000), globulin (P=0.041), ALT (P=0.016), ALP (P=0.025) and creatinine (P=0.047) were found to be significantly different between dry form and wet form FIP.

Keywords: Feline infectious peritonitis, hyperproteinaemia, hyperglobulinaem

1.0 INTRODUCTION

Feline Infectious Peritonitis (FIP) is a lethal immunopathological disease characterized as an immune-mediated pyogranulomatous vasculitis caused by mutated feline coronavirus (FCoV), known as feline infectious peritonitis virus (FIPV) which can be found in both wild and domesticated Felidae (Pedersen & Floyd, 1985; IDEXX, 2015). Its morbidity is low and barely surpasses 5% of infected cats despite the generally high prevalence of FCoV infection in the cat population, which can exceed 90% in multicat environment (reviewed by Pedersen, 2009).

Several studies reported FIP significantly more often in male cats (Rohrbach *et al*., 2001; Norris *et al*., 2005) and approximately 50% of FIP cats diagnosed worldwide are less than 2 years old with over representation of purebred cats (Norris *et al*., 2005). FIP is divided into two distinct clinical forms which are dry form and wet form (Goodson *et al.,* 2009). Wet form FIP is caused by complement-mediated vasculitis initiated by immune complex deposition in vessel walls while dry form FIP results when a cell-mediated immune response dominates and granulomas form in various organs (Pesteanu-Somogyi, 2005).

Nonregenerative anaemia, neutrophilic leukocytosis, lymphopaenia and hyperproteinaemia are well-recognized haematological and serum biochemical findings in FIP (Jain, 1993; Pedersen, 1995). In Malaysia, there is limited study on the pattern of haematological and serum biochemical parameters in FIP cats. Moreover, data regarding comparison of these parameters between dry form and wet form FIP cats are also lacking. Thus, this study was conducted with the following objectives:

i. to determine the pattern of haematological and serum biochemical parameters in cats suspected of FIP presented to UVH, UPM

ii. to compare the haematological and serum biochemical parameters in cats suspected of dry form and wet form FIP.

Significant differences for certain parameters between dry form and wet form FIP might contribute to its diagnostic value.

2.0 LITERATURE REVIEW

2.1 Causative Agents of FIP

Two recognized feline coronavirus (FCoV) biotypes are feline enteric coronavirus (FECV) and feline infectious peritonitis virus (FIPV) whereby each causing different biological outcomes (IDEXX, 2015). FIPV, which is invariably fatal, develops out of the virtually nonpathogenic FECV spontaneously within the infected cat (Hartmann, 2005; Addie & Jarrett, 2006). Pedersen *et al.* (2008) reported that FIPV mutation from FECV is more likely to occur during primary infection and in kittens as both conditions cause higher level of FECV replication and young cats have decreased resistance to the mutation once it occurs.

Feline infectious peritonitis virus (FIPV) is unique and different from other viruses in the sense that it is infrequently spread in horizontal manner from animal to animal, yet it is highly infectious when extracts of affected tissues or fluids are inoculated into naïve cats (Pedersen, 2009).

2.2 Epizootiology of FIP

Feline infectious peritonitis (FIP) can be seen worldwide and ubiquitous among almost all cat populations (reviewed Pedersen, 2009) as it can occur wherever FECV is found (Pedersen *et al.*, 1981; Addie *et al.*, 1995; Foley *et al.*, 1997). According to reviewed Pedersen (2009), epizootiology of FIP is closely linked to FECV.

Studies have shown multicat households have a higher prevalence of FECV (75% to 100%) than single-cat households (25%) (Addie, 2000; Hartmann *et al.*, 2003),

but only 5-10% of FECV-infected cats develop FIP in the multicat households and a much lower incidence occurs in single-cat households (Pedersen, 1976).

According to Norris *et al.* (2005), approximately 50% of all cats diagnosed with FIP worldwide are 2 years old and below and purebred cats are generally over represented. Rohrbach *et al.* (2001) reported that male and sexually-intact cats are over-represented but these are not seen by Foley *et al*. (1997).

2.3 Pathogenesis of FIP

Feline infectious peritonitis (FIP) develops when there is a spontaneous mutation in a certain region of the FECV genome most importantly genes 3C and 7B (Herrewegh *et al*., 1995). This mutated virus able to replicate within macrophages due to changes in the surface structures of the virus that allow it to be phagocytized by macrophages which contributes to the key event in the pathogenesis of FIP (Hartmann, 2005). According to Dewerchin (2005), FIPV infection is sustained in macrophages and monocytes, where the virus undergoes replication and spreads systemically.

In many infectious diseases, pre-existing antibodies protect against subsequent challenge, but for FIP, an enhanced form of disease may occur in cats with pre-existing antibodies (Pedersen, 1995; Scott *et al*., 1995). This mechanism is known as antibody-dependent enhancement (ADE) whereby antibodies facilitate the uptake of FECV into macrophages (Hohdatsu *et al*., 1991; Olsen *et al*., 1993). In a study conducted by Scott *et al*. (1995), a higher proportion of antibody-positive cats developed disease earlier and died as compared with antibody-negative controls because of ADE.

2.4 Clinical Manifestations of FIP

Feline infectious peritonitis (FIP) is divided into two distinct clinical forms: 1) the most common known as effusive (wet) form which is a transmissible inflammatory condition of the omentum and visceral serosa with exudation into abdomen (Wolfe & Griesemer, 1966), and 2) the other form is non-effusive (dry) form characterized by granulomatous involvement of parenchymatous organs such as the kidneys, liver, mesenteric lymph nodes, bowel wall, central nervous system and eyes (Montali & Strandberg, 1972). During the progression of disease, cats with FIP may undergo transition between dry form and wet form. Pedersen (1995) reported cats with non-effusive FIP may develop effusions during terminal stages of disease while there are reports of non-effusive FIP being preceded by a subtle effusive form.

The earliest signs of overt FIP include a progressively worsen malaise, inappetence, fluctuating fever, and weight loss. The most common physical finding in wet form FIP is abdominal distention and the abdomen is often doughy feeling and painless upon palpation (reviewed by Pedersen, 2009). Moreover, tachypnoea and dyspnoea can be a feature of cats with thoracic effusions and pleural involvement (reviewed by Pedersen, 2009; Goodson *et al*., 2009). Pedersen (2009) stated that involvement of the CNS and/ or eyes lesion predominates in 60% of the cats with dry form FIP whereas thoracic and abdominal effusions are either absent or too scant to be detected other than at necropsy as the name 'dry FIP' implies. Cats with neurological involvement frequently exhibit seizures, ataxia and nystagmus (Foley *et al*., 1998) while ocular lesions exhibited by FIP cats include uveitis, iritis and cuffing of the retinal vasculature (Colitz, 2005; Addie & Jarrett, 2006).

2.5 Diagnosis

Definitively diagnosing FIP antemortem can be awfully challenging in most clinical cases (Hartmann, 2005) and it has been described as one of the most misdiagnosed and over diagnosed diseases of cats due to its variable and complex pathogenesis (Pedersen, 1983).

By taking several parameters into account, including the patient signalment, history, presence of clinical signs, height of antibody titers, and laboratory changes; a weighted score system for FIP diagnosis has been suggested by Rohrer *et al*. (1993) but it does not help to confirm the diagnosis definitively. The only conclusive test for diagnosis of FIP is through observation of characteristic histopathological lesions (Barlough & Stoddart, 1988) in conjunction with detection of viral antigen within macrophages in the lesions using immunohistochemistry (Norris *et al*., 2005). However, it is important not to interpret only clinicopathology results as no test is 100% sensitive and specific.

2.6 Treatment and Prevention of FIP

There is no curative treatment for FIP and almost every cat with confirmed FIP dies. According to Goodson *et al.* (2009), therapy for FIP is directed at suppressing the formation of immune complexes by using relatively high doses of immunosuppressive and anti-inflammatory drugs, which control vasculitis that characterizes the disease. Immunosuppressive drugs, such as cyclophosphamide (2.5 mg/kg administered orally for four consecutive days weekly) or prednisone (4 mg/kg administered orally every 24 hours), may slow down disease progression but not

curative (Hartmann, 2005). Supplemental therapies such as fluids and nutritional support should be given to increase the overall well-being of the cat (Goodson *et al.*, 2009).

