

# Effect of sex, age and strain on hematological and blood clinical chemistry in healthy canine

Arunee Jangsangthong<sup>1</sup>, Pongpun Suwanachat<sup>2</sup>, Pariyakorn Jaykum<sup>2</sup>, Supakit Buamas<sup>2</sup>,  
Waraporn Kaewkongjan<sup>2</sup> and Shutipen Buranasinsup<sup>1\*</sup>

<sup>1</sup>Department of Pre-clinic and Applied Animal Science, Faculty of Veterinary Science, Mahidol University, Nakornpathom, Thailand, 73170

<sup>2</sup>Laboratory of Prasuarthon hospital, Faculty of Veterinary Science, Mahidol University, Nakornpathom, Thailand, 73170

\*Corresponding author, E-mail address: shutipen.bur@mahidol.ac.th

## Abstract

The hematological and blood clinical chemistry are essential for determine the physical health, diagnosis and prognosis of the disease. However, they may vary with race, nutrition, age, sex, stress and disease. The aim of the present study was to investigate the effect of sex, age and strain on the hematology and blood clinical chemistry. Canines (n=134) were divided into 5 groups depend on age, 2 groups depend on sex and 4 groups depend on strain. The effect of age was found on monocytes, neutrophils, hematocrit (Hct), plasma protein (PP) and alanine aminotransferase (ALT) values while the effect of sex was found on mean corpuscular hemoglobin concentration (MCHC) and ALT values. In addition, the effect of strain was found on many parameters including neutrophils, lymphocytes, hemoglobin (Hb), Hct, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), MCHC, platelet (Plt), red cell distribution width (RDW), ALT and blood urea nitrogen (BUN). In conclusion, hematological and blood clinical chemistry in canine which are essential for determine the physical health and for further diagnosis as well as prognosis the disease are influenced by many parameters studied such as sex, age and strain.

**Keywords:** Age, Sex, Strain, Hematology and blood clinical chemistry, Healthy canine

## ผลกระทบของเพศ อายุ และพันธุ์ ต่อค่าทางโลหิตวิทยาและเคมีในเลือด ของสุนัขที่มีสุขภาพดี

อรุณี แจ่มแสงทอง<sup>1</sup> พงษ์พันธุ์ สุวรรณชาติ<sup>2</sup> ปรียากร จายคำ<sup>2</sup>  
ศุภกิจ บัวมาศ<sup>2</sup> วราภรณ์ แก้วคงจันทร์<sup>2</sup> ชุตติเพ็ญ บุรณะสินทรัพย์<sup>1\*</sup>

<sup>1</sup>ภาควิชาปรีคลินิกและสัตวศาสตร์ประยุกต์ คณะสัตวแพทยศาสตร์ มหาวิทยาลัยมหิดล นครปฐม 73170

<sup>2</sup>ห้องปฏิบัติการโรงพยาบาลประจวบคีรีขันธ์ คณะสัตวแพทยศาสตร์ มหาวิทยาลัยมหิดล นครปฐม 73170

\*ผู้รับผิดชอบบทความ E-mail address: shutipen.bur@mahidol.ac.th

### บทคัดย่อ

ค่าทางโลหิตวิทยาและเคมีในเลือดมีความสำคัญต่อการตรวจสุขภาพสัตว์ วิจัยจัยโรค และพยากรณ์โรค อย่างไรก็ตาม ค่าทางโลหิตวิทยาและเคมีในเลือดสามารถแปรผันได้ตามสายพันธุ์ อาหาร อายุ เพศ ความเครียดและภาวะเป็นโรค การศึกษาที่ผู้วิจัยต้องการศึกษาถึงผลกระทบของเพศ อายุ และพันธุ์ที่มีต่อค่าทางโลหิตวิทยาและเคมีในเลือด สุนัขที่นำมาทำการศึกษากลับแบ่งออกเป็นกลุ่มๆ โดยแบ่งเป็น 5 กลุ่มตามเกณฑ์อายุ แบ่งเป็น 2 กลุ่มตามเพศ และแบ่งเป็น 4 กลุ่มตามเกณฑ์ขนาดของสายพันธุ์ ผู้วิจัยพบว่า อายุมีผลกระทบต่อค่าเม็ดเลือดขาวชนิดโมโนไซต์และนิวโทรฟิลด์ เม็ดเลือดแดงอัดแน่น (Hct) พลาสมาโปรตีน และเอนไซม์อะลานีน อะมิโนทรานเฟอเรส ในขณะที่ เพศมีผลกระทบต่อค่าความเข้มข้นเฉลี่ยของฮีโมโกลบินในเม็ดเลือดแดง (MCHC) และเอนไซม์อะลานีนอะมิโนทรานเฟอเรส นอกจากนี้ ผู้วิจัยยังพบอีกว่า การแบ่งสุนัขตามขนาดของสายพันธุ์มีผลกระทบต่อค่าทางโลหิตวิทยาและเคมีในเลือดหลายค่า ได้แก่ ค่าเม็ดเลือดขาวชนิดนิวโทรฟิลด์และลิมโฟไซต์ ค่าฮีโมโกลบิน ค่าเม็ดเลือดแดงอัดแน่น ปริมาตรของเม็ดเลือดแดงโดยเฉลี่ย (MCV) ปริมาณเฉลี่ยของฮีโมโกลบินในเม็ดเลือดแดง (MCH) ความเข้มข้นเฉลี่ยของฮีโมโกลบินในเม็ดเลือดแดง (MCHC) จำนวนเกล็ดเลือด ความกว้างของการกระจายขนาดเม็ดเลือดแดง (RDW) เอนไซม์อะลานีนอะมิโนทรานเฟอเรส และระดับไนโตรเจนในเลือด (BUN)

