A SEROEPIDEMIOLOGICAL SURVEY OF *THEILERIA EQUI* AND *BABESIA CABALLI* IN HORSES IN MONGOLIA

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21 **ABSTRACT**

22 Equine piroplasmosis caused by *Theileria equi* and *Babesia caballi* is an economically
23 important disease with a worldwide distribution. The objective of the present study was
24 to investigate the seroepidemiology of *T. equi* and *B. caballi* in horses reared in various
25 Mongolian provinces. Serum samples prepared from blood collected from horses in 19
26 Mongolian provinces were screened for antibodies specific to *T. equi* and *B. caballi*
27 using enzyme-linked immunosorbent assays based on recombinant forms of *T. equi*
28 merozoite antigen-2 and the *B. caballi* 48-kDa merozoite rhoptry protein, respectively.
29 Of 1,282 horses analyzed, 423 (33%) and 182 (14.2%) were sero-positive for *T. equi*
30 and *B. caballi*, respectively. Additionally, 518 (40.4%) were positive for at least 1
31 parasite species, of which 87 (16.8%) were co-infected with both parasites. Both *T. equi*
32 and *B. caballi* were detected in all surveyed provinces, and on a per province basis the
33 positive rates ranged from 19.0%–74.2% and 4.5%–39.8%, respectively. *Theileria equi*-
34 and *B. caballi*-positive rates were comparable between male (31.9% and 14.1%,
35 respectively) and female horses (34.5% and 14.3%, respectively). However, the positive
36 rates were higher in the >3-yr-old age group (37.7% and 15.6%, respectively) compared

with the 1–3-yr-old age group (19.4% and 10.0%, respectively). These findings confirmed that *T. equi* and *B. caballi* infections are widespread among horses all over Mongolia, and that horse age is a risk factor for infection in this country. Our results will be useful for designing appropriate control measures to minimize *T. equi* and *B. caballi* infections among Mongolian horses.

KEY WORDS

Babesia caballi, ELISA, Epidemiological Mapping, Equine Piroplasmosis, Horses, Mongolia, *Theileria equi*

Equine piroplasmosis is an acute, subacute, or chronic tick-borne disease of the Equidae (horses, donkeys, mules, and zebras) caused by hemoprotozoan parasites *Theileria equi* and *Babesia caballi* (Bruning, 1996). It is generally characterized by fever, anemia, jaundice, edema, and, in some cases, death (Schein, 1988; de Waal, 1992; Bruning, 1996). Although both *T. equi* and *B. caballi* cause clinical disease, the former is associated with more severe disease (Camacho et al., 2005).

Equine piroplasmosis is common in tropical and subtropical regions, including parts of Africa, the Middle East, Asia, Central and South America, the Caribbean, and

55 Europe, with 27 countries reporting disease incidence according to the World
56 Organisation for Animal Health (OIE, 2017). Once infected with *T. equi* and *B. caballi*,
57 horses become persistent carriers for a long period (Knowles et al., 1997). Detection of
58 these carrier animals is vital because they can be a source of infection for transmission
59 to uninfected horses. Therefore, epidemiological surveys have been conducted in
60 several endemic countries to identify such chronically infected carrier animals (Butler et
61 al., 2012; Oduori et al., 2015; Sumbria et al., 2016; Guven et al., 2017; Díaz-Sánchez et
62 al., 2018).

63 Mongolia is an agricultural country in which the livestock sector is key to its
64 economic growth. The horse population in Mongolia was estimated to be about 3.9
65 million head in 2017 (National Statistics Office of Mongolia, 2017). However, the
66 productivity of Mongolian horses has been severely undermined for various reasons,
67 including the presence of infectious diseases (Odontsetseg et al., 2005; Pagamjav et al.,
68 2011; Suganuma et al., 2017). This also limits the export market for Mongolian horses
69 and their products (World Bank., 2009).