Regrettably, FIP prevention is awfully difficult. Hartmann (2005) reported the only way to prevent FIP development is to prevent infection with FCEV. Effective vaccines for FIP have been as elusive as effective treatments (Pedersen, 2009) and FIP vaccine being listed as "not generally recommended" by The American Association of Feline Practitioners (Richards *et al*., 2006). Management of FIP should be directed at accurately diagnosing and supporting individual affected cats and minimizing the population impact (Hartmann, 2005).

3.0 MATERIAL AND METHODS

3.1 Case Selection

This project was conducted using a retrospective approach, where medical records of cats admitted to UVH from year 2014-2016 were obtained from the UVH's case logbook. The cases were selected based on history and clinical signs from patient medical records compatible with FIP (wet form or dry form) and tentative diagnosis of suspected FIP recorded in the case logbook. The sole inclusion criterion for this study was cats that tested for FCoV antibody using a commercial kit for dot-ELISA: Immunocomb® Feline Coronavirus (FCoV) [FIP] Antibody Test Kit (Biogal, Galed Laboratories) with medium positive FCoV antibody titre (S3), which is considered to be the 'cut-off' value of a significant antibody titre to high positive antibody titre (S5 and above).

3.2 Case Classification

Although the presence of antibodies does not indicate FIP, extremely high titres are of certain diagnostic value as it increases the likelihood of FIP (Hartmann, 2005) but it should never be interpreted alone. Combining other factors such as history, clinical signs and patient signalment that are compatible with FIP, the presumptive diagnosis of FIP was made. These selected cases were further classified into dry form or wet form FIP based on clinical findings from the medical records. For wet form FIP, clinical findings of lethargy, fever that are not responding to antibiotic, abdominal distention, pallor, tachypnoea, dyspnoea and muffled heart sounds were included for the criteria of selection, while for dry form FIP, lethargy, poor appetite, weight loss,

icterus, ocular lesions such as uveitis and retinal changes, and neurological involvement such as ataxia, nystagmus, and seizure were included for the criteria of selection.

3.3 Data Collection

Of the selected cases, data on patient signalment (age, sex, and breed) and Immunocomb® FCoV antibody titer (S3-S6) results were obtained from the medical records at UVH, UPM while data on complete blood count (CBC) and serum biochemistry were obtained from the Haematology and Clinical Biochemistry Laboratory, Faculty of Veterinary Medicine, UPM.

3.4 Statistical Analysis

All data were tabulated in Microsoft Excel spreadsheet and transferred (and/or coded) in the IBM® SPSS® Statistics Version 22 spreadsheet for further analyses such as frequency, medians and modes (where applicable). Mann-Whitney U test (non-parametric test) was conducted to identify the significant differences between the haematological and serum biochemical parameters of dry form and wet form FIP. Statistical significance was recorded at 95% C.I. ($P<0.05$), in which null hypothesis will be rejected, indicating the data is statistically significant.

Risk analysis was performed using Pearson chi-square (X^2) test for parameters that were significantly different between dry form and wet form FIP to determine the odds ratio (OR) for a 'cut-off' value of that particular parameter to help in differentiation of dry form and wet form FIP from haematological and serum biochemical parameters.

All statistical analysis was conducted using the IBM SPSS (Statistical Program for Social Science) software version 22.0.

4.0 RESULTS

4.1 Cases

A total of 153 cats with history and clinical signs compatible with FIP were tested for FCoV antibody titre from year 2014 to year 2016. Out of the 153 suspected FIP cats, 132 of them had moderate to high FCoV antibody titre (S3-S6) and were included in this study.

4.2 Descriptive Data of Patient Signalment

This study comprises of 92 male cats and 40 female cats. Out of the 92 male and 40 female cats, 10 cats were neutered, respectively, as shown in figure 1.

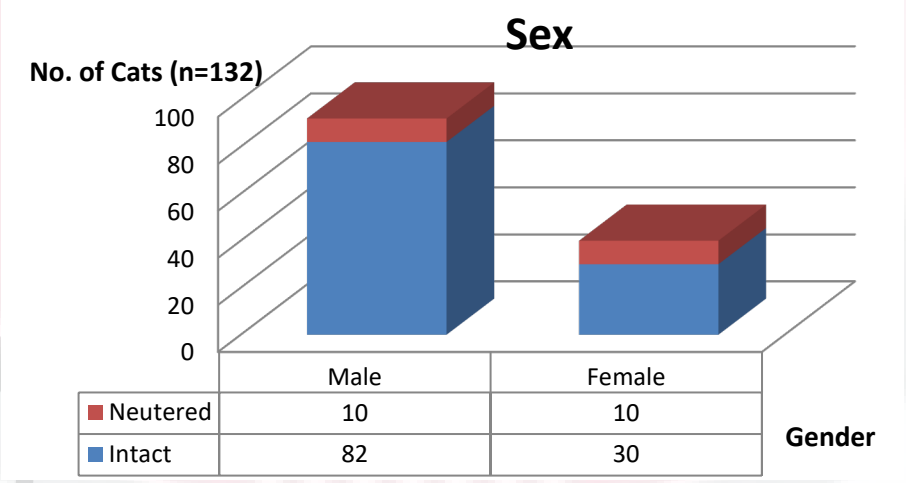
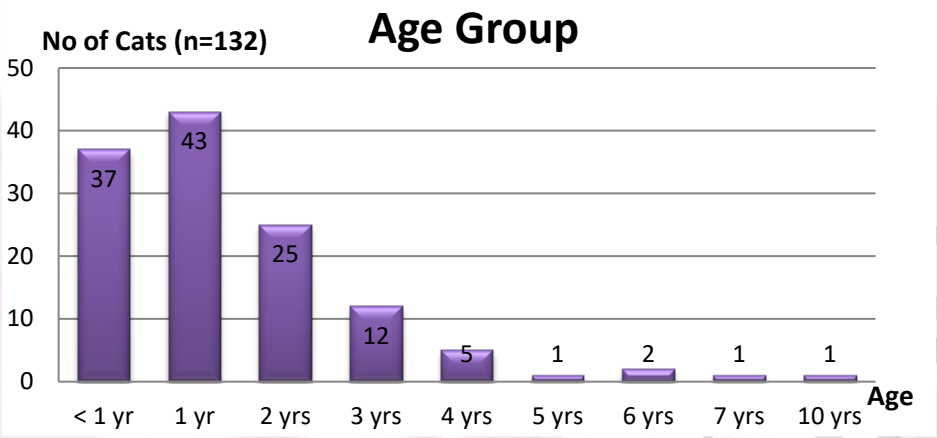


Figure 1: Sex distribution of suspected FIP cats

Figure 2 shows the age group of suspected FIP cats with the observation range from less than 1 year old to 10 years old. Majority of the cases (82.7%) were cats of 2 years old and below.



l FIP cats

Figure 3 shows the breed distribution of suspected FIP cats. Majority of the cases comprised of our local DSH cats (69%) followed by Persian (16%), DLH (6%), Maine Coon (4%), and the least breeds recorded were ASH, BSH, Bengal, Munchkin, and Siamese with 1% each respectively.

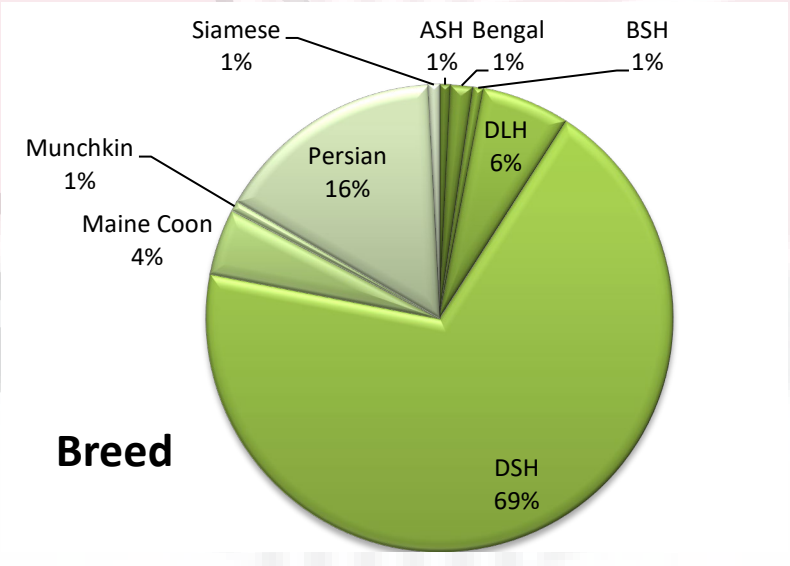


Figure 3: Breed distribution of suspected FIP cats

Table 1 shows the type of FIP among suspected FIP cats. Out of 132 suspected FIP cases, 77 cases (58.3%) consisted of suspected wet form FIP while the remaining 55 cases (41.7%) were suspected to be dry form FIP.