คำสำคัญ : อายุ เพศพันธุ์ ค่าทางโลหิตวิทยาและค่าเคมีในเลือด สุนัขสุขภาพดี

## Introduction

The hematological and blood clinical chemistry are essential for determine the physical health, diagnosis and prognosis of the disease. However, they may vary with race, nutrition, age, sex, stress and disease (Dimopoulos, 1963). There are several reported about the effect of age on hematological and blood clinical chemistry in canine (Harper *et al.*, 2003; Bulgin *et al.*, 1970; Earl *et al.*, 1973; Lowseth *et al.*, 1990). In addition, there are inborn hematological and serum biochemical differences in some breed such as microcytosis in ShibaInus (Gook in *et al.*, 1998), idiopathic macrothrombocytopenia in Cavalier King Charles Spaniels (Singh and Lamb, 2005), hyperlipoproteinemia in miniature Schnauzers (Rogers *et al.*, 1975) and hypercholesterolemia in rough collie dogs (Jeusette *et al.*, 2004). In other countries, there are many studies about the breed specific on hematological and blood clinical chemistry such as Afghan hound, saluki and whippet (Hilppo, 1986), beagle, German shepherd and golden retriever (Michaelson *et al.*, 1966; Cramer *et al.*, 1969; Lund *et al.*, 2000), mongrel and greyhound (Porter and Canaday, 1971; Watts, 2006; Shiel *et al.*, 2007) and adult Bernese mountain dogs (Nielsen *et al.*, 2009). In Thailand, Kaewsakorn *et al.* studied the effect of strain in term of small, medium and large in size on the hematology and blood clinical chemistry in canine. However, little is known about the effect of sex, age and strain on these parameters. Hence, the aim of this study was to investigate the effect of sex, age and strain on the hematology and blood clinical chemistry in canine.

## Materials and Methods

### Sample collection

Whole blood was collected from 92 healthy canines that visited Prasuarthon hospital and 42 canines that lived in the shelter, namely "Salaya-love-dog". The healthy canines were evaluated by veterinarian. The evaluated parameters compose of normal hair coat,

normal hydration status, normal appetite, normal gait and posture, pink mucous membrane, not emaciated no nasal-ocular discharge, no fever, no vomit, no diarrhea etc. Blood was collected from saphenous vein by aseptically technique. The method of specimen examination was performed according to the previous reported (Jangsangthong and Buranasinsup, 2011). For hematological analysis, blood was collected in EDTA-tube while blood for clinical chemistry analysis was collected in glass tube and let stand in room temperature for clotting. After blood clot, the serum was collected by centrifugation at 3,000 rpm for 5 minutes. The serum which didn't analyze within day of collection was kept at -20°C until analysis.

### Classification of canines

Healthy canines were classified by age, sex and strain.

For age, canines were divided into 5 groups: Group 1 was the canine 1 - 6 months of age; Group 2 was the canine over 6 months - 12 months of age; Group 3 was the canine over 1 year - 5 years of age; Group 4 was the canine over 5 years - 10 years of age and Group 5 was the canine over 10 years of age.

For sex, canines were divided into 2 groups: male and female.

For strain, canines were divided into 4 groups depend on dog breed standard and weight (trainpetdog.com, 2012): Group 1 was the canine which was very small in size; Group 2 was the canine which was small in size; Group 3 was the canine which is medium in size and Group 4 was the canine which was large in size.

### Hematological and blood clinical chemistry analysis

Complete blood count (CBC) was analyzed by hematology analyzer "Cell-Dyn 3700" (Abbott Diagnostics, USA). The following parameters were measured: total red blood cell count (RBC), hemoglobin (Hb), hematocrit (Hct), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular

hemoglobin concentration (MCHC), red cell distribution width (RDW), total white blood cell count (WBC), neutrophils, lymphocytes, monocytes, eosinophils, basophils, total platelet count (Plt). The white blood cell differential count was also performed by Modified Wright-stained blood smears. Plasma protein (PP) was measured by refractometer.