70 The causative agents of equine piroplasmosis, *T. equi* and *B. caballi*, have been
71 reported in Mongolia using microscopy (Rüegg et al., 2007), the indirect fluorescence
72 antibody test (IFAT) (Avarzed et al., 1997, Rüegg et al., 2007), enzyme-linked

73 immunosorbent assays (ELISAs) (Ikadai et al., 2000; Boldbaatar et al., 2005;
74 Munkhjargal et al., 2013), and PCR assays (Rüegg et al., 2007; Sloboda et al., 2011;
75 Munkhjargal et al., 2013). However, these studies were limited to only a few provinces
76 and no countrywide survey has been conducted, despite the fact that such investigations
77 will equip the veterinary authorities in Mongolia with the means of designing and
78 implementing a risk-based control strategy. In the present study, therefore, we prepared
79 serum samples from blood collected from horses in 19 of 21 Mongolian provinces, and
80 screened for *T. equi*- and *B. caballi*-specific antibodies using parasite-specific ELISAs.

81 **MATERIALS AND METHODS**

82 **Serum samples**

83 Blood samples were collected from a total of 1,282 horses in 19 of 21
84 Mongolian provinces in 2013–2017 (Table I). Sampling was not carried out in Orkhon
85 and Darkhan-Uul provinces, as the livestock farming is uncommon in these 2 urban
86 areas. Approximately 2 ml of blood was collected from each animal into a vacutainer
87 tube, without anticoagulant (Zhejiang Gongdong Medical Technology Co. Ltd., Taizhou,
88 Zhejiang, China). All sampled animals were apparently healthy during sampling. Serum
89 samples were prepared from blood and stored at –20 C until use. All animal procedures
90 were approved by the Animal Care and Use Committee of Obihiro University of

91 Agriculture and Veterinary Medicine, Japan (approval number: 29-1).

92 **ELISAs**

93 All serum samples were screened for *T*. *equi*- and *B*. *caballi*-specific antibodies
94 using previously described ELISAs (Huang et al., 2003; Ikadai et al., 1999). Briefly, the
95 truncated form of *T*. *equi* merozoite antigen-2 (EMA-2t) and the 48-kDa merozoite
96 rhoptry protein (BC48) of *B*. *caballi* were expressed as GST-fusion proteins
97 (rGST-EMA-2t and rGST-BC48, respectively) in *Escherichia coli*, then purified as
98 described by Huang et al. (2003) and Ikadai et al. (1999), respectively. Each well in
99 96-well ELISA microplates was coated with 5 μg/ml of rGST-EMA-2t, rGST-BC48, or
100 rGST antigen diluted in a carbonate–bicarbonate buffer, then incubated at 4 C overnight.
101 After discarding unabsorbed antigens, each well was blocked with 100 μl of 3%
102 skimmed milk in phosphate-buffered saline (PBS) with 0.05% Tween 20 (blocking
103 solution) at room temperature for 1 hr. After washing once with 200 μl of PBS
104 containing 0.05% Tween 20 (wash buffer), 100 μl of horse serum sample diluted 1:200
105 in blocking solution was added to each well. The ELISA plates were incubated at 37 C
106 for 1 hr, then each well was washed 6 times with wash buffer. Next, 100 μl of
107 horseradish peroxidase-conjugated goat anti-horse immunoglobulin G (Sigma-Aldrich,
108 St. Louis, Missouri) diluted 1:5,000 in blocking solution was added to each well, and

109 the plates were incubated at 37 C for 1 hr. After washing 6 times with wash buffer, 50
110 µl of tetramethylbenzidine (TMB) substrate solution (Sigma-Aldrich) was added to each
111 well, then incubated at 37 C for 30 min. After adding 50 µl of TMB stop solution
112 (Sigma-Aldrich), the optical density (OD) value was measured at 450 nm.
113 For each serum sample, the net OD value was calculated by subtracting the OD
114 value of the rGST-coated well from that of rGST-EMA2t- or rGST-BC48-coated wells.
115 A sample was considered to be positive for the *T. equi* or *B. caballi* antibody if the net
116 OD value was higher than the mean OD value + 3 standard deviations of 10 negative
117 serum samples.
118 **Statistical analyses**
119 The 95% confidence intervals for positive rates were calculated using an
120 OpenEpi software program (http://www.openepi.com/Proportion/Proportion.htm) based
121 on the Wilson score interval (Wilson, 1927). *P* values to compare positive rates between
122 female and male horses, as well as between 1–3-yr-old and >3-yr-old age groups, were
123 calculated using an "N-1" chi-squared test
124 (https://www.medcalc.org/calc/comparison_of_proportions.php) (Campbell, 2007;
125 Richardson, 2011). A P value < 0.05 was considered to indicate a significant difference
126 between the positive rates.

