

## SUPPLEMENTARY DATA

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**Evidence confirming the phylogenetic position of *Anaplasma centrale* (ex Theiler 1911)  
Ristic and Kreier 1984**

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**Supplementary Table S1.** Accession numbers for GenBank reference sequences used in the study.

Accession number	Species	Origin/Strain	Reference	Host
<b>16SrRNA</b>				
AB211163	<i>A. bovis</i>	Japan	[1]	Deer
HM131218	<i>A. bovis</i>	Japan	[2]	Dog
AF283007	" <i>A. capra</i> " (previously <i>A. centrale</i> Aomori)	Japan	[3]	Cattle
KP314237	" <i>A. capra</i> "	China	[4]	Tick
KX417195	" <i>A. capra</i> "	China	[5]	Sheep
KX417207	" <i>A. capra</i> "	China	[5]	Sheep
KY007144	" <i>A. capra</i> "	China	[6]	Tick
AF318944	<i>A. centrale</i>	South Africa	[7]	Vaccine Onderstepoort
AF414868	<i>A. centrale</i>	South Africa	[8]	Vaccine Onderstepoort
AF414869	<i>A. centrale</i>	South Africa L strain	[8]	Tick
CP001759	<i>A. centrale</i>	Israel strain	[9]	Cattle
EF520688	<i>A. centrale</i>	Italy	[10]	Cattle
EF520690	<i>A. centrale</i>	Italy	[10]	Cattle
KC189841	<i>A. centrale</i>	South Africa	[11]	Buffalo
KU686784	<i>A. centrale</i>	Uganda	[12]	Cattle
AF414871	<i>A. marginale</i>	South Africa	[8]	Black wildebeest
AF414878	<i>A. marginale</i>	Zimbabwe	[8]	Not known
CP000030	<i>A. marginale</i>	St. Maries	[13]	Cattle
CP001079	<i>A. marginale</i>	Florida	[14]	Cattle
DQ341369	<i>A. marginale</i>	China	[15]	Buffalo
AF414870	<i>A. ovis</i>	South Africa	[8]	Sheep
EF587237	<i>A. ovis</i>	China	[16]	Sheep
AB196720	<i>A. phagocytophilum</i>	Japan	[1]	Deer
KC470064	<i>A. phagocytophilum</i>	China	[17]	Rat
AY077619	<i>A. platys</i>	Japan	[18]	Dog
EF139459	<i>A. platys</i>	Thailand	[19]	Dog
U11021	<i>Rickettsia rickettsii</i>	USA	[20]	Tick
<b>GroEL</b>				
AF414866	<i>A. centrale</i>	South Africa L strain	[8]	Tick
CP001759	<i>A. centrale</i>	Israel strain	[9]	Cattle
EF520694	<i>A. centrale</i>	Italy	[10]	Cattle
AF414860	<i>A. marginale</i>	Australia	[8]	Cattle
CP000030	<i>A. marginale</i>	St. Maries	[13]	Cattle
FJ226455	<i>A. marginale</i>	Japan	[21]	Cattle
AF441131	<i>A. ovis</i>	South Africa	[8]	Goat
FJ460441	<i>A. ovis</i>	Cyprus	[22]	Goat
AF482760	<i>A. phagocytophilum</i>	Germany	[23]	Horse
KJ677107	<i>A. phagocytophilum</i>	South Korea	[24]	Human
AF478129	<i>A. platys</i>	DRC	[25]	Tick
AY077621	<i>A. platys</i>	Japan	[18]	Dog
AY050315	<i>Neorickettsia helminthoeca</i>	USA	[26]	Dog
<b>Msp4</b>				
KR261641	" <i>A. capra</i> "	China	[27]	Tick
KX417357	" <i>A. capra</i> "	China	[5]	Sheep
CP001759	<i>A. centrale</i>	Israel strain	[9]	Cattle
AY283194	<i>A. marginale</i>	Brazil	[28]	Cattle
AY702922	<i>A. marginale</i>	Italy	[29]	Tick
CP001079	<i>A. marginale</i>	Florida	[14]	Cattle
CP000030	<i>A. marginale</i>	St. Maries	[13]	Cattle
EU436159	<i>A. marginale</i>	Italy	[30]	Cattle

HQ456348	<i>A. ovis</i>	China	[31]	Sheep
JQ663993	<i>A. ovis</i>	Iran	[32]	Sheep
HQ661163	<i>A. phagocytophilum</i>	Slovakia	[33]	Sheep
KP861636	<i>A. phagocytophilum</i>	Spain	[34]	Tick
AF020068	<i>Wolbachia sp.</i>	USA	[35]	Fly

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**Supplementary Table S2.** Accession numbers for the 16S rRNA gene, *groEL* and *msp4* gene sequences generated in the study.