Table 1: Type of FIP among suspected FIP cats

Type of FIP	Frequency
Wet Form	77
Dry Form	55

4.3 Pattern of haematological parameters

Descriptive data for haematological parameters are summarised in Table 2. Cases were classified as anaemia if there was a reduction below normal in the PCV, total red blood cell (RBC), and/or haemoglobin concentration in accordance with the definition given by White & Reine (2009). Anaemia patients were identified and further categorised as regenerative or non-regenerative anaemia based on the corrected reticulocyte percentage (CRP). Out of the 132 suspected FIP cats, 83 cats (62.9%) did not have anaemia. On the other hand, 42 cats (31.8%) had non-regenerative anaemia and only 7 cats (5.3%) with regenerative anaemia.

There were 89 of 132 cats (67.4%) showed normal leukocytes (WBC) count although 24 of the 89 cats had neutrophilia with left shift; leukocytosis due to neutrophilia with left shift was observed in 39 of 132 cats (29.6%) while leukopenia was observed in the remaining 4 cats (3.0%). Lymphopenia was detected in 59 of 132 cats (44.7%) whereas the remaining 55.3% (73 cats) had normal lymphocyte count.

Out of the 132 cats, 55 (41.7%) cats showed monocytosis, 76 (57.6%) cats had normal monocyte count and only 1 (0.7%) cat showing monocytopenia. As for the eosinophil count, 73 of 132 (55.3%) cats had eosinopenia, the remaining 51 cats (38.6%) showed normal eosinophil count, while 8 cats (6.1%) showing eosinophilia. Majority of the cats (83%) had thrombocytopaenia However, this might not be significant in cat as study by Norman *et al*. (2001) showed high prevalence of apparent thrombocytopenia in automated platelet counts due to combination of the impedance method of cell differentiation by size as well as platelet aggregation. True thrombocytopaenia can only be confirmed through microscopic examination.

4.4 Pattern of serum biochemical parameters

Table 2: Mean for haematological parameters in suspected FIP cats

Parameters (Units)	Mean ±S.D.	Reference Range
Erythrocyte (RBC) ($x10^{12}/L$)	6.21 ±1.94	5-10
Haemoglobin (g/L)	92.65 ±24.99	80-150
PCV (L/L)	0.25 ±0.06	0.24-0.45
Leukocytes (WBC) ($x10^{9}/L$)	17.72 ±10.17	5.5-19.5
Band Neutrophils ($x10^{9}/L$)	0.47 ±0.40	< 0.3
Segmented Neutrophils ($x10^{9}/L$)	14.23 ±8.33	2.5-12.5
Lymphocytes ($x10^{9}/L$)	1.70 ±1.00	1.5-7.0
Monocytes ($x10^{9}/L$)	0.98 ±1.13	0.2-0.8
Eosinophils ($x10^{9}/L$)	0.33 ±0.60	0.1-1.5
Basophils ($x10^{9}/L$)	0.00 ±0.00	Rare
Thrombocytes ($x10^{9}/L$)	175.76 ±197.60	300-700

Descriptive data for serum biochemical parameters are summarised in Table 3. For renal parameters, there were only mild elevation of BUN and creatinine noticed in 20% and 8% of the cats respectively. A similar pattern was observed for liver parameters as there were only mild elevation of ALT and ALP in 13% and 1.5% of the cats, respectively.

A total of 107 from 132 cats (81.1%) showing hyperproteinaemia due to hyperglobulinaemia. In current study, 117 of 132 cats (88.6%) had hyperglobulinaemia. Besides, 61 of 132 cats (46.2%) had concurrent hypoalbuminaemia. Both hyperglobulinaemia and hypoalbuminaemia contribute to low A:G ratio which is consistent with FIP. Results in this study showed, 129 of 132 cats (97.7%) had A:G ratio ≤ 0.8.

Table 3: Mean for serum biochemical parameters in suspected FIP cats

Parameters (Units)	Mean ±S.D.	Reference Range
Urea (mmol/L)	7.66 ±3.91	3.0-10.0
Creatinine (µmol/L)	96.89 ±39.73	60-193
ALT (U/L)	54.02 ±39.81	10-90
AP (ALP) (U/L)	17.28 ±15.49	< 80
Total Protein (Serum) (g/L)	91.41 ±18.11	55-75
Albumin (g/L)	25.78 ±5.61	25-40
Globulin (g/L)	65.62 ±17.44	25-45
A:G (Unit)	0.40 ±0.16	0.5-1.4

4.5 Comparison of haematological and serum biochemical parameters in suspected dry form and wet form FIP cats

Mann-Whitney U test was conducted to compare the haematological and serum biochemical parameters of dry form and wet form FIP cats. Results showed haematological parameters such as lymphocyte count (P=0.002) and eosinophil count (P=0.009) were significantly different between dry form and wet form FIP. As for the serum biochemistry, total protein (P=0.000), albumin (P=0.000), globulin (P=0.041), ALT (P=0.016), ALP (P=0.025), and creatinine (P=0.047) were significantly different between dry form and wet form FIP.

Table 4 shows the mean for haematological and serum biochemical parameters that were significantly different in dry form and wet form FIP, respectively. Based on the findings, it was identified that dry form exhibits a higher mean compared to wet form for all the parameters that were significantly different in dry form and wet form FIP.

Table 4: Mean for haematological and serum biochemical parameters in wet form and drv form FIP

Parameters (Units)	Type of FIP	Mean ±S.D.	Reference Range
Lymphocytes ($x10^9$/L)	Wet Form	1.48 ±0.93	1.5-7.0
	Dry Form	2.00 ±1.04	
Eosinophils ($x10^9$/L)	Wet Form	0.23 ±0.49	0.1-1.5
	Dry Form	0.46 ±0.72	
Total Protein (Serum) (g/L)	Wet Form	86.00 ±15.43	55-75
	Dry Form	98.97 ±18.99	
Albumin (g/L)	Wet Form	23.64 ±4.00	25-40
	Dry Form	28.77 ±6.17	

Globulin (g/L)	Wet Form	62.36 ±14.59	25-45
	Dry Form	70.18 ±20.05	
ALT (U/L)	Wet Form	48.22 ±36.41	10-90
	Dry Form	62.18 ±43.20	
AP (ALP) (U/L)	Wet Form	15.36 ±16.98	< 80
	Dry Form	19.77 ±13.16	
Creatinine (µmol/L)	Wet Form	92.03 ±28.46	60-193
	Dry Form	103.58 ±50.93	

Risk analysis was then performed using Pearson chi-square (X^2) test for parameters that were significantly different between dry form and wet form FIP to determine the odds ratio (OR) for a 'cut-off' value for the differentiation of wet form and dry form FIP of that particular parameters are summarised in Table 5. For lymphocyte count, at a 'cut-off' point of 1.5 x10^9/L, the OR was 2.34. For eosinophil count, at a 'cut-off' point of 0.25 x10^9/L, the OR was 2.97. For total protein, at a 'cut-off' point of 98 g/L, the OR was 3.99. For albumin, at a 'cut-off' point of 24 g/L, the OR was 5.06. For globulin, at a 'cut-off' point of 70 g/L, the OR was 2.24. However, risk analysis was not perform on ALT, ALP and Creatinine as the 'cut-off' value for each could not be determined.