RESULTS

We screened a total of 1,282 horses in 19 Mongolian provinces for the presence of antibodies to *T. equi* and *B. caballi* using ELISAs (Table I). Among them, 423 (33.0%) and 182 (14.2%) were positive for *T. equi* and *B*. *caballi*, respectively. In addition, 518 (40.4%) horses were positive for at least 1 parasite species, and 87 (16.8%) among them had co-infection with *T. equi* and *B*. *caballi*. The overall positive rate of *T. equi* was significantly higher than that of *B. caballi* ($P < 0.0001$). On a per province basis, the positive rates of *T. equi* and *B. caballi* ranged from 19.0%–74.2% and 4.5%–39.8%, respectively. In each province, except for Dundgovi, the positive rate of *T. equi* was higher than that of *B. caballi* (Table I). Although the reason for the higher rate of *B*. *caballi* positivity compared with that of *T*. *equi* in Dundgovi is not very clear, the finding may not be conclusive as the sample size was relatively small.

Geographically, high rates of *T. equi* positivity (>25%) were observed in all provinces in central (Arkhangai, Tov, and Ovorkhangai) and Govi (Bayankhongor, Dundgovi, Govisumber, Omnogovi, and Dornogovi) regions, as well as in Bayan-Ulgii in the western region, Bulgan and Selenge in the northern region, and Dornod and Sukhbaatar in the eastern region (Fig. 1). The geographical variation of *B. caballi*-positive rates was comparable with that of *T. equi* (Fig. 1). All provinces with

high rates of *T. equi* positivity (>25%) also had relatively high rates of *B. caballi* positivity (>10%). However, *B. caballi*-positive rate in Govisumber was <10%, compared with >25% *T. equi* positivity, while in Khovsgol, *B. caballi*-positive rate was >10%, compared with <25% *T. equi* positivity (Fig. 1).

We next compared the positive rates between male and female horses, and between 1–3-yr-old and >3-yr-old age groups. Between males and females, the overall positive rates of both *T. equi* (31.9% and 34.5%) and *B. caballi* (14.1% and 14.3%, respectively) were comparable (Table II). In addition, positive rates of these parasite species in each surveyed province were also comparable between males and females. On the other hand, overall positive rates of *T. equi* and *B. caballi* were significantly higher ($P < 0.0001$ and 0.012, respectively) in the >3-yr-old age group (37.7% and 15.6%, respectively) compared with those in the 1–3-yr-old age group (19.4% and 10.0%, respectively) (Table III).

DISCUSSION

Seroepidemiological surveys of *T. equi* and *B. caballi* are very important to estimate the risk of infections in horses in endemic countries. The objective of the present study was to investigate the seroepidemiology of *T. equi* and *B. caballi* infections in horses reared throughout Mongolia. ELISA based on BC48 is widely used

for sero-diagnsosis of *B*. *caballi*, while EMA-1 and EMA-2 are the 2 most commonly used antigens in *T*. *equi*-specific ELISA (Salim et al., 2008; Munkhjargal et al., 2013; Rosales et al., 2013). However, a previous study found that EMA-2-based ELISA could detect *T*. *equi*-specific antibodies in infected horses 6-12 days earlier compared with EMA-1 ELISA (Huang et al., 2003). In the present study, therefore, BC48- and EMA-2-based ELISAs were employed for the sero-survey of *B*. *caballi* and *T*. *equi*, respectively. Our findings demonstrated that horses in all of the surveyed provinces had been exposed to both *T. equi* and *B. caballi*. The overall positive rate of *T. equi* infection was significantly higher than that of *B. caballi*. This observation is an agreement with the findings from previous studies conducted in Mongolia (Boldbaatar et al., 2005; Munkhjargal et al., 2013).

