



## NOTE

Internal Medicine

# Retrospective study on intercurrent pancreatitis with *Babesia gibsoni* infection in dogs

Misa MASUDA<sup>1)</sup>, Yayoi OTSUKA-YAMASAKI<sup>2)</sup>, Nobuyuki SHIRANAGA<sup>3)</sup>, Aiko IGUCHI<sup>4)</sup>, Naohiro UCHIDA<sup>1)</sup>, Reeko SATO<sup>1)</sup> and Masahiro YAMASAKI<sup>1)\*</sup>

<sup>1)</sup>Laboratory of Veterinary Small Animal Internal Medicine, Department of Veterinary Medicine, Faculty of Agriculture, Iwate University, 3-18-8 Ueda, Morioka 020-8550, Japan

<sup>2)</sup>The Organization for the Revitalization of the Sanriku Region and Regional Development, Iwate University, 3-18-8 Ueda, Morioka 020-8550, Japan

<sup>3)</sup>Shiranaga Animal Hospital, 2-12-18 Sakuragi, Syunan, 745-0806, Japan

<sup>4)</sup>Course of Veterinary Laboratory Medicine, Department of Veterinary Medicine, Faculty of Agriculture, Tottori University, Tottori 680-8553, Japan

**ABSTRACT.** *Babesia rossi* infection has been reported to be associated with the high prevalence of pancreatitis in dogs. In this study, we retrospectively investigated whether pancreatitis occurs in *B. gibsoni*-infected dogs. The clinical manifestations, and hematological and serum biochemical examination results, including canine pancreatic-specific lipase (cPL), in 20 *B. gibsoni*-infected dogs were analyzed. The cPL concentration exceeded 400  $\mu\text{g/l}$  in only 2 dogs, and they were suspected of having pancreatitis. Although the cPL concentration did not correlate with the degree of anemia or the level of parasitemia, it correlated with the band neutrophil count, platelet count, and blood urea nitrogen (BUN) level. Our study suggested that the prevalence of pancreatitis is lower among *B. gibsoni*-infected dogs than *B. rossi*-infected dogs.

**KEY WORDS:** *Babesia gibsoni*, pancreatitis, retrospective study

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Canine babesiosis, a tick-borne hematozoan disease, is caused by *Babesia* parasites. This disease is characterized by fever, lethargy, and anemia, and some cases may be severe, causing death. *Babesia gibsoni*, *B. canis*, *B. vogeli*, *B. rossi*, and *B. conradae* are well-known *Babesia* species in canine hosts [3, 6]. The degree of severity of canine babesiosis may depend on the causative *Babesia* species [11]. In particular, *B. rossi*, the dominant species found in South Africa, is highly virulent and causes acute disease, including acute kidney injury, neural symptoms, hepatic disorder, and pancreatitis [7]. These complications are considered to be the result of tissue hypoxia following anemia and concomitant systemic inflammatory response syndrome (SIRS) caused by marked cytokine release [7]. It was previously reported that *B. rossi*-infected dogs presenting with SIRS had a significantly higher serum pancreatic-specific lipase (Spec cPL) concentration than dogs that did not meet the criteria for SIRS, and that more than 28% of *B. rossi*-infected dogs had acute pancreatitis [7]. Spec cPL is one examination performed to detect canine pancreatitis and is useful for screening [10].

In Japan, *B. gibsoni* is an important pathogen for canine babesiosis and its infection follows a hyper-acute, acute, or chronic course [12]. The acute course is the most common, and dogs usually present increased C-reactive protein (CRP) [2] and liver enzyme levels such as alanine aminotransferase (ALT) and aspartic aminotransferase (AST) [12]. However, to our best knowledge, pancreatitis and increased Spec cPL have not been reported to be associated with *B. gibsoni* infection. In the present study, we retrospectively assessed whether acute pancreatitis develops in *B. gibsoni*-infected dogs.