Table 5: Risk analysis for haematological and serum biochemical parameters 'cut-off' value for the differentiation of wet form and drv form FIP

Variable	Wet Form	Dry Form	X^2	OR	95% CI	P-value
1) Lymphocytes 'cut-off' point (1.5 x10^9/L)						
Wet Form	41	18	5.465	2.341	1.140-4.807	0.019*
Dry Form	36	37	-	-	-	-
2) Eosinophils 'cut-off' point (0.25 x10^9/L)						
Wet Form	62	32	7.809	2.971	1.365-6.467	0.005*
Dry Form	15	23	-	-	-	-
3) Total protein 'cut-off' point (98 g/L)						
Wet Form	62	28	12.967	3.986	1.840-8.634	0.000*
Dry Form	15	27	-	-	-	-
4) Albumin 'cut-off' point (24 g/L)						
Wet Form	43	11	17.052	5.059	2.275-11.251	0.000*
Dry Form	34	44	-	-	-	-
5) Globulin 'cut-off' point (70 g/L)						
Wet Form	55	29	4.849	2.241	1.086-4.625	0.028*
Dry Form	22	26	-	-	-	-

CI: confidence interval; OR: odds ratio (relative risk); P-value: probability; *: significant at P<0.05

5.0 DISCUSSION

In this retrospective study, the suspected FIP cats were mostly males (69.7%). This is consistent with the studies by Norris *et al.* (2005) and Rohrbach *et al.* (2001) whereby there is an over-representation of males being diagnosed with FIP. According to Schuurs & Verheul (1990), sex steroid hormones such as androgens can dampen the immune response, which could potentially promote virus multiplication, hence raising the risk of mutations of the viral genome that result in FIP (Riemer *et al.*, 2016). However, Pedersen (1995) stated that no gender predisposition for FIP was found in majority of reports worldwide.

A lot of studies showed that young cats are more prone to developing FIP. According to reviewed Pedersen (2009), cats between 4 and 18 months of age are most commonly diagnosed with FIP, while Norris *et al.* (2005) reported 55% of the cats with FIP are less than 2 years old. In the current study, majority of the cats (82.7%) are 2 years old and below. This can be explained by immature immune systems in young cats and exposure to stressors such as de-sexing, weaning, re-homing, and *etc*.

As for the breed, 69% of the suspected FIP cats in this study consist of DSH. Conversely, study conducted by Norris *et al.* (2005) reported DSH are under represented in the FIP cohort while purebred cats are over represented. According to Tekelioglu *et al* (2015), breed is not associated with FCoV seropositivity.

Non-regenerative anaemia is commonly seen in chronic feline diseases. A study by Norris *et al.* (2005) stated that 60% of the FIP cats in their study are presented with non-regenerative anaemia. In this current study, only 31.8% of the suspected FIP

cats had non-regenerative anaemia while another 5.3% actually had regenerative anaemia. The exact cause of non-regenerative anaemia in FIP is still unknown yet many studies have shown its association with chronic inflammation (Hartmann, 2005; Norris *et al.*, 2005). Moreover, regenerative anaemia in FIP cats is suggested to be caused by secondary autoimmune haemolytic anaemia (Hartmann, 2005).

Although not pathognomonic, varying degrees of lymphopaenia and neutrophilia are quite typical of FIP indicating "stress leukogram" secondary to infection (Paltrinieri *et al.*, 2002; Hartmann *et al.*, 2003). In present study, 47.7% of the cats had neutrophilia with left shift while 44.7% of the cats had lymphopaenia. This neutrophilia is most likely due to neutrophilic granulocyte hyperplasia with a left shift of the granulocytic series which is a non-specific reactive change of the bone marrow in cats with FIP (Breuer, 1998). A left shift is considered hallmark of marked infection or inflammation (Latimer, 2011). According to Kipar *et al.* (2001), virus induced apoptosis of lymphocytes has been causing lymphopenia. While Sparkes *et al.* (1991) observed no significant difference in the lymphocyte count between dry form and wet form FIP cat, current study recognizes lymphocyte count significant different (P=0.002) among the two types of FIP from Mann-Whitney U test, whereby lymphopaenia was more often seen in cats with effusion (41/59; 69.5%) compared to cats without effusion (18/59; 30.5%). A significantly higher prevalence of lymphopaenia in wet form FIP could be due to vasculitis in cats with effusion (Hayashi *et al.*, 1977; Kipar *et al.,* 2005). Risk analysis for lymphocyte count at a cut-off point of 1.5 $x10^9/L$ to differentiate wet form and dry form FIP have an OR of 2.34, which

means the odds of being a wet form FIP at lymphocyte count 1.5 x10^9/L and below is 2.34 times the odds of being a dry form FIP.

In current study, more than half of the suspected FIP cats (55.3%) had eosinopaenia. To date, there are not many studies on FIP discuss on the pathophysiology of eosinopaenia in FIP cats. However, eosinopaenia is one of the characteristic of stress leukogram caused by decreased release of eosinophils from the bone marrow and increased lysis (Schmidt, 2015). A comparison of eosinophil count between wet form and dry form FIP in this present study found to be significantly different (P=0.009) whereby wet form FIP had a lower mean compared to dry form FIP. Risk analysis for eosinophil count at a cut-off point of 0.25 x 10^9/L to differentiate wet form and dry form FIP showed an OR of 2.97, which means the odds of being a wet form FIP at eosinophil count 0.25 x10^9/L and below is 2.97 times the odds of being a dry form FIP.

Although majority (57.6%) of the cats in this study had normal monocyte count, 41.7% cats had monocytosis. Monocytosis can be variably found in feline stress leukograms (Schmidt, 2015). On the other hand, monocytosis concurrent with hyperglobulinaemia is a characteristic of chronic inflammation. Thrombocytopaenia can be due to decreased bone marrow production of platelets or immune-mediated destruction (Kohn *et al.*, 2006); if only true thrombocytopaenia was confirmed microscopically.

Several studies reported that the most consistent laboratory finding in cats with FIP is an increase in total serum protein concentration (Hartmann *et al.*, 2003; Paltrinieri *et al.*, 2002), which is caused by increased globulins, mainly ɤ-globulins

(Rohrer *et al.*, 1994; Hartmann *et al.*, 2003). In this study, a high percentage of 81.1% (107/132) of suspected FIP cats exhibited hyperproteinaemia. Comparison between wet form and dry form FIP also showed total protein (serum) to be significantly different (P=0.000) whereby dry form FIP had a higher mean. Risk analysis for total protein (serum) at a cut-off point of 98 g/L to differentiate wet form and dry form FIP showed an OR of 3.99, which means the odds of being a dry form FIP at total protein 98 g/L and above is 3.99 times the odds of being a wet form FIP. However, some other studies have reported hyperproteinaemia in a much lower percentage. For instance, study by Sparkes *et al.* (1991) detected hyperproteinaemia in only 39% of FIP cats and even lesser was reported by Riemer *et al.* (2015) in only 17.5% of FIP cats which could be explained by high prevalence of hypoalbuminaemia in that study.

Hyperglobulinaemia was observed in 88.6% of the cats in the present study which is consistent with the study by Goodson *et al.* (2009) whereby more than 70% of patients with FIP have hyperglobulinaemia. Antibodies produced during the host's humoral immune response to the virus and the presence of complement and immune complexes could result in elevated serum globulin levels (Paltrinieri *et al.*, 2001). Globulin was also found to be significantly different (P=0.041) in current study between wet form and dry form FIP, whereby dry form FIP had a higher mean. This can be explained by the mechanism whereby macrophages are progressively being replaced by B-cells and plasma cells found in granulomatous infiltrates of FIP (Kipar & Meli, 2014) hence dry form FIP generally exhibits higher hyperglobulinaemia. Risk analysis for globulin at a cut-off point of 70 g/L to differentiate wet form and dry form

FIP showed an OR of 2.24, which means the odds of being a dry form FIP at globulin 70 g/L and above is 2.24 times the odds of being a wet form FIP.

Study by Hartmann *et al.* (2003) on the comparison of total serum protein concentration, ɤ-globulins, and A:G ratio revealed the later has a statistically significant better diagnostic value than the earlier two parameters. Thus, besides an increase in globulins, decrease in albumin concentrations seems to be characteristic of FIP (Hartmann, 2005). Current study documented that 46.2% of the cat had hypoalbuminaemia which can be explained by increase loss from endothelial leakage or decrease albumin production by the liver (Goodson *et al.*, 2009). Comparison between wet form and dry form FIP also showed albumin to be significantly different (P=0.000) whereby wet form FIP had a lower mean. Risk analysis for albumin at a cut-off point of 24 g/L to differentiate wet form and dry form FIP showed an OR of 5.06, which means the odds of being a wet form FIP at albumin 24 g/L and below is 5.06 times the odds of being a dry form FIP. Study by Duthie (1997) & Hartmann *et al.* (2003) agreed on the earlier point that A:G ratio presents a more valuable diagnostic tool than protein levels. Besides, Hartmann *et al.* (2003) also reported an optimum cut off value of 0.8 for A:G ratio in which the probability that the cats has FIP is high (92% positive predictive value) if serum A:G ratio is less than 0.8 while cat likely does not have FIP (61% negative predictive value) if the A:G ratio is higher than 0.8. However, one must be cautious when interpreting the result as positive predictive value is very much depends on the prevalence of disease in the population being tested. In this current study, almost all cats (97.7%) had A:G ratio ≤ 0.8. Low A:G ratio in FIP cats

is contributed by hyperglobulinaemia and hypoalbuminaemia. However, A:G ratio showed no significant difference (P=0.303) between wet form and dry form FIP.