The virulence of *T*. *equi* is known to be higher than that of *B*. *caballi* (Camacho et al., 2005). Therefore, the high rate of *T*. *equi* positivity suggests that horse populations throughout Mongolia are at risk of clinical piroplasmosis. Indeed, a recent study found evidence to suggest *T*. *equi* is the causative agent of severe equine piroplasmosis among Mongolian wild horses (Przewalski's horse) (Tarav et al., 2017). Possible reasons for observed differential positive rates of *T. equi* and *B. caballi* include differences in the density of infected tick vectors and waning of immunity following

parasite clearance. A previous study identified *Dermacentor nuttalli*, the most abundant tick species in Mongolia, as a vector of both *T. equi* and *B. caballi* in Mongolia (Battsetseg et al., 2001). Notably, however, the rate of *T. equi*-infected *D. nuttalli* was higher than that of *B. caballi*-infected ticks (Battsetseg et al., 2001). Compared with *B. caballi*, the *T. equi* infection usually persists in the host for longer, probably throughout its life, acting as a source of infection for ticks vectors (Zweygarth et al., 1996; Mehlhorn and Schein, 1998). Moreover, complete elimination of *T. equi* from such chronically infected horses is extremely difficult (Friedhoff and Soule, 1996). These observations could explain why the *T. equi*-positive rate was higher than the *B. caballi*-positive rate in the present study.

We also observed differences in the positive rates of *T. equi* and *B. caballi* infections among Mongolian provinces. Differences in the density of *D. nuttalli* in different Mongolian regions might explain these geographical variations; however, the geographical distribution of *D. nuttalli* in Mongolia is not completely understood. Therefore, future studies should focus on analyzing the relative abundance of *D. nuttalli* in various provinces of this country. As well as *D. nuttalli*, several other species of ticks are known to exist in Mongolia (Tuvshintulga et al., 2015; Boldbaatar et al., 2017). Thus, the investigation of *T. equi* and *B. caballi* infections in other tick species could

199 help understand the epidemiology of these parasite species in Mongolian horses.

200 Our findings also showed that the positive rates of both *T*. *equi* and *B*. *caballi*
201 infections were comparable between male and female horses. In Mongolia, both horse
202 sexes are reared together under the same management system, which may explain the
203 comparable positive rates of infection (Munkhjargal et al., 2013). In contrast, *T*. *equi*-
204 and *B*. *caballi*-positive rates of infection were higher in older horses compared with
205 younger animals. This is likely to reflect the greater chance of being exposed to infected
206 ticks with increasing horse age (Rüegg et al., 2007).

207 A limitation of the present study is relatively small sample size, which was not
208 defined statistically, compared with the horse population in each province. Previous
209 studies found potential strain variations among *T*. *equi* and *B*. *caballi* isolates (Bhoora,
210 et al., 2009; Munkhjargal et al., 2013). The genetic variations were also observed
211 among gene sequences encoding EMAs in *T*. *equi* and BC48 in *B*. *caballi* (Bhoora, et al.,
212 2010a, 2010b). However, impact of such genetic variations on our ELISA results was
213 not considered, and this is also a limitation of the present study.

214 In summary, the present study found that horses bred throughout Mongolia
215 were exposed to both *T. equi* and *B. caballi* infections. We also found that the positive
216 rates of both *T*. *equi* and *B*. *caballi* varied among the surveyed provinces. The present

findings must be useful for designing a risk-based control strategy with the objective of minimizing *T. equi* and *B. caballi* infections in horses in Mongolia.

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356
357 **FIGURE 1.** Epidemiological mapping of *Theileria equi* and *Babesia caballi*.
358 Epidemiological maps were prepared to illustrate geographical variations of the
359 seropositive rates of (**A**) *T. equi* and (B) *B. caballi* infections among Mongolian horses,
360 using ArcGIS v10.1 software program (Environmental Systems Research Institute,

Redlands, California). The differential prevalence rates are indicated by different colors.

Table I. Positive rates of *Theileria equi* and *Babesia caballi* infections in horses in 19 Mongolian provinces.