Blood clinical chemistry was analyzed by chemistry analyzer "BS-300" (Mindray, China). The measured parameters compose of alkaline phosphatase (ALP), alanine aminotransferase (ALT), aspartate aminotransferase (AST), blood urea nitrogen (BUN), creatinine (Crea) and total protein (TP).

#### **Statistical analysis**

Prior to analysis of variance (ANOVA), normal distribution of all data in each parameter, were checked by Kolmogorov-Smirnov test. The outlier data in each parameter were excluded. All of data have normal distribution except monocyte, eosinophil, basophil and creatinine. Data which have normal distribution were compared different in sex, age and strain by using ANOVA test. Data processing and statistical analysis were performed using Microsoft Excel 2010 and SPSS

version 18.0 (SPSS 18.0; SPSS Inc, Chicago, IL, USA). Duncan's multiple-comparison test was used to assess the statistical significance of differences among the study groups. Monocyte, eosinophil, basophil and creatinine were analyzed by Mann-Whitney U test for study the difference in sex whereas Kruskal-Wallis H test was used to study the difference in age and strain. A level of  $P < 0.05$  was accepted as statistically significant.

#### **Results**

The average values of hematological and blood clinical chemistry are shown in table 1. The effect of sex, age and strain on hematological and blood clinical chemistry values are shown in table 2. However, there are some missing values in age, sex and strain then the total number in table 2 did not equal to the total number of samples size ( $n = 134$ ). We found that age affect to monocytes, neutrophils, Hct, PP and ALT values while sex affect to MCHC and ALT values. The effect of strain was also found on many parameters including neutrophils, lymphocytes, Hb, Hct, MCV, MCH, MCHC, Plt, RDW, ALT and BUN.

**Table 1** Hematological and blood clinical chemistry values

Hematological and blood clinical chemistry	Number of samples	Mean $\pm$ SD	Range	Reference values
RBC ( $\times 10^{12}$ cells/L)	131	6.58 $\pm$ 0.90	5.68 - 7.48	5.5 - 8.5 <sup>a</sup>
Hb (g/dl)	131	15.56 $\pm$ 2.24	13.32 - 17.8	12 - 19 <sup>a</sup>
Hct (%)	131	44.38 $\pm$ 6.08	38.3 - 50.46	43 - 57 <sup>a</sup>
MCV (fl)	131	67.32 $\pm$ 4.19	63.13 - 71.51	66 - 77 <sup>a</sup>
MCH (pg)	131	23.59 $\pm$ 1.30	22.29 - 24.89	19.5 - 24.5 <sup>a</sup>
MCHC (g/dl)	131	35.09 $\pm$ 1.59	33.5 - 36.68	32 - 36 <sup>a</sup>
RDW (%)	131	17.38 $\pm$ 2.16	15.22 - 19.54	12 - 15 <sup>a</sup>
WBC ( $\times 10^9$ cells/L)	131	11.84 $\pm$ 4.12	7.72 - 15.96	6 - 17 <sup>a</sup>
Neutrophil (%)	131	70.44 $\pm$ 13.99	56.45 - 84.43	60 - 77 <sup>a</sup>
Lymphocyte (%)	131	22.38 $\pm$ 10.06	12.32 - 32.44	12 - 30 <sup>a</sup>
Monocyte (%)	131	1.44 $\pm$ 1.68	0 - 3.12	3 - 10 <sup>a</sup>
Eosinophil (%)	131	4.18 $\pm$ 4.33	0 - 8.51	2 - 10 <sup>a</sup>
Basophil (%)	131	0.11 $\pm$ 1.22	0 - 1.33	Rare <sup>a</sup>
PLT ( $\times 10^9$ cells/L)	131	271.92 $\pm$ 137.80	134.12 - 409.72	200 - 500 <sup>a</sup>
Plasma protein (g/dl)	134	9.16 $\pm$ 0.92	8.24 - 10.08	6 - 7.5 <sup>b</sup>
ALP (U/L)	117	62.68 $\pm$ 33.61	29.07 - 96.29	1 - 114 <sup>b</sup>
ALT (U/L)	120	38.13 $\pm$ 15.09	23.04 - 53.22	10 - 109 <sup>b</sup>
AST (U/L)	124	33.19 $\pm$ 10.16	23.03 - 43.35	13 - 15 <sup>b</sup>
BUN (mg/dl)	130	15.84 $\pm$ 6.71	9.13 - 22.55	8 - 28 <sup>b</sup>
Creatinine (mg/dl)	131	1.03 $\pm$ 0.23	0.8 - 1.26	0.5 - 1.7 <sup>b</sup>
Total protein (g/dl)	130	7.41 $\pm$ 1.23	6.18 - 8.64	5.4 - 7.5 <sup>b</sup>

<sup>a</sup>Data from Salakij (2005)<sup>b</sup>Data from Latimer *et al.* (2003)