Accession number	Sample name	Species	Origin	Host	Genotype
<b>16S rRNA</b>					
KY287616	HiP_4_B	<i>A. centrale</i>	Hluhluwe iMfolozi Park	Buffalo	Ac1
KY287615	HiP_3_B	<i>A. centrale</i>	Hluhluwe iMfolozi Park	Buffalo	Ac2
KY287623	KNP_581_B	<i>A. centrale</i>	Kruger National Park	Buffalo	Ac2
KY287630	KNP_584_F	<i>A. centrale</i>	Kruger National Park	Buffalo	Ac4
KY287618	HiP_6_L	<i>A. centrale</i>	Hluhluwe iMfolozi Park	Buffalo	Ac4
KY287614	HiP_2_A	<i>A. centrale</i>	Hluhluwe iMfolozi Park	Buffalo	Ac4
KY287600	AEP_1007_2	<i>A. centrale</i>	Addo Elephant National Park	Buffalo	Ac4
KY287622	HiP_6_a	<i>A. centrale</i>	Hluhluwe iMfolozi Park	Buffalo	Ac4
KY287605	AEP_1013_G	<i>A. centrale</i>	Addo Elephant National Park	Buffalo	Ac4
KY287624	KNP_581_C	<i>A. centrale</i>	Kruger National Park	Buffalo	Ac4
KY287627	KNP_584_A2	<i>A. centrale</i>	Kruger National Park	Buffalo	Ac4
KY287611	CNP_978_B	<i>A. centrale</i>	Camdeboo National Park	Buffalo	Ac4
KY287612	CNP_985_B	<i>A. centrale</i>	Camdeboo National Park	Buffalo	Ac4
KY287607	Berg_27_d	<i>A. centrale</i>	Bergville Farm 2	Cattle	Ac4
KY287636	MNP_999_2	<i>A. centrale</i>	Mokala National Park	Buffalo	Ac4
KY287619	HiP_6_L1	<i>A. centrale</i>	Hluhluwe iMfolozi Park	Buffalo	Ac4
KY287613	CNP_976_A	<i>A. centrale</i>	Camdeboo National Park	Buffalo	Ac4
KY287606	Berg_27_a	<i>A. centrale</i>	Bergville Farm 2	Cattle	Ac3
KY287632	MNP_1000_4	<i>A. centrale</i>	Mokala National Park	Buffalo	Ac3
KY287626	KNP_584_A	<i>A. centrale</i>	Kruger National Park	Buffalo	Ac3
KY287621	HiP_6_Z	<i>A. centrale</i>	Hluhluwe iMfolozi Park	Buffalo	Ac3
KY287620	HiP_6_p	<i>A. centrale</i>	Hluhluwe iMfolozi Park	Buffalo	Ac3
KY287604	AEP_1013_F	<i>A. centrale</i>	Addo Elephant National Park	Buffalo	Ac3
KY287631	MNP_1000_1	<i>A. centrale</i>	Mokala National Park	Buffalo	Ac3
KY287671	HiP_6_aJan	<i>A. marginale</i>	Hluhluwe iMfolozi Park	Buffalo	Am3
KY287625	KNP_581_H	<i>A. marginale</i>	Kruger National Park	Buffalo	Am3
KY287629	KNP_584_C2	<i>A. marginale</i>	Kruger National Park	Buffalo	Am3
KY287628	KNP_584_C	<i>A. marginale</i>	Kruger National Park	Buffalo	Am3
KY287610	CNP_976_3	<i>A. marginale</i>	Camdeboo National Park	Buffalo	Am3
KY287609	CNP_976_1	<i>A. marginale</i>	Camdeboo National Park	Buffalo	Am3
KY287603	AEP_1013_A	<i>A. marginale</i>	Addo Elephant National Park	Buffalo	Am3
KY287602	AEP_1007_8	<i>A. marginale</i>	Addo Elephant National Park	Buffalo	Am3
KY287608	Berg_27_E	<i>A. marginale</i>	Bergville Farm 2	Cattle	Am3
KY287634	MNP_1021_1	<i>A. marginale</i>	Mokala National Park	Buffalo	Am3
KY287638	MNP_999_A	<i>A. marginale</i>	Mokala National Park	Buffalo	Am3
KY287639	MNP_999_D	<i>A. marginale</i>	Mokala National Park	Buffalo	Am3
KY287635	MNP_1021_2	<i>A. marginale</i>	Mokala National Park	Buffalo	Am3
KY287633	MNP_1000_A	<i>A. marginale</i>	Mokala National Park	Buffalo	Am3
KY287637	MNP_999_5_1	<i>A. marginale</i>	Mokala National Park	Buffalo	Am1
KY287601	AEP_1007_5	<i>A. marginale</i>	Addo Elephant National Park	Buffalo	Am2
<b>GroEL</b>					
KY305539	HiP_6_A	<i>A. centrale</i>	Hluhluwe iMfolozi Park	Buffalo	Ac1
KY305547	HiP_3_A	<i>A. centrale</i>	Hluhluwe iMfolozi Park	Buffalo	Ac1
KY305540	AEP_1013_C	<i>A. centrale</i>	Addo Elephant National Park	Buffalo	Ac1
KY305541	CNP_976_1	<i>A. centrale</i>	Camdeboo National Park	Buffalo	Ac1
KY305542	CNP_985_A2	<i>A. centrale</i>	Camdeboo National Park	Buffalo	Ac1
KY305543	AEP_1013_D	<i>A. centrale</i>	Addo Elephant National Park	Buffalo	Ac1
KY305544	AEP_1003_B	<i>A. centrale</i>	Addo Elephant National Park	Buffalo	Ac1
KY305553	AEP_1007_1	<i>A. centrale</i>	Addo Elephant National Park	Buffalo	Ac1
KY305556	AEP_1003_E	<i>A. centrale</i>	Addo Elephant National Park	Buffalo	Ac1
KY305545	CNP_978_C	<i>A. centrale</i>	Camdeboo National Park	Buffalo	Ac1