Serum samples and clinical data were collected at a private animal hospital located in Yamaguchi Prefecture in western Japan. A total of 20 dogs diagnosed with acute canine babesiosis in 2014–2015 were examined in this study. The study population of dogs had a mean age of  $6.9 \pm 3.7$  years old. Canine babesiosis was diagnosed by detecting *Babesia* parasites using Giemsa staining of thin blood smears. As Yamaguchi Prefecture has been an endemic area of *B. gibsoni*, all 20 dogs were considered to be infected with *B. gibsoni*. At the diagnosis, ticks were detected on three dogs (dog 9, 14 and 19). Moreover, 17 dogs had taken a walk out of door every day. Serum was collected with informed owner consent after the diagnosis of canine babesiosis and stocked at  $-15^{\circ}\text{C}$  at the private animal hospital until later analysis.

All dogs underwent a physical examination, complete blood cell count (CBC), blood biochemical analysis, and measurement

\*Correspondence to: Yamasaki, M.: masayama@iwate-u.ac.jp

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of the level of parasitemia at the private animal hospital before treatment (Table 1). The range of parasitemia was 0.04–5.01%, and the hematocrit values were 9–46%. The criterion of SIRS for dog was reported previously [4]. In the present study, the heart rate and respiratory rate of many dogs were not recorded. Although we could not determine dogs with SIRS, at least seven dogs (dog 2, 4, 5, 6, 10, 11 and 12) were suspected as SIRS. No dogs presented the clinical signs of pancreatitis, such as vomiting and abdominal tenderness, at the first examination. After the stored sera were transported on ice to Iwate University, the lipase activity (reference range: 13–200 U/l) was measured using an autoanalyzer (IDEXX VetTest Chemistry Analyzer, IDEXX Laboratories, Inc., Westbrook, ME, U.S.A.). Spec cPL was measured by a commercial laboratory (IDEXX Laboratories, Tokyo, Japan). The reference interval was set at <200 µg/l and concentrations >400 µg/l were considered to indicate pancreatitis [10]. Moreover, the identification of species of *Babesia* parasites was performed using PCR. Genomic DNA was extracted from dog serum using NucleoSpin® Blood (Macherey-Nagel GmbH & Co, KG, Düren, Germany). Since serum of dog 1 and 9 were not enough for the DNA extraction, DNA were extracted from 18 dog serum. The primers used for the amplification of 18S rRNA of *B. gibsoni* were described previously [14]. Genomic DNA in reaction mixture were prepared according to the manufacture’s protocol (Platinum™ Taq DNA polymerase, Thermo Fisher Scientific K. K., Tokyo, Japan), and then, it was amplified for 35 cycles (denaturation for 30 sec at 94°C, annealing for 30 sec at 55°C and extension for 30 sec at 72°C) followed by the final extension for 5 min at 72°C in a T100™ Thermal Cycler (BIO-RAD Laboratories, Inc., CA, U.S.A.). As a result, the fragments of 18S rRNA of *B. gibsoni* were detected from 18 dogs tested, suggesting that those 18 dogs were infected with *B. gibsoni* (Fig. 1). According to the previous studies, *B. vogeli* which is mainly detected in Okinawa Prefecture in Southern Japan was not identified in Yamaguchi Prefecture [5, 8]. It was considered that dog 1 and 9 were also infected with *B. gibsoni*. Data were analyzed using a commercial statistical software package (StatView5, SAS institute Inc., Cary, NC, U.S.A.). The correlation of lipase activity, cPL concentration, degree of anemia, the level of parasitemia, and the results of clinical pathological parameters were evaluated using Pearson product-moment

**Table 1.** The results of the Spec canine pancreatic-lipase (cPL) value, parasitemia, the parameters of complete blood cell count, biochemical parameters in dogs with *Babesia gibsoni* infection