Province	No. samples	*T. equi*		*B. caballi*		Co-infection[†]	
		No. positive	% (CI*)	No. positive	% (CI)	No. positive	% (CI)
Arkhangai	54	20	37.0 (25.4-50.4)	7	13.0 (6.4-24.4)	5	22.7 (10.1-43.4)
Bayankhongor	57	18	33.3 (21.0-44.5)	7	12.3 (6.1-23.3)	4	19.0 (7.7-40.0)
Bayan-Ulgii	105	45	43.0 (33.8-52.4)	17	16.2 (10.4-24.4)	10	19.2 (10.8-31.9)
Bulgan	20	6	30.0 (14.5-51.9)	2	10.0 (2.8-30.1)	0	0.0 (0.0-32.4)
Dornod	93	69	74.2 (64.5-82.0)	37	39.8 (30.4-49.9)	30	39.5 (29.3-50.7)
Dornogovi	57	16	28.1 (18.1-40.8)	9	16.0 (8.5-27.4)	4	19.0 (7.7-40.0)
Dundgovi	33	10	30.3 (17.4-47.3)	12	36.3 (22.2-53.4)	4	22.2 (9.0-45.2)
Govi-Altai	29	17	59.0 (40.7- 74.5)	7	24.1 (12.2-42.1)	4	20.0 (8.1-41.6)
Govisumber	25	7	28.0 (14.3-47.6)	2	8.0 (2.2- 24.9)	2	28.6 (8.2-64.1)
Khentii	98	24	24.5 (17.1-33.9)	7	7.1 (3.5-14.02)	1	3.3 (0.6-16.7)
Khovd	110	21	19.0 (12.8-27.4)	5	4.5 (1.9-10.2)	3	13.0 (4.5-32.1)
Khovsgol	62	15	24.1 (15.2-36.1)	9	14.5 (7.8-25.3)	3	14.3 (5.0-34.6)
Omnogovi	57	20	35.0 (24.0-48.1)	12	21.0 (12.5-33.3)	6	23.1 (11.0-42.1)
Ovorkhangai	26	11	42.3 (25.6-61.1)	3	11.5 (4.0-28.9)	0	0.0 (0.0-21.5)
Selenge	64	13	26.5 (12.3-31.7)	9	14.0 (7.6-24.6)	1	4.8 (0.8-22.7)
Sukhbaatar	136	42	31.0 (23.8-39.1)	15	11.0 (6.8-17.4)	4	7.5 (3.0-17.9)
Tov	48	23	48.0 (34.5-61.7)	6	12.5 (5.8-24.7)	3	11.5 (4.0-29.0)
Uvs	75	17	23.0 (14.7-33.3)	5	6.6 (2.9-14.7)	2	10.0 (2.8-30.1)
Zavkhan	133	29	22.0 (15.6- 29.6)	11	8.2 (4.7-14.2)	1	2.6 (0.5-13.2)
Total	1,282	423	33.0 (30.5-35.6)	182	14.2 (12.4-16.2)	87	16.8 (13.8-20.3)

* 95% confidence interval

[†] Expressed as a percentage of the number of animals infected with at least one parasite species (No. *T. equi*-positive + No. *B. caballi*-positive – No. co-infected).

Table II. Positive rates of *Theileria equi* and *Babesia caballi* infection in male and female horses in 19 Mongolian provinces.