**Table 2** Effect of sex, age and strain on hematological and blood clinical chemistry values

Parameters	Factors	Levels	Number	Mean $\pm$ SD	p-value
RBC ( $\times 10^{12}$ cells/L)	Age	1 - 6 Mo	3	7.47 $\pm$ 0.67	0.090
		over 6 Mo - 12 Mo	5	6.94 $\pm$ 0.55	
		over 1 Y - 5 Y	52	6.63 $\pm$ 0.80	
		over 5 Y - 10 Y	29	6.26 $\pm$ 1.01	
		over 10 Y	6	6.69 $\pm$ 0.82	
	Sex	Male	48	6.42 $\pm$ 0.94	0.060
		Female	54	6.74 $\pm$ 0.76	
	Strain	Very small	22	6.88 $\pm$ 0.65	0.194
		Small	15	6.61 $\pm$ 0.82	
		Medium	48	6.39 $\pm$ 0.98	
		Large	9	6.53 $\pm$ 0.75	
Hb (g/dl)	Age	1 - 6 Mo	3	18.00 $\pm$ 1.49	0.052
		over 6 Mo - 12 Mo	5	16.36 $\pm$ 2.07	
		over 1 Y - 5 Y	52	15.51 $\pm$ 2.07	
		over 5 Y - 10 Y	29	14.65 $\pm$ 2.31	
		over 10 Y	6	16.05 $\pm$ 1.80	
	Sex	Male	48	15.08 $\pm$ 2.33	0.056
		Female	54	15.90 $\pm$ 1.99	
	Strain	Very small	22	16.74 $\pm$ 1.62	0.000
		Small	15	15.83 $\pm$ 1.95	
		Medium	48	14.51 $\pm$ 2.20	
		Large	9	15.7 $\pm$ 1.35	
Hct (%)	Age	1 - 6 Mo	3	52.07 $\pm$ 4.44	0.015
		over 6 Mo - 12 Mo	5	47.76 $\pm$ 4.84	
		over 1 Y - 5 Y	52	44.28 $\pm$ 5.51	
		over 5 Y - 10 Y	29	41.97 $\pm$ 6.29	
		over 10 Y	6	46.52 $\pm$ 5.11	
	Sex	Male	48	43.57 $\pm$ 6.46	
		Female	54	45.08 $\pm$ 5.27	
	Strain	Very small	22	47.85 $\pm$ 4.24	0.000
		Small	15	46.01 $\pm$ 5.23	
		Medium	48	41.16 $\pm$ 5.60	
		Large	9	46.72 $\pm$ 4.16	

**Table 2** Effect of sex, age and strain on hematological and blood clinical chemistry values (cont.)

Parameters	Factors	Levels	Number	Mean $\pm$ SD	p-value
MCV (fl)	Age	1 - 6 Mo	3	69.4 $\pm$ 0.69	0.510
		over 6 Mo - 12 Mo	5	68.56 $\pm$ 2.99	
		over 1 Y - 5 Y	52	66.88 $\pm$ 4.67	
		over 5 Y - 10 Y	29	66.98 $\pm$ 4.38	
		over 10 Y	6	69.62 $\pm$ 4.20	
	Sex	Male	48	67.8 $\pm$ 4.15	0.238
		Female	54	66.79 $\pm$ 4.45	
	Strain	Very small	22	69.46 $\pm$ 2.86	0.000
		Small	15	69.51 $\pm$ 2.44	
		Medium	48	64.67 $\pm$ 4.04	
		Large	9	71.11 $\pm$ 4.28	
MCH (pg)	Age	1 - 6 Mo	3	24.07 $\pm$ 0.91	0.552
		over 6 Mo - 12 Mo	5	23.74 $\pm$ 1.49	
		over 1 Y - 5 Y	52	23.38 $\pm$ 1.40	
		over 5 Y - 10 Y	29	23.29 $\pm$ 1.04	
		over 10 Y	6	24.1 $\pm$ 1.37	
	Sex	Male	48	23.47 $\pm$ 1.07	0.882
		Female	54	23.51 $\pm$ 1.46	
	Strain	Very small	22	24.3 $\pm$ 1.02	0.000
		Small	15	23.93 $\pm$ 1.31	
		Medium	48	22.75 $\pm$ 0.99	
		Large	9	23.83 $\pm$ 1.18	
MCHC (g/dl)	Age	1 - 6 Mo	3	34.4 $\pm$ 1.06	0.788
		over 6 Mo - 12 Mo	5	34.42 $\pm$ 1.01	
		over 1 Y - 5 Y	52	35.06 $\pm$ 1.71	
		over 5 Y - 10 Y	29	34.88 $\pm$ 1.38	
		over 10 Y	6	34.52 $\pm$ 0.93	
	Sex	Male	48	34.63 $\pm$ 1.34	0.039
		Female	54	35.27 $\pm$ 1.72	
	Strain	Very small	22	34.96 $\pm$ 1.42	0.024
		Small	15	34.37 $\pm$ 1.32	
		Medium	48	35.24 $\pm$ 1.65	
		Large	9	33.76 $\pm$ 0.51	