	Dog No.									
	1	2	3	4	5	6	7	8	9	10
Breed	T. P.	S. T.	M. D.	Shiba	CH	M. D.	M. D.	M. D.	Shiba	PM
Sex	Male	Female	Male	Female	Male	Male	Female	Male	Male	Male
Age	9	4	9	2	5	6	6	15	7	8
Body temperature (°C)	39.6	39.3	39.8	39.2	39.5	40.3	39.8	38.9	40.1	39.2
Respiratory rate (/min)	20	ND	20	30	ND	ND	ND	ND	ND	12
Spec cPL (µg/l)	73	104	104	66	49	60	44	234	186	124
Lipase (U/l)	349	505	407	1,662	457	427	709	640	366	377
Parasitemia (%)	2.85	0.3	1.5	0.18	0.41	0.06	0.3	1.4	5.01	1.3
WBC (/µl)	12,200	4,800	11,200	10,000	4,200	3,800	6,400	14,400	15,924	28,225
Band neutrophil	0	48	0	0	84	0	0	144	0	282
Segmented neutrophil	10,126	3,120	8,288	8,600	2,562	2,964	4,416	8,532	15,526	21,733
Lymphocyte	732	1,248	2,576	400	1,218	152	1,472	5,472	79	4,798
Monocyte	1,220	336	224	900	336	684	512	288	318	1,411
Eosinophil	122	48	112	100	0	0	0	144	0	0
RBC (×10 <sup>6</sup> /µl)	2.67	4.80	3.03	2.55	5.38	4.85	6.34	4.83	1.85	1.00
Hb (g/dl)	6.3	11.4	7.5	5.6	12.0	11.8	15.7	11.6	4.0	8.6
Ht (%)	19	30	21	15	38	35	46	35	11	9
Plat (×10 <sup>3</sup> /µl)	41	9	46	28	41	11	12	29	12	47
Glucose (mg/dl)	99	89	103	97	110	111	105	95	91	103
Total protein (g/dl)	6.2	6.0	6.0	6.8	6.0	6.8	7.8	5.6	6.6	6.2
Albumin (g/dl)	2.3	2.6	2.9	2.8	2.9	3.0	3.5	2.4	2.4	2.1
ALT (U/l)	38	60	57	21	61	69	51	48	29	499
AST (U/l)	30	62	33	21	49	72	56	37	50	112
ALP (U/l)	391	680	279	365	636	418	342	417	128	>3,500
Total cholesterol (mg/dl)	173	225	114	175	265	181	289	209	162	248
Total bilirubin (mg/dl)	0.7	0.5	0.9	0.4	0.3	0.7	1.7	0.4	1.1	1.4
BUN (mg/dl)	21.7	14.9	10.8	27.9	15.5	11.2	19.7	22.8	16.0	27.4
Creatinine (mg/dl)	0.3	0.4	0.3	0.7	0.4	0.3	0.5	0.5	0.5	0.3
Na (mEq/l)	148	ND	145	149	143	144	148	148	147	151
K (mEq/l)	3.4	ND	3.7	4.0	3.8	4.1	3.5	4.1	3.6	4.1
Cl (mEq/l)	119	ND	114	117	113	110	121	112	119	115
Ca (mg/dl)	8.1	8.5	8.8	9.5	8.6	9.3	9.6	8.7	8.3	8.9
CRP (mg/dl)	>20	>20	15	13	>20	>20	16	18	15	13

correlation and the test of no correlation ( $r \geq 0.7$  was strong correlation,  $0.4 \leq r < 0.7$  was moderate correlation,  $0.2 \leq r < 0.4$  was weak correlation, and  $r < 0.2$  was no correlation). A  $P$ -value of  $\leq 0.05$  was considered significant.