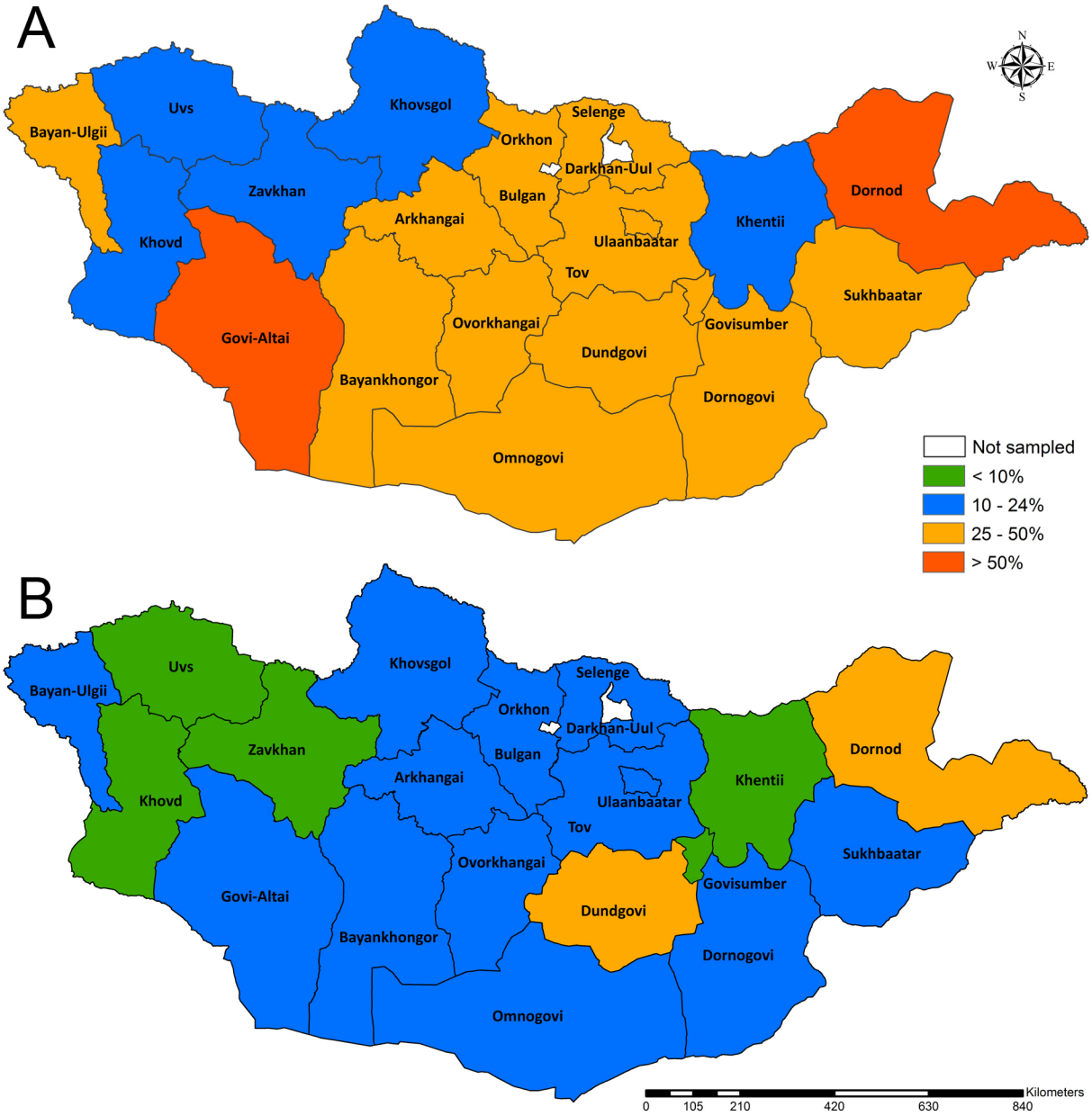
Province	No. Samples		*T. equi*					*B. caballi*				
	Male	Female	Male		Female		*P* value	Male		Female		*P* value
			No. positive	% (CI*)	No. positive	% (CI)		No. positive	% (CI)	No. positive	% (CI)	
Arkhangai	30	24	10	33.3 (19.2-51.2)	10	41.7 (24.5-61.2)	0.5292	4	13.3 (5.3-29.7)	3	12.5 (4.3- 31.0)	0.9313
Bayankhongor	28	29	10	36.0 (20.7-54.2)	8	27.6 (14.7-45.7)	0.4996	5	17.8 (7.9-35.6)	2	6.9 (1.9- 21.9)	0.2137
Bayan- Ulgii	40	65	13	32.5 (20.1-47.9)	32	49.2 (37.5-61.1)	0.0947	7	17.5 (8.7-31.9)	10	15.4 (8.6- 26.0)	0.7777
Bulgan	12	8	5	42.0 (19.3-68.0)	1	12.5 (2.2-47.1)	0.1700	1	8.3 (1.5-35.4)	1	12.5 (2.2-47.1)	0.7648
Dornod	65	28	49	75.4 (63.7-84.2)	20	71.4 (52.9-84.7)	0.6875	24	36.9 (26.2-49.1)	13	46.4 (29.5-64.2)	0.3931
Dornogovi	32	25	4	12.5 (4.9-28.1)	12	48.0 (30.0-66.5)	0.0033	5	15.6 (6.9-31.7)	4	16.0 (6.4-34.6)	0.9675
Dundgovi	4	29	2	50.0 (15.0-85.0)	8	27.6 (14.7-45.7)	0.3682	2	50.0 (15.0-85.0)	10	34.5 (19.9-52.6)	0.5520
Govi- Altai	22	7	14	63.6 (42.9-80.3)	3	42.8 (15.8-74.9)	0.3390	5	22.7 (10.1-43.4)	2	28.6 (8.2- 64.1)	0.7548
Govisumber	17	8	3	17.6 (6.2-41.0)	4	50.0 (21.5-78.5)	0.0990	1	5.9 (1.0-26.9)	1	12.5 (2.2-47.1)	0.5785