KY305546	CNP_978_A	<i>A. centrale</i>	Camdeboo National Park	Buffalo	Ac1
KY305550	CNP_978_B	<i>A. centrale</i>	Camdeboo National Park	Buffalo	Ac1
KY305548	CNP_985_A	<i>A. centrale</i>	Camdeboo National Park	Buffalo	Ac1
KY305549	CNP_985_C	<i>A. centrale</i>	Camdeboo National Park	Buffalo	Ac1
KY305551	KNP_584_A	<i>A. centrale</i>	Kruger National Park	Buffalo	Ac1
KY305557	KNP_581_B	<i>A. centrale</i>	Kruger National Park	Buffalo	Ac1
KY305560	KNP_581_A	<i>A. centrale</i>	Kruger National Park	Buffalo	Ac1
KY305552	MNP_1000_1	<i>A. centrale</i>	Mokala National Park	Buffalo	Ac1
KY305555	MNP_999_3	<i>A. centrale</i>	Mokala National Park	Buffalo	Ac1
KY305554	Berg_27_C	<i>A. centrale</i>	Bergville Farm 2	Cattle	Ac1
KY305559	Berg_27_A	<i>A. centrale</i>	Bergville Farm 2	Cattle	Ac1
KY305558	Berg_27_B	<i>A. centrale</i>	Bergville Farm 2	Cattle	Ac1
KY305561	CNP_976_2	<i>A. marginale</i>	Camdeboo National Park	Buffalo	Am1
KY305562	AEP_1007_3	<i>A. marginale</i>	Addo Elephant National Park	Buffalo	Am1
KY305563	MNP_1021_3	<i>A. marginale</i>	Mokala National Park	Buffalo	Am2
KY305564	MNP_1021_2	<i>A. marginale</i>	Mokala National Park	Buffalo	Am2
KY305565	MNP_1000_4	<i>A. marginale</i>	Mokala National Park	Buffalo	Am2
KY305567	MNP_1000_5	<i>A. marginale</i>	Mokala National Park	Buffalo	Am2
KY305568	KNP_582_A	<i>A. marginale</i>	Kruger National Park	Buffalo	Am2
KY305569	Berg_27_F	<i>A. marginale</i>	Bergville Farm 2	Cattle	Am2
KY305570	Berg_27_Z	<i>A. marginale</i>	Bergville Farm 2	Cattle	Am2
KY305571	KNP_582_A1	<i>A. marginale</i>	Kruger National Park	Buffalo	Am2
KY305572	HiP_6_D	<i>A. marginale</i>	Hluhluwe iMfolozi Park	Buffalo	Am2
KY305573	HiP_7_C	<i>A. marginale</i>	Hluhluwe iMfolozi Park	Buffalo	Am2
KY305574	MNP_958_C	<i>A. marginale</i>	Mokala National Park	Buffalo	Am2
KY305575	MNP_999_1	<i>A. marginale</i>	Mokala National Park	Buffalo	Am2
KY305576	MNP_999_4	<i>A. marginale</i>	Mokala National Park	Buffalo	Am2
KY305566	MNP_1000_2	<i>A. marginale</i>	Mokala National Park	Buffalo	Am2
KY305577	HiP_2_A	<i>A. marginale</i>	Hluhluwe iMfolozi Park	Buffalo	Am2
KY305578	KNP_584_2A2	<i>A. marginale</i>	Kruger National Park	Buffalo	Am2
KY305579	HiP_3_B	<i>A. marginale</i>	Hluhluwe iMfolozi Park	Buffalo	Am2
KY305580	AEP_1002_E	<i>A. marginale</i>	Addo Elephant National Park	Buffalo	Am2
KY305581	AEP_1002_A	<i>A. marginale</i>	Addo Elephant National Park	Buffalo	Am2
KY305582	HiP_4_A	<i>A. marginale</i>	Hluhluwe iMfolozi Park	Buffalo	Am2
KY305583	HiP_2_D	<i>A. marginale</i>	Hluhluwe iMfolozi Park	Buffalo	Am2