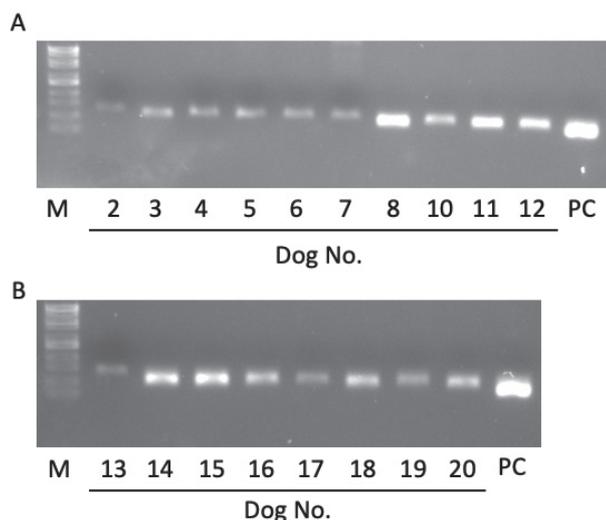
To investigate the prevalence of pancreatitis, the lipase activity and the Spec cPL concentration were examined. As shown in Fig. 2, all dogs had lipase activity greater than 200 U/l. The range of the Spec cPL concentration for all tested dogs was 44–655  $\mu\text{g/l}$  (Fig. 3). Although one dog (dog 4) with high lipase activity had a low cPL concentration, the cPL concentrations were strongly positively correlated with the lipase activity ( $r=0.73$ ;  $P=0.0002$ ) (Fig. 4). Two of 20 dogs (dog 12 and 14) had a cPL concentration above 400  $\mu\text{g/l}$  and they were suspected of having pancreatitis based on the reference range of Spec cPL. In our study, the prevalence of pancreatitis among *B. gibsoni*-infected dogs was 10% (2/20). Although dog 12 was suspected as SIRS, dog 14 was not suspected as SIRS. The CBC and serum biochemical parameter measurements of all dogs are shown in Table 1. In 2 dogs (dog 12 and 14), the concentrations of CRP and alkaline phosphatase (ALP), which are supportive parameters for pancreatitis, were higher than the normal ranges. In the field of medicine, hypotension, ischemia, and circulation insufficiency are known causes of acute pancreatitis [1]. Therefore, we suspected that anemia induced pancreatitis in the *B. gibsoni*-infected dogs. However, the degree of anemia and the level of parasitemia in the two dogs were moderate among the 20 dogs (Table 1). Therefore, the degree of anemia and the level of parasitemia may not be related to the pathogenesis of pancreatitis. Additionally, dogs with hyperadrenocorticism or glucocorticoid administration were reported to have a high cPL concentration [1, 9]. Thus, the increased cPL concentration in the two dogs was due to other causes.

We next analyzed the correlation between the cPL concentration and the level of parasitemia, the degree of anemia (erythrocyte count, and hemoglobin [Hb] and hematocrit [Ht] levels), and leukocyte and platelet counts in all tested dogs (Figs. 5 and 6). Consistent with the above supposition, the cPL concentration was not correlated with the level of parasitemia ( $r=0.086$ ;  $P=0.72$ ), erythrocyte count ( $r=0.10$ ;  $P=0.66$ ), Hb level ( $r=0.12$ ;  $P=0.61$ ), or Ht level ( $r=0.13$ ;  $P=0.58$ ) (Fig. 5). The cPL concentration was