Study by Wolf (1997) showed that other laboratory parameters such as liver enzymes, urea, creatinine and bilirubin are non-specific and can be variably increased depending on the degree and localization of organ damage, hence not helpful in making an aetiological diagnosis. Addie & Jarrett (2006) also stated that liver enzyme levels in FIP cats are frequently normal. Consistent with results in this study, there were only very small percentages of cats having mild elevation of ALT and ALP which were 13% and 1.5% of the suspected FIP cats, respectively. As for renal parameters, there were only mild elevation of blood urea nitrogen and creatinine noticed in 20% and 8% of the cats, respectively.

6.0 CONCLUSION

All in all, the most consistent haematological and serum biochemical findings in FIP cats in the current study were hyperproteinaemia (81.1%; n=132), hyperglobulinaemia (88.6%; n=132), and A:G ratio ≤ 0.8 (97.7%; n=132).

Parameters such as lymphocyte count (P=0.002), eosinophil count (P=0.009), total protein (P=0.000), albumin (P=0.000), globulin (P=0.041), ALT (P=0.016), ALP (P=0.025) and creatinine (P=0.047) were found to be significantly different between dry form and wet form FIP.

7.0 RECOMMENDATION

The main limitation in this study is that almost all cases included in this study did not have a definitive diagnosis of FIP but a presumptive diagnosis. This is due to difficulty to obtain an ante-mortem definitive diagnosis of FIP especially for dry form FIP as the owners usually will not proceed with post-mortem confirmative diagnosis for FIP after their cats had died. Besides, some of the records were unable to be retrieved.

In future, a case-control study can be conducted with confirmed FIP cases as samples with definitive diagnosis of FIP will provide a more convincing result. Study should include complete patient signalments and clinical signs to study the risk factors associate with FIP.

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APPENDICES

Table 6: Patient signalment and FCoV antibody titer for suspected FIP cats presented to UVH, UPM from 2014-2016

No.	Case#	Breed	Sex	Age	Dry/Wet Form	FCoV AB titer
1	061353	DLH	M	2 yrs	Susp wet form FIP	S3
2	045001	DSH	M	2 yrs	Susp Wet Form FIP	S3
3	073668	DSH	M	1 yr	Susp. Wet Form FIP	S3
4	060780	DSH	M	4 yrs	Susp. Wet Form FIP	S3
5	074309	DSH	SF	2 yrs	Susp. Wet Form FIP	S3
6	054852	DSH	CM	4 yrs	Susp Wet Form FIP	S3
7	074470	Persian	M	1 yr	Susp. Wet Form FIP	S3
8	064025	DSH	M	2 yrs	Susp wet form FIP	S3
9	057413	DSH	F	9 mths	Susp Dry Form FIP	S3
10	070373	British Blue	M	7 mths	Susp. Wet Form FIP	S3
11	073654	DSH	M	1 yr	Susp. Wet Form FIP	S3
12	074685	DSH	F	3 mths	Susp. Dry Form FIP	S3
13	070461	DSH	M	Adult	Susp. Wet Form FIP	S3
14	063578	Persian	M	1 yr	Susp wet form FIP	S3
15	063291	DSH	M	10 mths	Susp dry form FIP	S3
16	063316	DSH	SF	7 mths	Susp wet form FIP	S3
17	061332	DSH	M	2 yrs	Susp wet form FIP	S3
18	063231	DSH	F	1 yr	Susp wet form FIP	S3
19	062402	DSH	M	2 yrs	Susp wet form FIP	S3
20	057897	DSH	M	1 yr	Susp Dry Form FIP	S3
21	055327	DSH	F	9 mths	Susp Wet Form FIP	S3
22	068144	Persian	M	7 mths	Susp dry form FIP	S3
23	062849	DSH	M	1 yr	Susp dry form FIP	S3
24	066166	DSH	SF	1 yr	Susp dry form FIP	S3
25	067573	Mainecoon	F	5 mths	Susp wet form FIP	S3
26	071652	DSH	M	8 mths	Susp. Wet Form FIP	S3
27	070287	DSH	M	2 yrs	Susp. Wet Form FIP	S3
28	069697	DSH	CM	1 yr	Susp. Wet Form FIP	S4
29	057900	DSH	CM	2 yrs	Susp Wet Form FIP	S4
30	070565	DSH	F	4 mths	Susp. Wet Form FIP	S4
31	059411	Persian	M	1 yr	Susp Wet Form FIP	S4
32	072521	DLH	F	1 yr	Susp. Dry Form FIP	S4
33	059147	Persian	M	4 mths	Susp Wet Form FIP	S4
34	055395	DSH	F	5 mths	Susp Wet Form FIP	S4
35	063117	Bengal	M	6 mths	Susp dry form FIP	S4
36	062543	Persian	M	2 yrs	Susp dry form FIP	S4
37	063331	DSH	M	3 yrs	Susp dry form FIP	S4
38	058256	Persian	F	6 mths	Susp Wet Form FIP	S4
39	055380	DSH	F	1 yr	Susp Dry Form FIP	S4
40	059066	DSH	F	2 yrs	Susp Wet Form FIP	S4
41	058174	DSH	F	9 mths	Susp Wet Form FIP	S4
42	060751	DSH	F	1 yr	Susp Dry Form FIP	S4

43	057071	DSH	M	1 yr	Susp dry form FIP	S4
44	055264	DSH	M	3 yrs	Susp Dry Form FIP	S4
45	055755	DSH	CM	3 yrs	Susp Dry Form FIP	S4
46	055647	DSH	M	1 yr	Susp Wet Form FIP	S4
47	073029	DSH	M	9 mths	Susp. Wet Form FIP	S4
48	051350	DSH	SF	1 yr	Susp Dry Form FIP	S4
49	054712	DSH	M	3 yrs	Susp Wet Form FIP	S4
50	056051	DSH	M	1 yr	Susp Wet Form FIP	S4
51	063266	Maincoon	M	9 mths	Susp dry form FIP	S4
52	043816	DSH	M	6 yrs	Susp Wet Form FIP	S4
53	054613	DSH	CM	3 yrs	Susp Dry Form FIP	S4
54	073706	DLH	M	2 yrs	Susp. Dry Form FIP	S4
55	063458	DSH	F	4 mths	Susp wet form FIP	S4
56	062544	DSH	F	adult	Susp dry form FIP	S4
57	072968	ASH	M	3 yrs	Susp. Dry Form FIP	S4
58	055709	DSH	M	6 mths	Susp Dry Form FIP	S4
59	073234	Munchkin	F	1 yr	Susp. Dry Form FIP	S4
60	073865	DSH	M	1 yr	Susp. Wet Form FIP	S4
61	065982	Persian	M	5 mths	Susp wet form FIP	S4
62	073495	DSH	M	1 yr	Susp. Wet Form FIP	S5
63	061321	DSH	SF	7 yrs	Susp wet form FIP	S5
64	066147	DSH	F	2 yrs	Susp wet form FIP	S5
65	054769	DSH	SF	10 mths	Susp Dry Form FIP	S5
66	066227	DSH	M	adult	Susp wet form FIP	S5
67	068546	DSH	M	1 yr	Susp. Wet Form FIP	S5
68	062471	Persian	M	1 yr	Susp wet form FIP	S5
69	067524	DSH	CM	6 yrs	Susp dry form FIP	S5
70	061249	Maine Coon	M	7 mths	Susp wet form FIP	S5
71	056568	DSH	M	1 yr	Susp Wet Form FIP	S5
72	061586	DSH	CM	3 yrs	Susp wet form FIP	S5
73	058752	Persian	SF	4 yrs	Susp Wet Form FIP	S5
74	066300	DSH	M	2 yrs	Susp wet form FIP	S5
75	058729	DSH	M	10 yrs	Susp Wet Form FIP	S5
76	067411	DLH	M	1 yr	Susp dry form FIP	S5
77	062155	DSH	F	2 yrs	Susp. Wet Form FIP	S5
78	072220	DSH	SF	2 yrs	Susp. Dry Form FIP	S5
79	066051	DSH	M	7 mths	Susp dry form FIP	S5
80	066975	DSH	CM	2 yrs	Susp dry form FIP	S5
81	066258	Persian	F	1 yr	Susp dry form FIP	S5
82	068417	Mainecoon	M	1 yr	Susp wet form FIP	S5
83	066788	DSH	M	2 yrs	Susp wet form FIP	S5
84	067221	DLH	F	8 mths	Susp wet form FIP	S5
85	056535	DSH	CM	2 yrs	Susp Wet Form FIP	S5
86	056146	DSH	M	6 mths	Susp Wet Form FIP	S5
87	069596	Persian	M	1 yr	Susp. Dry Form FIP	S5
88	074719	DSH	M	3 yrs	Susp. Dry Form FIP	S5
89	057650	DSH	F	10 mths	Susp Dry Form FIP	S5