Khentii	55	43	12	21.8 (12.9-34.4)	12	27.9 (16.7-42.7)	0.4881	5	9.1 (3.9-19.6)	2	4.6 (1.3-15.4)	0.3926
Khovd	79	31	13	16.4 (9.9-26.1)	8	25.8 (13.7-43.2)	0.2609	5	6.3 (2.7-13.9)	0	0.0 (0-11.0)	0.1545
Khovsgol	35	27	7	20.0 (10.0-35.9)	8	29.6 (15.8-48.5)	0.3853	5	14.3 (6.3-29.4)	4	14.8 (5.9-32.5)	0.9562
Omnogovi	47	10	17	36.2 (12.1-64.6)	3	30.0 (10.8-60.3)	0.7116	8	17.0 (8.9-30.1)	4	40.0 (16.8-68.7)	0.1086
Ovorkhangai	9	17	3	33.3 (23.9-50.5)	8	47.0 (26.2-69.0)	0.5094	1	11.1 (1.9-43.5)	2	11.8 (3.3-34.3)	0.9685
Selenge	40	24	8	20.0 (10.5-34.8)	5	20.8 (9.2-40.5)	0.9370	5	12.5 (5.4- 26.1)	4	16.7 (6.7-35.9)	0.6426
Sukhbaatar	78	58	20	25.6 (17.3-36.3)	22	37.9 (26.6-50.8)	0.1259	10	12.8 (7.1-22.0)	5	8.6 (3.7-18.6)	0.4407
Tov	9	39	7	77.8 (45.3-93.7)	16	41.0 (27.1-56.6)	0.0487	1	11.1 (1.9-43.5)	5	12.8 (5.6-26.7)	0.8857
Uvs	46	29	12	26.1 (15.6-40.3)	5	17.2 (7.6-34.5)	0.3731	2	4.3 (1.2-14.5)	3	10.3 (3.6-26.4)	0.3120
Zavkhan	66	67	18	27.3 (18.0-39.0)	11	16.4 (9.4-27.1)	0.1295	5	7.6 (3.3-16.5)	6	8.9 (4.2-18.2)	0.7861
Total	714	568	228	31.9 (28.6-35.4)	196	34.5 (30.7-38.5)	0.3258	101	14.1 (11.8-16.9)	81	14.3 (11.6- 17.4)	0.9188