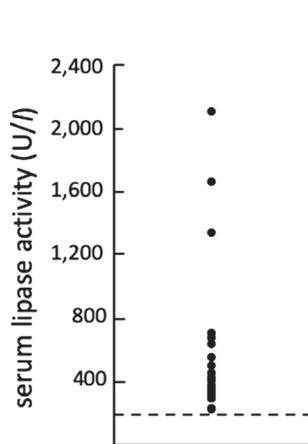
Table 1. Continued

	Dog No.									
	11	12*	13	14*	15	16	17	18	19	20
Breed	PL	M. D.	mix	S. T.	BG	M. D.	CH	S. T.	mix	CKCS
Sex	Male	Female	Male	Female	Female	Female	Female	Male	Female	Male
Age	7	8	10	UK	3	1	10	13	0	7
Body temperature ( $^{\circ}\text{C}$ )	39.7	40.3	40.7	38.0	39.9	39.0	38.3	38.7	40.5	38.8
Respiratory rate (/min)	30	40	ND	20	ND	20	ND	ND	ND	ND
Spec cPL ( $\mu\text{g/l}$ )	48	661	92	655	52	78	58	198	88	112
Lipase (U/l)	309	2,111	236	1,343	295	333	224	675	293	553
Parasitemia (%)	0.4	0.27	0.16	0.62	2.0	0.11	0.04	0.8	0.06	0.94
WBC ( $/\mu\text{l}$ )	9,300	7,129	6,100	29,000	8,727	16,900	16,200	4,074	8,800	18,300
Band neutrophil	0	0	0	676	0	338	0	0	0	296
Segmented neutrophil	7,174	5,775	4,036	25,520	6,894	13,182	14,742	1,140	5,368	8,436
Lymphocyte	1,594	1,069	610	1,740	1,309	2,873	972	2,077	3,344	4,958
Monocyte	88	142	854	966	523	507	486	855	88	888
Eosinophil	0	142	0	96	0	0	0	0	0	222
RBC ( $\times 10^6/\mu\text{l}$ )	3.59	3.96	6.80	1.88	2.02	0.79	1.93	3.37	3.45	1.83
Hb (g/dl)	9.0	9.4	15.7	4.6	5.0	2.3	4.5	7.6	7.1	4.6
Ht (%)	27	26	44	14	16	9	12	22	25	14
Plat ( $\times 10^3/\mu\text{l}$ )	23	52	24	99	17	71	89	81	24	13
Glucose (mg/dl)	96	79	91	88	94	89	110	101	89	90
Total protein (g/dl)	7.6	6.8	8.4	6.8	6.8	7.2	8.0	7.4	7.0	6.6
Albumin (g/dl)	2.7	2.2	3.0	2.4	2.2	2.1	2.7	3.0	2.5	2.7
ALT (U/l)	26	15	44	33	27	>1,000	63	66	12	28
AST (U/l)	59	56	52	35	49	623	21	25	91	25
ALP (U/l)	573	353	979	287	192	432	1,310	382	847	279
Total cholesterol (mg/dl)	201	112	411	124	129	114	175	298	372	176
Total bilirubin (mg/dl)	1.1	0.5	0.8	0.8	0.8	0.7	0.7	0.5	0.4	0.9
BUN (mg/dl)	12.8	45.3	10.6	45.9	13.5	37.3	30.5	60.1	9.0	54.6
Creatinine (mg/dl)	0.4	0.7	0.7	0.3	0.3	0.2	0.3	1.0	0.9	0.2
Na (mEq/l)	147	152	148	142	147	148	146	150	130	147
K (mEq/l)	3.9	4.1	3.5	3.3	3.3	3.7	3.3	4.1	3.3	3.8
Cl (mEq/l)	116	121	113	107	112	121	109	109	110	112
Ca (mg/dl)	9.0	9.0	9.2	7.8	9.4	8.6	8.5	10.7	8.9	9.0
CRP (mg/dl)	>20	12	>20	>20	>20	9.1	>20	4.6	>20	>20

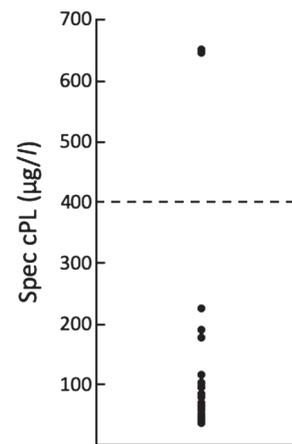
T. P.=Toy Poodle, S. T.=Shih Tzu, M. D.=Miniature Dachshund, CH=Chihuahua, PM=Pomeranian, PL=Papillon, BG=Beagle, CKCS=Cavalier King Charles Spaniel, mix=mix breed. ND=not determined. UK=unknown. \*Dogs having high Spec cPL concentration.