#### Msp4

KY305601	CNP_976AC2	<i>A. centrale</i>	Camdeboo National Park	Buffalo	Ac4
KY305603	CNP_979AC2	<i>A. centrale</i>	Camdeboo National Park	Buffalo	Ac4
KY305602	CNP_978AC2	<i>A. centrale</i>	Camdeboo National Park	Buffalo	Ac4
KY305604	Berg_25AC2	<i>A. centrale</i>	Bergville Farm 2	Cattle	Ac4
KY305605	Berg_19AC2	<i>A. centrale</i>	Bergville Farm 1	Cattle	Ac4
KY305606	Berg_27AC2	<i>A. centrale</i>	Bergville Farm 1	Cattle	Ac4
KY305607	HiP_3AC	<i>A. centrale</i>	Hluhluwe iMfolozi Park	Buffalo	Ac4
KY305608	HiP_7AC	<i>A. centrale</i>	Hluhluwe iMfolozi Park	Buffalo	Ac4
KY305609	MNP_1000AC	<i>A. centrale</i>	Mokala National Park	Buffalo	Ac4
KY305610	HiP_4AC	<i>A. centrale</i>	Hluhluwe iMfolozi Park	Buffalo	Ac4
KY305611	HiP_2AC	<i>A. centrale</i>	Hluhluwe iMfolozi Park	Buffalo	Ac4
KY305612	CNP_976AC	<i>A. centrale</i>	Camdeboo National Park	Buffalo	Ac4
KY305613	AEP_1007AC	<i>A. centrale</i>	Addo Elephant National Park	Buffalo	Ac4
KY305614	HiP_6AC	<i>A. centrale</i>	Hluhluwe iMfolozi Park	Buffalo	Ac4
KY305615	CNP_978AC	<i>A. centrale</i>	Camdeboo National Park	Buffalo	Ac4
KY305616	KNP_581AC	<i>A. centrale</i>	Kruger National Park	Buffalo	Ac1
KY305617	Berg_27AC	<i>A. centrale</i>	Bergville Farm 2	Cattle	Ac3
KY305618	Berg_25AC	<i>A. centrale</i>	Bergville Farm 2	Cattle	Ac3
KY305619	AEP_999AC	<i>A. centrale</i>	Addo Elephant National Park	Buffalo	Ac3
KY305620	KNP_584AC	<i>A. centrale</i>	Kruger National Park	Buffalo	Ac3
KY305612	Berg_19AC	<i>A. centrale</i>	Bergville Farm 1	Cattle	Ac2
KY305590	KNP_581_AM	<i>A. marginale</i>	Kruger National Park	Buffalo	Am3