**Table 2** Effect of sex, age and strain on hematological and blood clinical chemistry values (cont.)

Parameters	Factors	Levels	Number	Mean $\pm$ SD	p-value
RDW (%)	Age	1 - 6 Mo	3	15.77 $\pm$ 1.19	0.098
		over 6 Mo - 12 Mo	5	15.42 $\pm$ 3.23	
		over 1 Y - 5 Y	52	17.46 $\pm$ 2.54	
		over 5 Y - 10 Y	29	17.91 $\pm$ 1.95	
		over 10 Y	6	16.08 $\pm$ 2.29	
	Sex	Male	48	17.04 $\pm$ 1.76	0.090
		Female	54	17.79 $\pm$ 2.55	
	Strain	Very small	22	16.39 $\pm$ 1.61	0.001
		Small	15	16.85 $\pm$ 1.75	
		Medium	48	18.27 $\pm$ 2.59	
		Large	9	15.78 $\pm$ 2.52	
WBC ( $\times 10^9$ cells/L)	Age	1 - 6 Mo	3	11.77 $\pm$ 1.61	0.866
		over 6 Mo - 12 Mo	5	12.05 $\pm$ 4.33	
		over 1 Y - 5 Y	52	12.07 $\pm$ 4.18	
		over 5 Y - 10 Y	29	10.99 $\pm$ 4.85	
		over 10 Y	6	11.21 $\pm$ 3.39	
	Sex	Male	48	11.59 $\pm$ 4.03	0.698
		Female	54	11.93 $\pm$ 4.56	
	Strain	Very small	22	11.55 $\pm$ 3.46	0.765
		Small	15	11.43 $\pm$ 2.32	
		Medium	48	12.13 $\pm$ 5.13	
		Large	9	10.59 $\pm$ 3.81	
Neutrophil (%)	Age	1 - 6 Mo	3	61.67 $\pm$ 24.17	0.026
		over 6 Mo - 12 Mo	5	76.80 $\pm$ 7.79	
		over 1 Y - 5 Y	52	66.00 $\pm$ 15.38	
		over 5 Y - 10 Y	29	72.93 $\pm$ 13.61	
		over 10 Y	6	82.5 $\pm$ 8.12	
	Sex	Male	48	69.75 $\pm$ 14.95	0.868
		Female	54	69.29 $\pm$ 14.68	
	Strain	Very small	22	74.64 $\pm$ 6.64	0.004
		Small	15	78.60 $\pm$ 9.23	
		Medium	48	65.23 $\pm$ 15.16	
		Large	9	64.44 $\pm$ 26.09	

**Table 2** Effect of sex, age and strain on hematological and blood clinical chemistry values (cont.)

Parameters	Factors	Levels	Number	Mean $\pm$ SD	p-value
Lymphocyte (%)	Age	1 - 6 Mo	3	25.67 $\pm$ 12.10	0.067
		over 6 Mo - 12 Mo	5	18.80 $\pm$ 8.12	
		over 1 Y - 5 Y	52	24.85 $\pm$ 10.60	
		over 5 Y - 10 Y	29	21.76 $\pm$ 9.81	
		over 10 Y	6	13.00 $\pm$ 6.54	
	Sex	Male	48	21.83 $\pm$ 9.10	0.367
		Female	54	23.69 $\pm$ 11.26	
	Strain	Very small	22	19.36 $\pm$ 5.87	0.001
		Small	15	17.93 $\pm$ 8.15	
		Medium	48	27.02 $\pm$ 11.39	
		Large	9	18.33 $\pm$ 9.29	
Monocyte (%)	Age	1 - 6 Mo	3	3.00 $\pm$ 3.00	0.011 <sup>b</sup>
		over 6 Mo - 12 Mo	5	0.00 $\pm$ 0.00	
		over 1 Y - 5 Y	52	1.83 $\pm$ 1.75	
		over 5 Y - 10 Y	29	0.97 $\pm$ 1.24	
		over 10 Y	6	0.67 $\pm$ 1.63	
	Sex	Male	48	1.29 $\pm$ 1.68	0.174 <sup>a</sup>
		Female	54	1.76 $\pm$ 1.81	
	Strain	Very small	22	1.45 $\pm$ 1.53	0.684 <sup>b</sup>
		Small	15	1.13 $\pm$ 1.46	
		Medium	48	1.63 $\pm$ 1.86	
		Large	9	1.00 $\pm$ 1.41	
Eosinophil (%)	Age	1 - 6 Mo	3	3.00 $\pm$ 1.00	0.112 <sup>b</sup>
		over 6 Mo - 12 Mo	5	4.40 $\pm$ 5.03	
		over 1 Y - 5 Y	52	4.96 $\pm$ 4.99	
		over 5 Y - 10 Y	29	2.62 $\pm$ 3.00	
		over 10 Y	6	3.83 $\pm$ 4.62	
	Sex	Male	48	4.5 $\pm$ 4.64	0.636 <sup>a</sup>
		Female	54	3.93 $\pm$ 4.07	
	Strain	Very small	22	4.55 $\pm$ 3.35	0.154 <sup>b</sup>
		Small	15	2.20 $\pm$ 1.82	
		Medium	48	4.23 $\pm$ 4.71	
		Large	9	5.11 $\pm$ 7.36	