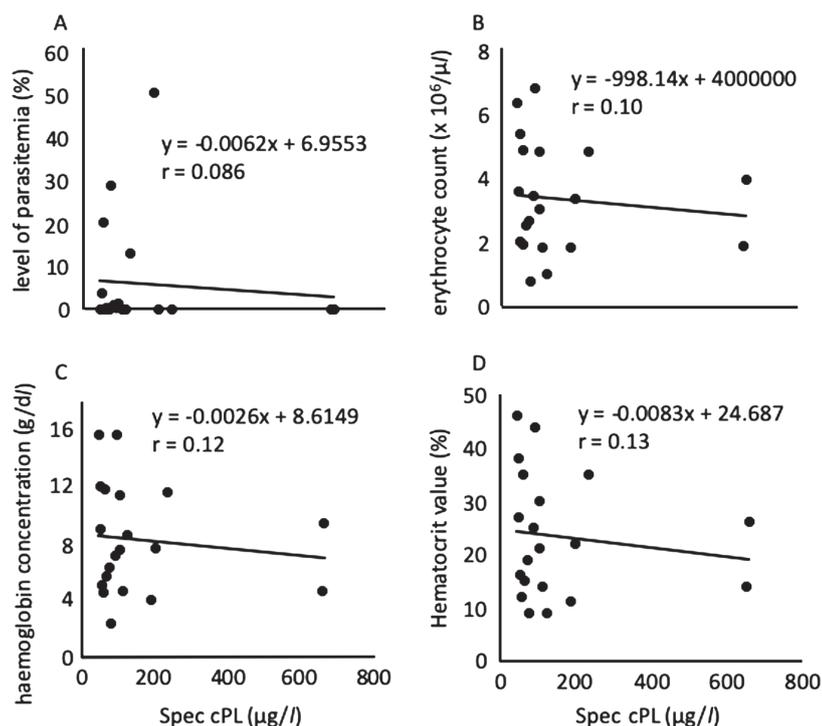
**Fig. 1.** The detection of the partial 18S rRNA of *Babesia gibsoni* in 18 dogs. Gel electrophoresis analysis of PCR products from 18 dog serum. Lane number showed the dog number. Lane PC, positive control (genomic DNA from cultured *B. gibsoni* isolate). Lane M, molecular marker.



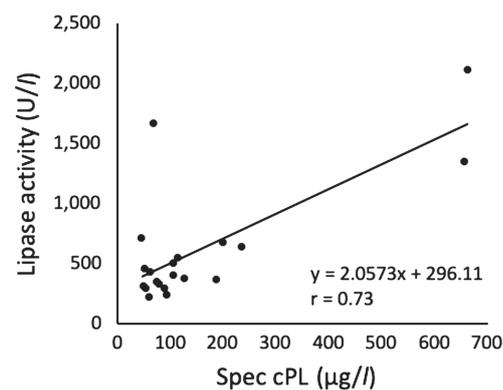
**Fig. 2.** A plot depicting the serum lipase activity in 20 dogs diagnosed with acute *Babesia gibsoni* infection. The dashed line indicates the upper limit of the reference range (200 U/l).



**Fig. 3.** A plot depicting the Spec canine pancreatic-lipase (cPL) concentration in 20 dogs diagnosed with acute *Babesia gibsoni* infection. The dashed line indicates the threshold for the diagnosis of canine pancreatitis (400 µg/dl).



**Fig. 5.** Relationship between the Spec canine pancreatic-lipase (cPL) concentration and the level of parasitemia (A), erythrocyte count (B), haemoglobin concentration (C), and Hematocrit value (D) in 20 dogs infected with *Babesia gibsoni*.