90	055487	DSH	M	1 yr	Susp Wet Form FIP	S5
91	055332	DLH	M	3 yrs	Susp Wet Form FIP	S5
92	073317	Persian	M	6 mths	Susp. Wet Form FIP	S5
93	072416	DSH	M	1 yr	Susp. Dry Form FIP	S5
94	055940	DSH	M	5 mths	Susp Wet Form FIP	S5
95	056720	DSH	M	4 yrs	Susp Wet Form FIP	S5
96	075187	DSH	SF	2 yrs	Susp. Wet Form FIP	S5
97	073965	DSH	M	1 yr	Susp. Wet Form FIP	S5
98	055961	DSH	M	5 mths	Susp Wet Form FIP	S5
99	059112	DSH	M	2 yrs	Susp Wet Form FIP	S5
100	056137	Bengal	M	1 yr	Susp Dry Form FIP	S5
101	066660	DSH	CM	1 yr	Susp wet form FIP	S5
102	067264	Persian	F	1 yr	Susp wet form FIP	S5
103	066222	Persian	M	2 yrs	Susp wet form FIP	S5
104	059055	Persian	F	1 yr	Susp Dry Form FIP	S5
105	062217	Persian	M	8 mths	Susp dry form FIP	S5
106	056443	Maine Coon	F	6 mths	Susp Wet Form FIP	S5
107	069494	DLH	M	3 yrs	Susp. Dry Form FIP	S5
108	064157	DSH	M	1 yr	Susp wet form FIP	S5
109	068452	Persian	M	8 mths	Susp. Dry Form FIP	S5
110	068230	DSH	M	1 yr	Susp wet form FIP	S5
111	056067	Maine Coon	M	1 yr	Susp Wet Form FIP	S5
112	058613	Persian	M	1 yr	Susp Dry Form FIP	S5
113	073567	DSH	M	1 yr	Susp. Dry Form FIP	S5
114	056262	DSH	M	4 yrs	Susp Wet Form FIP	S5
115	072904	DSH	M	3 yrs	Susp. Dry Form FIP	S5
116	068311	DSH	M	2 yrs	Susp dry form FIP	S5
117	064002	Persian	M	1 yr	Susp wet form FIP	S5
118	071013	Persian	M	5 mths	Susp. Wet Form FIP	S5
119	066758	DSH	F	5 mths	Susp dry form FIP	S5
120	057541	DSH	M	5 yrs	Susp Dry Form FIP	S5
121	059610	DSH	M	3 yrs	Susp Dry Form FIP	S5
122	061613	DSH	M	2 yrs	Susp wet form FIP	S5
123	071615	Siamese	M	1 yr	Susp. Dry Form FIP	S5
124	062360	DSH	F	1 yr	Susp dry form FIP	S5
125	056279	DSH	M	5 mths	Susp Wet Form FIP	S5
126	072181	DSH	M	7 mths	Susp. Dry Form FIP	S5
127	070628	DLH	F	2 yrs	Susp. Dry Form FIP	S5
128	064291	DSH x	M	8 mths	Susp. Dry Form FIP	S5
129	054832	DSH	SF	adult	Susp Dry Form FIP	S5
130	063967	DSH	F	2 yrs	Susp dry form FIP	S5
131	054759	DSH	F	adult	Susp Wet Form FIP	S5
132	066016	DSH	F	1 yr	Susp dry form FIP	S5

Table 7: Haematological parameters for suspected FIP cats presented to UVH. UPM from 2014-2016

No.	Anemic Status	Total WBC	Band Neu	Seg Neu	Lymph ocyte	Mono cyte	Eosin ophil	Baso phil	Throm bocyte
1	normal	7.12	0.07	6.48	0.36	0.21	0	0	33.6
2	normal	7.79	0.08	6.23	0.47	1.01	0	0	60.4
3	non resp anemia	14	0.42	12.18	0.56	0.84	0	0	78.6
4	non resp anemia	11.1	0.22	9.32	0.56	0.89	0.11	0	144
5	normal	17.1	0.51	14.88	0.86	0.68	0.17	0	298
6	normal	8.61	0.17	7.06	0.86	0.34	0.17	0	40
7	normal	6.96	0.14	5.64	0.9	0.28	0	0	69.9
8	non resp anemia	18.9	0.57	16.07	0.95	1.13	0.19	0	35.9
9	non resp anemia	7.42	0.3	5.05	1.04	0.37	0.67	0	32.5
10	normal	19.1	0.57	16.43	1.15	0.96	0	0	24.5
11	normal	15.9	0.48	13.36	1.27	0.8	0	0	165
12	non resp anemia	10.7	0.21	8.67	1.39	0.32	0.11	0	470
13	non resp anemia	14.8	0.3	11.99	1.48	1.04	0	0	0.1
14	non resp anemia	11.7	0.12	9.13	1.52	0.82	0.12	0	66.5
15	non resp anemia	14	0.28	10.78	1.68	0.42	0.84	0	412
16	non resp anemia	21.3	0.64	16.19	1.7	2.34	0.43	0	129
17	normal	11.4	0.11	8.66	1.71	0.46	0.46	0	278
18	non resp anemia	15.8	0.47	12.8	1.74	0.79	0	0	184
19	resp anemia	19.6	0.58	14.55	1.75	0.58	1.94	0	320
20	normal	45.3	1.36	39.41	1.81	2.27	0.45	0	126
21	normal	11.2	0.11	8.51	1.9	0.45	0.22	0	235
22	normal	15.3	0.31	11.63	1.99	1.22	0.15	0	158
23	non resp anemia	8.17	0.25	5.47	2.04	0.41	0	0	10
24	normal	17.9	0.54	13.6	2.15	1.25	0.36	0	52.4
25	normal	23	0.69	17.48	2.76	1.84	0.23	0	57.6
26	normal	24.9	0.5	20.17	2.99	1.25	0	0	418
27	normal	30.3	0.91	21.82	4.24	1.21	2.12	0	246
28	normal	17.9	0.54	16.65	0.18	0.54	0	0	68
29	non resp anemia	10.7	0.21	9.74	0.32	0.43	0	0	10
30	normal	6.66	0.07	5.73	0.53	0.27	0.07	0	.
31	normal	8.6	0.09	7.48	0.6	0.43	0	0	900
32	normal	6.2	0.06	4.96	0.74	0.37	0.06	0	950