<sup>a</sup>Data was analyzed by Mann-Whitney U test<sup>b</sup>Data was analyzed by Kruskal-Wallis H test

**Table 2** Effect of sex, age and strain on hematological and blood clinical chemistry values (cont.)

Parameters	Factors	Levels	Number	Mean $\pm$ SD	p-value
Basophil (%)	Age	1 - 6 Mo	3	0.00 $\pm$ 0.00	0.935 <sup>b</sup>
		over 6 Mo - 12 Mo	5	0.00 $\pm$ 0.00	
		over 1 Y - 5 Y	52	0.02 $\pm$ 0.14	
		over 5 Y - 10 Y	29	0.00 $\pm$ 0.00	
		over 10 Y	6	0.00 $\pm$ 0.00	
	Sex	Male	48	0.02 $\pm$ 0.14	0.289 <sup>a</sup>
		Female	54	0.00 $\pm$ 0.00	
	Strain	Very small	22	0.00 $\pm$ 0.00	0.811 <sup>b</sup>
		Small	15	0.00 $\pm$ 0.00	
		Medium	48	0.02 $\pm$ 0.14	
		Large	9	0.00 $\pm$ 0.00	
PLT ( $\times 10^9$ cells/L)	Age	1 - 6 Mo	3	256.67 $\pm$ 51.81	0.159
		over 6 Mo - 12 Mo	5	304.20 $\pm$ 94.72	
		over 1 Y - 5 Y	52	237.99 $\pm$ 131.99	
		over 5 Y - 10 Y	29	262.45 $\pm$ 157.71	
		over 10 Y	6	389.00 $\pm$ 183.87	
	Sex	Male	48	242.51 $\pm$ 113.30	0.162
		Female	54	281.71 $\pm$ 160.16	
	Strain	Very small	22	358.14 $\pm$ 154.11	0.000
		Small	15	344.40 $\pm$ 138.88	
		Medium	48	187.47 $\pm$ 106.75	
		Large	9	247.22 $\pm$ 65.05	
Plasma protein (g/dl)	Age	1 - 6 Mo	4	9.70 $\pm$ 1.01	0.016
		over 6 Mo - 12 Mo	6	8.87 $\pm$ 0.78	
		over 1 Y - 5 Y	53	8.96 $\pm$ 0.88	
		over 5 Y - 10 Y	29	9.57 $\pm$ 0.73	
		over 10 Y	6	9.47 $\pm$ 1.09	
	Sex	Male	49	9.21 $\pm$ 0.88	0.334
		Female	56	9.04 $\pm$ 0.94	
	Strain	Very small	24	9.18 $\pm$ 0.81	0.634
		Small	15	9.45 $\pm$ 0.88	
		Medium	49	9.17 $\pm$ 0.96	
		Large	9	9.00 $\pm$ 0.80	

<sup>a</sup>Data was analyzed by Mann-Whitney U test<sup>b</sup>Data was analyzed by Kruskal-Wallis H test

**Table 2** Effect of sex, age and strain on hematological and blood clinical chemistry values (cont.)

Parameters	Factors	Levels	Number	Mean $\pm$ SD	p-value
ALP (U/L)	Age	1 - 6 Mo	5	82.80 $\pm$ 40.09	0.182
		over 6 Mo - 12 Mo	5	88.20 $\pm$ 45.22	
		over 1 Y - 5 Y	51	59.08 $\pm$ 31.41	
		over 5 Y - 10 Y	27	61.11 $\pm$ 35.54	
		over 10 Y	3	83.00 $\pm$ 9.64	
	Sex	Male	47	65.00 $\pm$ 35.43	0.494
		Female	50	60.28 $\pm$ 32.27	
	Strain	Very small	21	59.43 $\pm$ 31.31	0.630
		Small	15	73.53 $\pm$ 38.95	
		Medium	46	61.43 $\pm$ 32.40	
		Large	9	60.67 $\pm$ 45.48	
ALT (U/L)	Age	1 - 6 Mo	5	33.20 $\pm$ 9.96	0.031
		over 6 Mo - 12 Mo	6	32.17 $\pm$ 11.05	
		over 1 Y - 5 Y	48	32.69 $\pm$ 11.95	
		over 5 Y - 10 Y	24	41.04 $\pm$ 19.18	
		over 10 Y	5	50.60 $\pm$ 16.74	
	Sex	Male	45	39.96 $\pm$ 16.68	0.013
		Female	48	32.48 $\pm$ 11.42	
	Strain	Very small	23	38.48 $\pm$ 12.04	0.002
		Small	11	41.91 $\pm$ 16.43	
		Medium	41	29.78 $\pm$ 14.19	
		Large	11	46.18 $\pm$ 15.02	
AST (U/L)	Age	1 - 6 Mo	5	31.80 $\pm$ 5.59	0.863
		over 6 Mo - 12 Mo	5	31.00 $\pm$ 3.67	
		over 1 Y - 5 Y	52	32.71 $\pm$ 11.55	
		over 5 Y - 10 Y	28	30.18 $\pm$ 7.61	
		over 10 Y	5	30.20 $\pm$ 13.18	
	Sex	Male	47	33.47 $\pm$ 10.81	0.238
		Female	53	31.04 $\pm$ 9.64	
	Strain	Very small	23	31.83 $\pm$ 10.34	0.202
		Small	15	33.00 $\pm$ 9.51	
		Medium	48	30.15 $\pm$ 9.80	
		Large	9	37.67 $\pm$ 9.98	