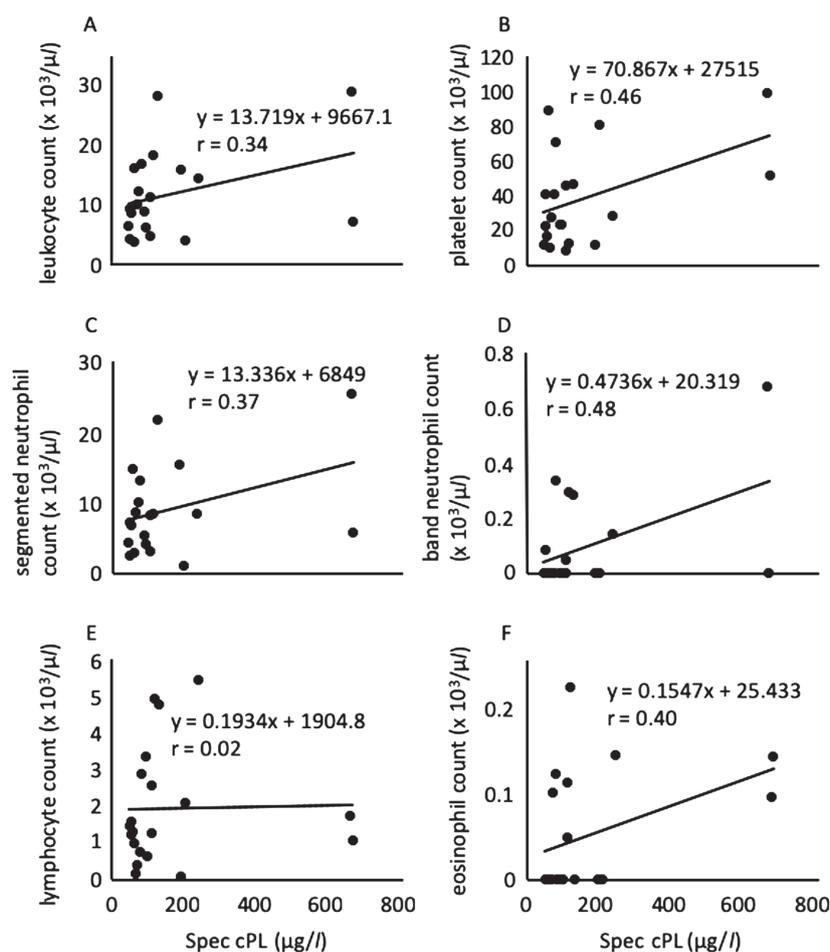
**Fig. 4.** Relationship between the Spec canine pancreatic-lipase (cPL) concentration and the lipase activity in 20 dogs infected with *Babesia gibsoni*.

previously reported not to correlate with the level of parasitemia or the degree of anemia in *B. rossi*-infected dogs [7]. Similarly, the lipase activity was not correlated with the level of parasitemia or the degree of anemia (data not shown). These results suggested that *B. gibsoni* does not directly damage the pancreas and that the severity of anemia in *B. gibsoni* infection is not related to the pancreatitis. On the other hand, the cPL concentration was moderately positively correlated with the band neutrophil count ( $r=0.48$ ;  $P=0.031$ ) (Fig. 6D) and platelet count ( $r=0.46$ ;  $P=0.040$ ) (Fig. 6B). However, it was not correlated with the leukocyte count ( $r=0.34$ ;  $P=0.15$ ), segmented neutrophil count ( $r=0.37$ ;  $P=0.10$ ), lymphocyte count ( $r=0.02$ ;  $P=0.93$ ), or eosinophil count

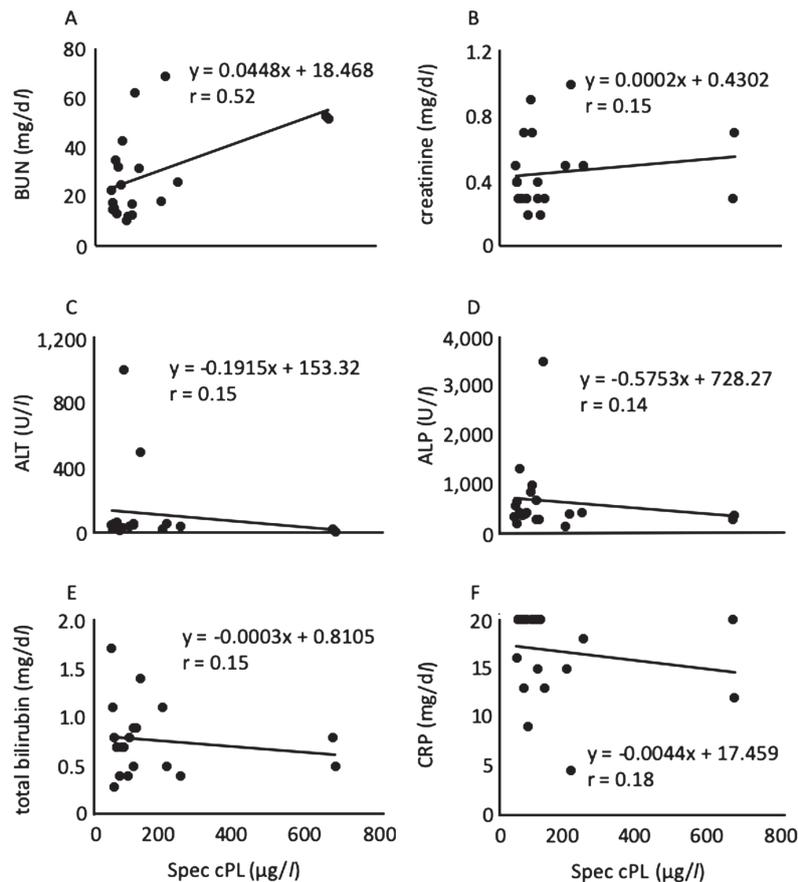
( $r=0.40$ ;  $P=0.08$ ) (Fig. 6A, 6C, 6E and 6F). The cPL concentration in *B. rossi*-infected dogs was significantly positively correlated with the immature neutrophil count [7]. This previous finding is consistent with the result of this study. The inflammation with pancreatitis may be related to the increase in the band neutrophil and platelet counts.