33	non resp anemia	15	0.45	13.35	0.75	0.45	0	0	53.7
34	non resp anemia	10.9	0.22	9.48	0.76	0.44	0	0	64.1
35	normal	17	0.51	14.28	0.85	1.02	0	0	106
36	normal	21.2	0.42	18.23	0.85	1.27	0.42	0	64.9
37	normal	9.1	0.09	6.83	0.91	0.55	0.73	0	81.1
38	normal	18.8	0.75	16.54	1.13	0.38	0	0	591
39	normal	12	0.36	9.84	1.2	0.48	0.12	0	78.3
40	normal	12.2	0.12	9.52	1.22	0.73	0.61	0	69.9
41	normal	13	0.39	10.66	1.3	0.52	0.13	0	41.8
42	normal	11.4	0.11	9.01	1.37	0.68	0.23	0	39.1
43	resp anemia	18.2	0.64	13.3	1.61	0.5	0	0	67
44	normal	15	0.3	12.3	1.65	0.75	0	0	540
45	normal	16.9	0.34	13.35	1.69	0.51	1.01	0	208
46	normal	34.2	0.68	28.39	1.71	3.42	0	0	73
47	non resp anemia	17.2	0.52	14.28	1.72	0.69	0	0	277
48	non resp anemia	12.5	0.25	9.88	1.88	0.5	0	0	124
49	non resp anemia	16.2	0.49	12.64	1.94	0.81	0.32	0	33.8
50	normal	11.3	0.23	8.48	2.03	0.45	0.11	0	97.4
51	normal	11.6	0.23	7.77	2.09	0.23	1.28	0	259
52	non resp anemia	35.1	0.7	29.48	2.11	2.81	0	0	23.2
53	normal	18.1	0.54	13.94	2.17	1.45	0	0	211
54	normal	14.8	0.3	11.25	2.22	0.44	0.59	0	77.6
55	normal	23.3	0.47	19.34	2.33	0.93	0.23	0	141
56	normal	23.6	0.47	17.23	2.36	0.47	3.07	0	415
57	normal	14.6	0.29	10.8	2.48	0.88	0.15	0	92
58	normal	18.5	0.56	13.88	2.59	1.48	0	0	25.5
59	normal	11.4	0.11	7.07	3.42	0.57	0.23	0	78.7
60	normal	29.5	0.89	22.13	3.54	1.18	1.77	0	77
61	normal	44.1	1.32	35.28	4.41	2.65	0.44	0	451
62	normal	19.1	0.57	17.19	0.19	1.15	0	0	101
63	non resp anemia	11.3	0.45	9.94	0.34	0.57	0	0	38.1
64	normal	3.58	0.07	3.04	0.36	0.11	0	0	14.1
65	non resp anemia	5.15	0.1	4.27	0.46	0.31	0	0	169
66	non resp anemia	7.77	0.08	6.45	0.54	0.62	0.08	0	14.9
67	normal	11.6	0.23	10.44	0.58	0.35	0	0	90.2
68	normal	9.98	0.2	8.38	0.6	0.8	0	0	900
69	normal	20.2	0.81	17.17	0.61	1.62	0	0	41.3
70	normal	10.7	0.21	9.31	0.64	0.54	0	0	112

71	non resp anemia	8.51	0.17	7.4	0.68	0.26	0	0	246
72	non resp anemia	11.7	0.23	10.41	0.7	0.35	0	0	31.1
73	non resp anemia	10.2	0.2	8.98	0.71	0.31	0	0	31.3
74	non resp anemia	36.1	1.08	31.41	0.72	2.89	0	0	82.5
75	non resp anemia	14.6	0.58	12.85	0.73	0.44	0	0	61.5
76	normal	7.3	0.07	6.13	0.73	0.29	0.07	0	85.2
77	non resp anemia	7.75	0.08	6.51	0.78	0.39	0	0	72.3
78	normal	8.34	0.08	7.01	0.83	0.42	0	0	68
79	normal	6.16	0.06	4.87	0.86	0.31	0.06	0	465
80	non resp anemiaa	12.7	0.25	11.18	0.89	0.38	0	0	43.9
81	non resp anemia	8.88	0.27	7.28	0.89	0.36	0.09	0	249
82	anemia	5.07	0.1	3.8	0.91	0.2	0.05	0	171
83	normal	16	0.64	13.76	0.96	0.64	0	0	131
84	normal	24.6	0.49	21.65	0.98	1.48	0	0	36.2
85	non resp anemia	13.3	0.4	11.31	1.06	0.53	0	0	191
86	non resp anemia	10.7	0.21	9.1	1.07	0.32	0	0	10
87	resp anemia	5.25	0.11	3.73	1.1	0.21	0.11	0	64.5
88	non resp anemia	14.1	0.28	12.13	1.13	0.56	0	0	49.1
89	normal	12.6	0.25	9.2	1.26	0.63	1.26	0	218
90	normal	20.2	0.61	17.17	1.41	1.01	0	0	176
91	normal	16	0.48	13.12	1.44	0.8	0.16	0	16.8
92	non resp anemia	12.2	0.12	10.13	1.46	0.49	0	0	150
93	normal	15.4	0.15	11.7	1.54	1.23	0.77	0	277
94	normal	15.9	0.32	12.24	1.59	0.64	1.11	0	306
95	normal	16.5	0.5	13.53	1.65	0.66	0.17	0	218
96	normal	13.1	0.13	10.22	1.7	0.92	0.13	0	55.5
97	normal	9.49	0.09	7.21	1.71	0.38	0.09	0	287
98	normal	19.1	0.57	15.28	1.72	1.15	0.38	0	1059
99	normal	21.6	0.65	17.93	1.73	1.3	0	0	36.8
100	normal	21.6	0.86	17.71	1.73	1.3	0	0	144
101	normal	17.4	0.52	13.22	1.74	0.7	1.22	0	204
102	normal	17.5	0.53	12.6	1.75	0.53	2.1	0	655
103	normal	44.8	1.34	38.98	1.79	2.69	0	0	274
104	normal	11.5	0.23	8.28	1.84	0.81	0.35	0	153
105	normal	5.75	0.06	3.45	1.9	0.29	0.06	0	110
106	non resp anemia	27.1	0.81	23.31	1.9	1.08	0	0	106

107	normal	14.7	0.15	11.32	1.91	0.74	0.59	0	52.9
108	non resp anemia	39.2	1.18	33.71	1.96	2.35	0	0	77.3
109	non resp anemia	11	0.22	8.14	1.98	0.66	0	0	94.9
110	non resp anemia	18.3	0.55	14.82	2.01	0.92	0	0	404
111	normal	40.4	2.42	34.74	2.02	1.21	0	0	230
112	normal	20.3	0.41	16.85	2.03	1.02	0	0	630
113	normal	27.2	0.82	20.67	2.18	3.54	0	0	48.6
114	resp anemia	16	0.48	12.48	2.24	0.8	0	0	107
115	non resp anemia	12.1	0.12	9.32	2.3	0.36	0	0	73
116	normal	13.6	0.27	9.79	2.31	0.95	0.27	0	148
117	normal	42.4	1.27	36.89	2.54	1.7	0	0	129
118	normal	25.4	0.76	20.07	2.54	0.76	1.27	0	389
119	normal	21.2	0.64	16.96	2.54	1.06	0	0	123
120	non resp anemia	39.8	1.99	33.43	2.79	1.59	0	0	37.4
121	normal	29	0.58	23.2	2.9	2.03	0.29	0	32.8
122	normal	23.5	0.47	18.57	3.06	1.18	0.24	0	36.4
123	normal	18.3	0.37	12.44	3.11	0.92	1.46	0	376
124	non resp anemia	26.5	1.04	21.06	3.12	0.78	0	0	85.5
125	normal	45.5	1.37	36.86	3.19	3.64	0.46	0	361
126	non resp anemia	62	1.86	44.64	3.72	11.16	0.62	0	54
127	normal	34.1	0.68	26.6	3.75	0.68	2.39	0	181
128	normal	10.7	0.11	5.89	3.75	0.21	0.75	0	78.6
129	non resp anemia	22.3	0.45	15.16	3.79	0.67	2.23	0	143
130	non resp anemiaa	23.4	0.7	16.85	3.98	1.17	0.7	0	72.5
131	non resp anemia	22.2	0.67	15.98	4	1.11	0.44	0	31
132	normal	35.1	1.05	23.87	5.62	1.76	2.81	0	479

Table 8: Serum biochemical parameters for suspected FIP cats presented to UVH. UPM from 2014-2016