**Table 2** Effect of sex, age and strain on hematological and blood clinical chemistry values (cont.)

Parameters	Factors	Levels	Number	Mean $\pm$ SD	p-value
BUN (mg/dl)	Age	1 - 6 Mo	5	16.76 $\pm$ 3.11	0.915
		over 6 Mo - 12 Mo	5	16.58 $\pm$ 6.63	
		over 1 Y - 5 Y	56	15.54 $\pm$ 7.07	
		over 5 Y - 10 Y	29	15.27 $\pm$ 4.52	
		over 10 Y	5	17.96 $\pm$ 12.37	
	Sex	Male	50	15.48 $\pm$ 6.23	0.955
		Female	57	15.55 $\pm$ 7.05	
	Strain	Very small	24	18.10 $\pm$ 6.90	0.000
		Small	15	19.94 $\pm$ 8.53	
		Medium	51	12.80 $\pm$ 4.28	
		Large	10	18.70 $\pm$ 5.92	
Creatinine (mg/dl)	Age	1 - 6 Mo	5	0.92 $\pm$ 0.16	0.125 <sup>b</sup>
		over 6 Mo - 12 Mo	6	1.23 $\pm$ 0.22	
		over 1 Y - 5 Y	56	1.00 $\pm$ 0.20	
		over 5 Y - 10 Y	30	1.00 $\pm$ 0.24	
		over 10 Y	6	1.02 $\pm$ 0.23	
	Sex	Male	53	1.02 $\pm$ 0.23	0.808 <sup>a</sup>
		Female	57	1.00 $\pm$ 0.22	
	Strain	Very small	24	0.98 $\pm$ 0.21	0.078 <sup>b</sup>
		Small	15	0.89 $\pm$ 0.18	
		Medium	52	1.02 $\pm$ 0.18	
		Large	11	1.16 $\pm$ 0.34	
Total protein (g/dl)	Age	1 - 6 Mo	5	6.60 $\pm$ 1.57	0.953
		over 6 Mo - 12 Mo	5	7.14 $\pm$ 0.91	
		over 1 Y - 5 Y	56	8.58 $\pm$ 8.87	
		over 5 Y - 10 Y	28	8.01 $\pm$ 1.18	
		over 10 Y	5	7.28 $\pm$ 1.27	
	Sex	Male	49	8.9 $\pm$ 9.44	0.209
		Female	57	7.30 $\pm$ 1.28	
	Strain	Very small	23	9.64 $\pm$ 13.83	0.684
		Small	15	7.35 $\pm$ 1.44	
		Medium	51	7.90 $\pm$ 1.34	
		Large	10	7.48 $\pm$ 1.28	

<sup>a</sup>Data was analyzed by Mann-Whitney U test<sup>b</sup>Data was analyzed by Kruskal-Wallis H test

## Discussion

In this study, we compared the range of hematological parameters with the reference values from Salakij (2005) while we compared the range of blood clinical chemistry parameters with the reference values from Latimer *et al.* (2003). In the present results, some of the hematological and blood clinical chemistry parameters are similar in that of reference values from Salakij (2005) and Latimer *et al.* (2003) except Hct, MCV, monocyte, Plt, RDW, PP, AST and TP. For Hct, MCV, monocyte and Plt, the values are lower than that of reference values from Salakij (2005) whereas RDW, PP, AST and TP are higher than that of reference values from Salakij (2005) and Latimer *et al.* (2003). In addition, ALP, ALT and creatinine in the present study are narrower of range than that of reference values of Latimer *et al.* (2003). This might be due to the differences in the population of studies in term of age, sex and strain, environmental, lifestyle, and nutrition. However, one can use the present results in tandem with the reference values of Salakij and Latimer *et al.* to evaluate the physical health, diagnosis and prognosis disease in canine.

## Conclusions

Hematological and blood clinical chemistry in canine which are essential for determine the physical health and for further diagnosis as well as prognosis the disease are influenced by many parameters studied such as sex, age and strain.