* 95% confidence interval

Table III. Positive rates of *Theileria equi* and *Babesia caballi* infection in 1–3-year-old and >3-year-old horse age groups in 19 Mongolian provinces.

Province	No. Samples		*T. equi*					*B. caballi*				
	1-3 years	>3 years	1-3 years		>3 years		*P* value	1-3 years		>3 years		*P* value
			No. positive	% (CI*)	No. positive	% (CI)		No. positive	% (CI)	No. positive	% (CI)	
Arkhangai	15	39	10	66.7 (41.7-84.8)	10	25.6 (14.6-41.1)	0.0055	4	26.7 (10.9-51.9)	3	7.7 (2.6-20.3)	0.0652
Bayankhongor	11	46	0	0.0 (0-25.9)	18	39.1 (26.4-53.5)	0.0130	0	0.0 (0-25.9)	7	15.2 (7.6-28.2)	0.1712
Bayan- Ulgii	17	88	2	11.8 (3.3-34.3)	43	48.9 (38.7-59.1)	0.0049	1	5.9 (1.0-26.9)	16	18.2 (11.5-27.5)	0.2099
Bulgan	11	9	4	36.4 (15.2-64.6)	2	22.2 (6.3-54.7)	0.5017	1	9.1 (1.6-37.7)	1	11.1 (1.9-43.5)	0.8851
Dornod	24	69	18	75.0 (55.1-88.0)	51	73.9 (62.5-82.8)	0.9160	10	41.7 (24.5-59.3)	27	39.1 (28.5-50.9)	0.8236
Dornogovi	18	39	3	16.7 (5.8-39.2)	13	33.3 (20.6-49.0)	0.1987	0	0.0 (0-17.6)	9	23.1 (12.6-38.3)	0.0276
Dundgovi	6	27	2	33.3 (9.7-70.0)	8	29.6 (15.8-48.5)	0.8605	1	16.7 (3.0-56.3)	11	40.7 (24.5-59.3)	0.2763
Govi- Altai	10	19	3	30.0 (10.8-60.3)	14	73.7 (51.2-88.2)	0.0256	0	0.0 (0-27.8)	7	36.8 (19.1-58.9)	0.0305
Govisumber	10	15	0	0.0 (0-27.8)	7	46.7 (24.8-69.9)	0.0126	0	0.0 (0-27.8)	2	13.3 (3.7-37.9)	0.2388
Khentii	11	87	2	18.2 (5.1-47.7)	22	25.3 (17.3-35.3)	0.6078	0	0.0 (0-25.9)	7	8.0 (3.9-15.7)	0.2388
Khovd	23	87	1	4.3 (0.8-20.9)	20	22.9 (15.4-32.9)	0.0442	0	0.0 (0-14.3)	5	5.7 (2.5-12.8)	0.2435
Khovsgol	13	49	2	15.4 (4.3-42.2)	13	26.5 (16.2-40.3)	0.5593	5	38.5 (17.7-64.5)	4	8.2 (4.4-21.8)	0.0063
Omnogovi	22	35	3	13.6 (4.7-33.3)	17	48.6 (33.0-64.4)	0.0075	3	13.6 (4.7-33.3)	9	25.7 (13.4-40.1)	0.2794
Ovorkhangai	7	19	1	14.3 (2.6-51.3)	10	52.6 (31.7-72.7)	0.0855	0	0.0 (0-35.4)	3	15.8 (5.5- 37.6)	0.2729
Selenge	20	44	2	10.0 (2.8-30.1)	11	25.0 (14.6-39.4)	0.1702	3	15.0 (5.2-36.0)	6	13.6 (6.4-26.7)	0.8821
Sukhbaatar	42	94	5	11.9 (5.2-25.0)	37	39.4 (30.1-49.5)	0.0014	1	2.4 (0.4-12.3)	14	14.9 (9.1-23.5)	0.0323
Tov	11	37	2	18.2 (5.1-47.7)	21	56.7 (40.9-71.3)	0.0264	1	9.1 (1.6-37.7)	5	13.5 (5.9-27.9)	0.7014
Uvs	26	49	2	7.7 (2.1-24.1)	15	30.6 (19.5-44.5)	0.0251	2	7.7 (2.1-24.1)	3	6.1 (2.1-16.5)	0.7927
Zavkhan	32	101	2	6.2 (1.7-20.1)	27	26.7 (19.1-36.1)	0.0147	1	3.1 (0.5-15.7)	10	9.9 (5.5-17.3)	0.2252
Total	329	953	64	19.4 (15.5-24.0)	359	37.7 (34.6-40.8)	<0.0001	33	10.0 (7.2-13.7)	149	15.6 (13.5-18.1)	0.0120

* 95% confidence interval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