No.	Total protein	Albumin	Globulin	A:G	ALT	AP	Urea	Creatinine
1	110	27.7	82.3	0.3	35.4	.	6.2	112
2	106.8	24.4	82.4	0.3	72.5	.	8.8	100
3	68.7	17	51.7	0.3	28	.	.	.
4	76.4	21.8	54.6	0.4	33	12	7.7	69
5	94.2	20.3	73.9	0.3	93	.	.	.
6	76.9	27.4	49.5	0.6	50.3	7	5.2	75
7	82.3	19.6	62.7	0.3	40	.	6.7	64
8	74.4	21.6	52.8	0.4	40.8	5	5.1	76
9	65.6	23.5	42.1	0.6	46.5	55	11.8	95
10	85	20.3	64.7	0.3	64	.	4.9	74
11	107.9	20	87.9	0.2	61	.	.	.
12	94.9	19.8	75.1	0.3	59	46	4.3	28
13	107.8	21.1	86.7	0.2	75.9	.	11.1	113
14	96.1	24.4	71.7	0.3	25.9	13	6.9	124
15	97	32.1	64.9	0.5	54.8	11	7	75
16	100.1	27	73.1	0.4	139.8	22	6.3	99
17	105.3	27.1	78.2	0.3	40.7	.	8	133
18	109.1	27.9	81.2	0.3	73.5	8	7.2	118
19	106.4	27	79.4	0.3	113.4	.	10.2	107
20	91.1	25	66.1	0.4	67.1	.	21.8	139
21	71.5	33.4	38.1	0.9	68.4	30	8.4	126
22	134.1	35.3	98.8	0.4	26.1	.	5	8.6
23	68.2	26.4	41.8	0.6	29.7	1	13.8	96
24	142.8	31.3	111.5	0.3	55.7	36	12.4	154
25	83.2	22.5	60.7	0.4	46.5	4	7.4	125
26	77.8	17.5	60.3	0.3	28	4	5.36	71
27	77.9	23.3	54.6	0.4	28.5	.	6.8	109
28	85.9	23.1	62.8	0.4	39	40	1.3	66
29	56.2	18.7	37.5	0.5	26.9	3	3.1	71
30	76.1	22.9	53.2	0.4	33.2	.	5.6	97
31	72.6	21.5	51.1	0.4	37.9	.	2.8	56
32	80.1	32.4	47.7	0.7	73	.	7.2	87
33	90	14.4	75.6	0.2	30.9	.	3.4	56
34	59.9	22.4	37.5	0.6	18.6	3	5.6	61
35	94.3	27.7	66.6	0.4	31.2	.	11.2	102
36	87.2	38.7	48.5	0.8	37	10	5.2	97
37	115.3	39	76.3	0.5	138.3	17	9.2	129
38	84	26.1	57.9	0.5	71.4	.	4.8	63
39	118.1	26.2	91.9	0.3	139.9	43	5.6	130
40	94	28.5	65.5	0.4	24.9	.	9	108
41	91.9	26.4	65.5	0.4	37.3	12	5.2	87

42	113.5	30.7	82.8	0.4	44	.	9.1	139
43	90.1	26.4	62.7	0.4	30.3	.	7.9	107
44	81.6	25.7	55.9	0.5	34	18	3.7	95
45	77.4	29.1	48.3	0.6	.	.	.	.
46	97.3	22.2	75.1	0.3	26.2	3	5.6	94
47	74.5	21.1	53.4	0.4	37	12	8.9	68
48	130.1	21.8	108.3	0.2	39.6	13	5.8	94
49	103	26.8	76.2	0.4	33.5	12	8.1	115
50	92.2	29.1	63.1	0.5	46	.	6.1	96
51	79.6	39.9	39.7	1.0	58.8	.	11.5	151
52	95.1	27.2	67.9	0.4	28.7	.	5.9	87
53	118.5	31.8	86.7	0.4	26.9	4	5.5	105
54	86.8	29	57.8	0.5	29	.	5.4	82
55	95.8	28.2	67.6	0.4	54.2	11	5.4	124
56	91.7	39	52.7	0.7	265	18	8	128
57	108.5	28	80.5	0.3	28	.	8.4	92
58	57.5	26.4	31.1	0.8	128	17	7.4	118
59	99.9	22.4	77.5	0.3	49	.	4.8	51
60	108.8	22	86.8	0.3	.	.	.	.
61	97.3	30.4	66.9	0.5	56.8	.	7.7	117
62	72.7	16.9	55.8	0.3	23	39	4.3	64
63	79.8	23.7	56.1	0.4	29	3	5.3	66
64	91.4	21.2	70.2	0.3	112	38	17.7	189
65	120	31	89	0.3	45.4	21	7.2	108
66	111.3	26.2	85.1	0.3	36.4	.	6.9	95
67	70.6	21.9	48.7	0.4	28.4	.	4.3	64
68	87.7	24.6	63.1	0.4	28.2	1	3.3	77
69	103.3	26.2	77.1	0.3	63.5	.	5.2	102
70	93.3	23.7	69.6	0.3	109.8	90	7.8	69
71	82.5	22.6	59.9	0.4	29.7	1	8.8	81
72	49	18.5	30.5	0.6	28.7	4	4.4	82
73	79.3	18.6	60.7	0.3	13.7	6	5.4	74
74	78	19.6	58.4	0.3	25.9	.	3.2	51
75	88.1	20.5	67.6	0.3	19.5	6	7.1	82
76	114.6	28.5	86.1	0.3	89.7	.	6.3	87
77	94.4	26.5	67.9	0.4	20	15	12	74
78	115.7	23.1	92.6	0.2	28	.	6.4	69
79	100.8	42.9	57.9	0.7	95.7	.	11	95
80	115.1	25.2	89.9	0.3	19.4	9	4.8	93
81	90.4	20.5	69.9	0.3	21.3	9	5.1	46
82	109.4	22.2	87.2	0.3	68.9	.	11.5	125
83	83.4	20.2	63.2	0.3	16.6	3	10	77
84	83.6	34.1	49.5	0.7	35.8	16	6	57
85	90.2	23.2	67	0.3	35	.	3.2	69
86	50.7	14.7	36	0.4	30.8	.	3.7	53
87	84.9	28.8	56.1	0.5	39.9	.	6.1	102
88	108.1	20.3	87.8	0.2	127	.	7	56

89	136.1	26.2	109.9	0.2	26.1	.	5.3	91
90	68	16.4	51.6	0.3	255.9	15	6.4	120
91	69	25.5	43.5	0.6	28.7	4	8.3	112
92	70.8	21.1	49.7	0.4	53	.	3.8	63
93	87.6	33.5	54.1	0.6	84	.	7.2	109
94	72	24.3	47.7	0.5	21.9	.	6.7	80
95	84.4	28.9	55.5	0.5	56.1	17	4.6	120
96	92	24.6	67.4	0.4	30	12	10.4	71
97	111.8	25	86.8	0.3	103	.	6.9	122
98	89.9	28	61.8	0.5	51.8	.	12.8	95
99	60.7	23	37.7	0.6	71.8	6	6.4	76
100	74.7	31.4	43.3	0.7	48.4	8	7.8	132
101	123.1	26.7	96.4	0.3	34.5	9	11.7	125
102	84.1	31.2	52.9	0.6	65.8	28	8	83
103	89.5	23	66.5	0.3	31.2	.	7.4	91
104	93.5	28.3	65.2	0.4	24.6	13	5	72
105	95.9	30.5	65.4	0.5	77.3	15	6.3	114
106	84.1	28.8	55.3	0.5	52.2	21	6.7	83
107	110.3	26.6	83.7	0.3	24.5	10	10.5	114
108	71.8	21.9	49.9	0.4	16.1	.	8.8	91
109	108.1	25.7	82.4	0.3	33.3	.	3.6	92
110	80.7	23.7	57	0.4	12.3	.	9.3	102
111	61.1	25.2	35.9	0.7	122.5	46	15.1	96
112	115.2	29.8	85.4	0.3	35.6	20	14.4	148
113	72.7	22.3	50.4	0.4	86	26	.	.
114	95.8	25.3	70.5	0.4	33.5	.	8.7	89
115	112.1	19.4	92.8	0.2	80	.	11	82
116	88.2	38.6	49.6	0.8	35.1	19	5.8	121
117	95.8	20.4	75.4	0.3	62.4	18	4	64
118	89.1	23.8	65.3	0.4	33.9	.	5.8	162
119	99.8	48.4	51.4	0.9	121.3	39	15.5	112
120	118	25.6	92.4	0.3	65.2	6	16.3	103
121	100.6	27.4	73.2	0.4	123.5	28	8	125
122	73.3	24.3	49	0.5	36.6	.	10.3	184
123	86	27.9	58.1	0.5	73.4	.	6.8	85
124	128.9	29.4	99.5	0.3	42.1	.	12.9	78
125	67.8	27.6	40.2	0.7	19.5	.	4.7	79
126	80	17.2	62.8	0.3	95	10	17.9	79
127	80.4	27.2	53.2	0.5	29.1	32	3.1	62
128	78	33.8	44.2	0.8	33.2	.	.	143
129	83.8	31.1	52.7	0.6	72.5	18	28.8	399
130	114	24.8	89.2	0.3	72.7	21	6	77
131	99.8	20.4	79.4	0.3	19.7	.	5.2	100
132	102.4	23.1	79.3	0.3	54.2	.	6.8	91