## Acknowledgements

The authors would like to express our sincere thankfulness to clinicians in Prasuarthon hospital, Dr. Sivapong Sungpradit, Charoonluk Jirapattharasate and the present fifth year students from Faculty of Veterinary Science for their kindness in sample collection. We would like to thank Panpanga Sangsuriya from Faculty of Veterinary Science for valuable advices and suggestions about statistical

analysis. We are also very grateful to Faculty of Veterinary Sciences, Mahidol University for providing grants to support this research.

## References

- Bulgim M.S., Munn S.L. and Gee W. (1970). Hematologic changes to 4 and one-half years on age in clinically normal beagles. *J Am Vet Med Assoc*, 157: 1064-70.
- Cramer M.B., Turbyfill C.L. and Dewes W.A. (1969). Serum chemistry values for the beagle. *Am J Vet Res*, 30: 1183-6.
- Dimopoulos G.T. (1963). "Plasma proteins", in *clinical biochemistry of domestic animals*, Vol. 1, Kandko JJ and Cornelius CC (Ed.), Academic Press, New York and London, pp. 97-129.
- Earl F.L., Melveger B.E. and Wilson R.L. (1973). The hemogram and bone marrow profile of normal neonatal and weanling beagle dogs. *Lab Anim Sci*, 23: 690-5.
- Gookin J.L., Bunch S.E., Rush L.J. and Grindem C.B. (1998). Evaluation of microcytosis in 18 Shibas. *J Am Vet Med Assoc*, 212: 1258-9.
- Harper E.J., Hackett R.M., Wilkinson J. and Heaton P.R. (2003). Age-related variations in hematologic and plasma biochemical test results in beagles and Labrador retrievers. *J Am Vet Med Assoc*, 223: 1436-42.
- Hilppo M. (1986). Some haematological and clinical-chemical parameters of sight hounds (Afghan hound, saluki and whippet). *Nord Vet Med*, 38: 148-55.
- Jangsanthong A. and Buranasinsup S. (2011). Normal hematological and clinical chemistry blood values in normal long-tailed macaque lived in Mahidol University, Sai-Yok campus, Kanchanaburi. *Journal of Applied Animal Science*, 4: 39-44.
- Jeusette I., Grauwels M., Cuvelier C., *et al.* (2004). Hypercholesterolaemia in a family of rough collie dogs. *J Small Anim Pract*, 45: 319-24.

- Kaewsakorn T., Chotayaporn M., Suwankong N., Nganwongpanit K., Jitpean S. and Cutesuwan P. (2546). Normal hematology and blood chemistry in small, medium and larged adult healthy dogs. *Chiang Mai Veterinary Journal*.1: 39-45.
- Latimer K., Mahaffey E.A. and Prasse K.W. (2003). *Duncan & Prasse's veterinary laboratory medicine: Clinical pathology*. 4<sup>th</sup> edition. Iowa State Press.
- Lowseth L.A., Gillett N.A., Gerlach R.F. and Muggenburg B.A. (1990). The effects of aging on hematology and serum chemistry values in the beagle dog. *Vet Clin Pathol*, 19: 13-19.
- Lund C., Kuhl S., Mischke R. and Gunzel-Apel A.R. (2000). Reference values of the red blood profile in beagle, German shepherd and golden retriever puppies. *Berl Munch Tieraztl Wochenschr*, 113: 447-53.
- Michaelson S.M., Scheer K. and Gilt S. (1966). The blood of the normal beagle. *J Am Vet Med Assoc*, 148: 532-4.
- Nielsen L., Kjelgaard-Hansen M., Jensen A.L. and Kristensen A.T. (2010). Breed-specific variation of hematologic and biochemical analytes in healthy adult Bernese Mountain dogs. *Vet Clin Pathol*, 39(1): 20-28.
- Porter J.A. Jr. and Canaday W.R. Jr. (1971). Hematologic values in mongrel and greyhound dogs being screened for research use. *J Am Vet Med Assoc*, 159: 1603-6.
- Rogers W.A., Donovan E.F. and Kociba G.J. (1975). Idiopathic hyperlipoproteinemia in dogs. *J Am Vet Med Assoc*, 166: 1087-91.
- Salakij C.(2005). *Veterinary hematology*. National Agricultural Extension and Training Center Printing. Kasetsart University, Nakornpathom.
- Shiel R.E., Brennan S.F., O'Rourke L.G., McCullough M. and Mooney C.T. (2007). Hematologic values in young pretraining healthy greyhounds. *Vet Clin Pathol*, 36: 274-7.
- Singh M.K. and Lamb W.A. (2005). Idiopathic thrombocytopenia in Cavalier King Charles Spaniels. *Aust Vet J*, 83: 700-3.
- Watts M. (2006). Haematology and blood chemistry values in greyhounds. *Vet Rec*, 159: 128.
- <http://www.trainpetdog.com/dog-breed-size-chart.html>  
Accessed on 2011, March 10.