In addition, we examined the correlation between the cPL concentration and the other biochemical parameters. In the present study, the values of ALT (dog 16), ALP (dog 10) and CRP (dog 1, 2, 5, 6, 11, 13, 14, 15, 17, 19 and 20) were greater than the measurement limit. Therefore, the values of measurement limit were used for the analysis. As a result, the blood urea nitrogen (BUN) level was moderately positively correlated ( $r=0.52$ ;  $P=0.019$ ) with the cPL concentration (Fig. 7A), whereas CRP ( $r=0.18$ ;  $P=0.46$ ), ALT ( $r=0.15$ ;  $P=0.53$ ), ALP ( $r=0.14$ ;  $P=0.55$ ), total bilirubin ( $r=0.17$ ;  $P=0.47$ ), and creatinine ( $r=0.15$ ;  $P=0.52$ ) levels were not correlated (Fig. 7B–F). Additionally, the cPL concentrations of dogs having high concentration of CRP were less than 200 ( $\mu\text{g/l}$ ) except for dog 14. Moreover, the BUN level was moderately positively correlated ( $r=0.48$ ;  $P=0.033$ ) with the lipase activity. The BUN level was previously reported to be a prognosis factor for pancreatitis [13]. The BUN levels of the 2 dogs suspected of having pancreatitis in this study (dog 12 and 14) were higher than the normal range (Table 1). Accordingly, it is possible that the BUN level is related to the severity of pancreatitis in canine *B. gibsoni* infection, although the reason remains unknown.

In conclusion, the prevalence of pancreatitis may be low among *B. gibsoni*-infected dogs. In previous reports, the prevalence of pancreatitis among *B. rossi*-infected dogs was greater than 28% [7]. The prevalence of pancreatitis among *B. gibsoni*-infected dogs in this study (10%) was less than that among *B. rossi*-infected dogs. In *B. rossi* infection, the different clinical signs are considered to be the result of tissue hypoxia following anemia and concomitant SIRS caused by marked cytokine release [7]. As anemia is also main symptom in *B. gibsoni* infection, there should be some difference between *B. gibsoni* infection and *B. rossi* infection in dogs. Therefore, further studies using more samples from *B. gibsoni*-infected dogs with severe anemia are necessary to elucidate the relationship between *B. gibsoni* infection in dogs and pancreatitis.



**Fig. 6.** Relationship between the Spec canine pancreatic-lipase (cPL) concentration and leukocyte count (A), platelet count (B), segmented neutrophil count (C), band neutrophil count (D), lymphocyte count (E), and eosinophil count (F) in 20 dogs infected with *Babesia gibsoni*.



**Fig. 7.** Relationship between the Spec canine pancreatic-lipase (cPL) concentration and blood urea nitrogen (BUN) (A), creatinine (B), alanine aminotransferase (ALT) (C), Alkaline phosphatase (ALP) (D), total bilirubin (E), and C-reactive protein (CRP) (F) in 20 dogs infected with *Babesia gibsoni*.

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