KY305584	HiP_17AM	<i>A. marginale</i>	Hluhluwe iMfolozi Park	Buffalo	Am3
KY305585	HiP_7AM	<i>A. marginale</i>	Hluhluwe iMfolozi Park	Buffalo	Am3
KY305595	HiP_6AM	<i>A. marginale</i>	Hluhluwe iMfolozi Park	Buffalo	Am3
KY305586	Berg_27AM	<i>A. marginale</i>	Bergville Farm 2	Cattle	Am3
KY305587	KNP_584AM	<i>A. marginale</i>	Kruger National Park	Buffalo	Am3
KY305588	MNP_999AM	<i>A. marginale</i>	Mokala National Park	Buffalo	Am3
KY305589	HiP_2AM	<i>A. marginale</i>	Hluhluwe iMfolozi Park	Buffalo	Am3
KY305591	HiP_10AM	<i>A. marginale</i>	Hluhluwe iMfolozi Park	Buffalo	Am3
KY305592	MNP_1000AM	<i>A. marginale</i>	Mokala National Park	Buffalo	Am3
KY305593	MNP_1021AM	<i>A. marginale</i>	Mokala National Park	Buffalo	Am3
KY305596	AEP_1007AM	<i>A. marginale</i>	Addo Elephant Park	Buffalo	Am3
KY305594	HiP_13AM	<i>A. marginale</i>	Hluhluwe iMfolozi Park	Buffalo	Am3
KY305597	HiP_6REPAM	<i>A. marginale</i>	Hluhluwe iMfolozi Park	Buffalo	Am3
KY305597	KNP_582AM	<i>A. marginale</i>	Kruger National Park	Buffalo	Am2
KY305599	HiP_5AM	<i>A. marginale</i>	Hluhluwe iMfolozi Park	Buffalo	Am2
KY305600	CNP_976AM	<i>A. marginale</i>	Camdeboo National Park	Buffalo	Am1

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## REFERENCES FOR SUPPLEMENTARY TABLE S1:

1. **Kawahara M, Rikihisa Y, Lin Q, Isogo E, Tahara K *et al.*** Novel genetic variants of *Anaplasma phagocytophilum*, *Anaplasma bovis*, *Anaplasma centrale*, and novel *Ehrlichia* sp. in wild deer and ticks on two major Islands in Japan. *Appl Environ Microbiol* 2006; 72: 1102-1109.
2. **Sakamoto L, Ichikawa Y, Sakata Y, Matsumoto K, Inokuma H.** Detection of *Anaplasma bovis* DNA in the peripheral blood of domestic dogs in Japan. *Jpn J Infect Dis* 2010; 63: 394-352.
3. **Inokuma H, Yutaka T, Kamio T, Raoult D, Brouqui P.** Analysis of the 16S rRNA gene sequence of *Anaplasma centrale* and its phylogenetic relatedness to other Ehrlichiae. *Clin Diagn Lab Immunol* 2001;8:241–244.
4. **Sun XF1, Zhao L1, Wen HL1, Luo LM1, Yu XJ.** *Anaplasma* species in China. *Lancet Infect Dis* 2015. 15(11):1263-1264.
5. **Yang J, Liu Z, Niu Q, Liu J, Han R *et al.*** A novel zoonotic *Anaplasma* species is prevalent in small ruminants: potential public health implications. *Parasit Vectors* 2017;10:1–6.
6. **Zhuang L, Liu W, Tong Y, Fan H, Cui X *et al.*** Identification of tick-borne pathogen diversity in *Haemaphysalis longicornis* by metagenome analysis. 2017. GenBank record.
7. **Bekker CP, de Vos S, Taoufik A, Sparagano OA, Jongejan F.** Simultaneous detection of *Anaplasma* and *Ehrlichia* species in ruminants and detection of *Ehrlichia ruminantium* in *Amblyomma variegatum* ticks by reverse line blot hybridization. *Vet. Microbiol* 2002, 89 (2-3): 223-238.
8. **Lew AE, Gale KR, Minchin CM, Shkap V, de Waal TD.** Phylogenetic analysis of the erythrocytic *Anaplasma* species based on 16S rDNA and GroEL (HSP60) sequences of *A. marginale*, *A. centrale*, and *A. ovis* and the specific detection of *A. centrale* vaccine strain. *Vet Microbiol* 2003; 92: 145-160.
9. **Herndon DR, Palmer GH, Shkap V, Knowles DP Jr, Brayton KA.** Complete genome sequence of *Anaplasma marginale* subsp. *centrale*. *J Bacteriol* 2010; 192:379-380.
10. **Ceci L, Decaro N, Lorusso E, Paradies P, Elia G *et al.*** First report of bovine anaplasmosis by *Anaplasma centrale* in Europe, molecular identification and phylogenetic analysis. *Vet Res Commun* 2008; 32: 263-266.
11. **Debeila EM.** Occurrence of *Anaplasma* and *Ehrlichia* species in African buffalo (*Syncerus caffer*) in Kruger National Park and Hluhluwe-iMfolozi Park in South Africa. *MSc*

dissertation. Department of Veterinary Tropical Diseases, University of Pretoria, Pretoria, South Africa. 2012.

12. **Byaruhanga C, Collins N, Knobel D, Oosthuizen M.** Phylogeny of *Anaplasma* species and sequence analysis of *Anaplasma marginale* in cattle from a pastoral area of Karamoja in Uganda. 2016. GenBank record.
13. **Brayton KA, Kappmeyer LS, Herndon DR, Dark MJ, Tibbals DL et al.** Complete genome sequencing of *Anaplasma marginale* reveals that the surface is skewed to two superfamilies of outer membrane proteins. *Proc Natl Acad Sci USA* 2005; 102: 844-849.
14. **Dark MJ, Herndon DR, Kappmeyer LS, Gonzales MP, Nordeen E et al.** Conservation in the face of diversity: multistrain analysis of an intracellular bacterium. *BMC Genomics* 2009; 10:16.
15. **Du K, Zhao J.** Amplification of 16S rRNA genes of *Anaplasma* species in south of China for phylogenetic analysis. 2006. GenBank record.
16. **Mo ZC, Huang WY, Zhang WY, Shi YL, Dai HL.** Amplification of 16S rRNA gene of *Anaplasma ovis* in Guangxi for phylogenetic analysis. 2007. GenBank record.
17. **Zhao XG, Li H, Sun Y, Zhang YY, Jiang JF et al.** Dual infection with *Anaplasma phagocytophilum* and *Babesia microti* in a *Rattus norvegicus*, China. *Ticks Tick Borne Dis* 2013; 4: 399-402.
18. **Inokuma H, Fujii K, Matsumoto K, Okuda M, Nakagome K et al.** Demonstration of *Anaplasma (Ehrlichia) platys* inclusions in peripheral blood platelets of a dog in Japan. *Vet Parasitol* 2002; 110: 145-152.
19. **Pinyoowong D, Jittapalapong S, Suksawat F, Stich RW, Thamchaipenet A.** Molecular characterization of Thai *Ehrlichia canis* and *Anaplasma platys* strains detected in dogs. *Infect Genet Evol* 2008; 8: 433-438.
20. **Stothard DR, Clark JB, Fuerst PA.** Ancestral divergence of *Rickettsia bellii* from the spotted fever and typhus groups of *Rickettsia* and antiquity of the genus *Rickettsia*. *Int J Syst Evol Microbiol* 1994; 44: 798-804.
21. **Ooshiro M, Zakimi S, Matsukawa Y, Yafuso M, Katagiri Y et al.** *Anaplasma marginale* infection in a Japanese Black cow 13 years after eradication of *Rhipicephalus (Boophilus) microplus* in Okinawa, Japan. *Vet Parasitol* 2009; 160: 351-355.
22. **Psaroulaki A, Chochlakis D, Sandalakis V, Vranakis I, Ioannou I et al.** Phylogenetic analysis of *Anaplasma ovis* strains isolated from sheep and goats using *groEL* and *mps4* genes. *Vet Microbiol* 2009; 138: 394-400.

23. Von Loewenich FD, Stumpf G, Baumgarten BU, Rollinghoff M, Dumler JS *et al.* A case of equine granulocytic ehrlichiosis provides molecular evidence for the presence of pathogenic *Anaplasma phagocytophilum* (HGE agent) in Germany. *Eur J Clin Microbiol Infect Dis* 2003. 22, 303-305.
24. Kim KH, Yi J, Oh WS, Kim NH, Choi SJ *et al.* Human granulocytic anaplasmosis, South Korea, 2013. *Emerg Infect Diseases* 2014; 20: 1708-1711.
25. Sanogo YO, Davoust B, Inokuma H, Parola P, Camicas JL *et al.* Amplification and sequence analysis of the 16S rRNA, the groESL and the gltA genes of *Ehrlichia platys* detected in *Rhipicephalus sanguineus* (Acari, Ixodida), collected on dogs in the Democratic Republic of Congo (RDC). 2016. GenBank record.
26. Rikihisa Y, Zhang C, Ohashi N, Zhi N, Kanter M. Characterization of p51 and groESL of *Ehrlichia sennetsu*, *Stellantchasmus falcatus* agent, and *Neorickettsia helminthoeca*. 2016. GenBank record.
27. Sun X-F and Yu X-J. Detection of *Anaplasma* sp. and *Anaplasma bovis* in *Haemaphysalis longicornis* ticks in Shandong Province, China. 2016. GenBank record.
28. de la Fuente J, Passos LM, van den Bussche RA, Ribeiro MF, Facury-Filho EJ *et al.* Genetic diversity and molecular phylogeny of *Anaplasma marginale* isolates from Minas Gerais, Brazil. *Vet Parasitol* 2004; 121: 317-316.
29. de la Fuente J, Torina A, Caracappa S, Tumino G, Furla R *et al.* Serologic and molecular characterization of *Anaplasma* species infection in farm animals and ticks from Sicily. *Vet Parasitol* 2005; 133: 357-362.
30. Torina A, Alongi A, Naranjo V, Estrada-Pena A, Vicente J *et al.* Prevalence and genotypes of *Anaplasma* species and habitat suitability for ticks in a Mediterranean ecosystem. *Appl. Environ. Microbiol* 2008. 74 (24): 7578-7584.
31. Ma M, Liu Z, Sun M, Yang J, Guan G *et al.* Development and Evaluation of a Loop-Mediated Isothermal Amplification Method for Rapid Detection of *Anaplasma ovis*. *J Clin Microbiol* 2011; 49: 2143-2146.
32. Yasini SP, Khaki Z, Rahbari S, Kazemi B, Amoli JS *et al.* Hematologic and clinical aspects of experimental ovine anaplasmosis caused by *Anaplasma ovis* in Iran. *Iran J Parasitol* 2012; 7: 91.
33. Derdáková M, Štefančíková A, Špitalská E, Taragel'ová V, Košťálová T *et al.* Emergence and genetic variability of *Anaplasma* species in small ruminants and ticks from central Europe. *Vet Microbiol* 2011; 153: 293-298.

- 34. Alberdi P, Ayllon N, Cabezas-Cruz A, Bell-Sakyi L, Zwegarth E *et al.*** Early survival of *Anaplasma phagocytophilum* isolates in *Ixodes* spp. tick cells requires the inhibition of apoptotic cell death. 2015. GenBank record.
- 35. Braig HR, Zhou W, Dobson SL, O'Neill SL.** Cloning and characterization of a gene encoding the major surface protein of the bacterial endosymbiont *Wolbachia pipientis*. *J Bacteriol* 1998; 180: 2373-2378.