

Ticks Collected from Selected Mammalian Hosts Surveyed in the Republic of Korea During 2008-2009

Heung Chul Kim¹, Sang Hoon Han², Sung Tae Chong¹, Terry A. Klein³, Chang-Yong Choi⁴, Hyun-Young Nam⁴, Hee-Young Chae⁴, Hang Lee⁵, Sungjin Ko⁶, Jun-Gu Kang⁶ and Joon-Seok Chae^{6,*}

¹5th Medical Detachment, 168th Multifunctional Medical Battalion, 65th Medical Brigade, Unit 15247, APO AP 96205-5247, USA; ²Division of Vertebrates Research, National Institute of Biological Resources, Incheon 404-708, Korea; ³Force Health Protection and Preventive Medicine, 65th Medical Brigade/U.S. Army MEDDAC-Korea, Unit 15281, APO AP 96205-5281, USA; ⁴Migratory Birds Center, National Park Research Institute, Korea National Park Service, Shinan-gun, Jeollanam-do 535-917, Korea; ⁵Conservation Genome Resource Bank for Korean Wildlife, College of Veterinary Medicine, Seoul National University, Seoul 151-742, Korea; ⁶Research Institute for Veterinary Science and BK21 Program for Veterinary Science, College of Veterinary Medicine, Seoul National University, Seoul 151-742, Korea

Abstract: A tick survey was conducted to determine the relative abundance and distribution of ticks associated with selected mammals in the Republic of Korea (ROK) during 2008-2009. A total of 918 ticks were collected from 76 mammals (6 families, 9 species) captured at 6 provinces and 3 Metropolitan Cities in ROK. *Haemaphysalis longicornis* (54.4%) was the most frequently collected tick, followed by *Haemaphysalis flava* (28.5%), *Ixodes nipponensis* (7.6%), *Ixodes pomertzevi* (4.8%), *Ixodes persulcatus* (4.6%), and *Haemaphysalis japonica* (0.1%). Adults (57.0%) and nymphs (28.7%) of *Ixodes* and *Haemaphysalis* spp. were collected most frequently from medium or large mammals in this survey, while few larvae (14.3%) were collected. *Hydropotes inermis* was the most frequently captured mammal (52.6%), with a 16.4 tick index and 5 of 6 species of ticks collected during this survey. *H. longicornis* (69.7%) was the predominant tick collected from *H. inermis*, followed by *H. flava* (22.2%), *I. persulcatus* (6.1%), *I. nipponensis* (1.8%), and *H. japonica* (0.2%).

Key words: *Haemaphysalis longicornis*, *Haemaphysalis flava*, *Ixodes nipponensis*, mammal, host, distribution

In the Republic of Korea (ROK), mammals and their associated ticks are hosts to a number of zoonotic pathogens, such as spotted fever group rickettsiae [1], *Ehrlichia* and *Anaplasma* spp. [2], *Bartonella* spp. [3], *Borrelia burgdorferi* [4-5], and tick-borne encephalitis virus [6-8]. Humans are incidental hosts as a result of outdoor activities, i.e., agriculture, construction, maintenance, recreation, and military training activities. New information, including retrospective febrile patient surveys, indicates that tick-borne diseases are underdiagnosed in the ROK [9-11].

Outdoor activities, including recreational hiking, agriculture, construction, and military operations, expose large sectors of human populations and their pets to all life stages of ticks, and associated pathogens of mammal [12]. Military populations

are at increased risk for acquiring tick-borne infections because they often conduct training operations in unmanaged lands where small mammals (i.e., rodents, soricomorphs, rabbits, and weasels), as well as larger species (i.e., deer, wild pigs, raccoon dogs, badgers, and feral cats) and pathogen-infected ectoparasites are present.

In a large mammal tick survey, Kang (1984) reported 565 ticks to determine baseline susceptibility to selected acaricides of ticks collected from domestic livestock (cows) from 35 cities and counties and 6 provinces from 1982 to 1984. Species collected included, *Haemaphysalis longicornis* (87.4%), *Boophilus microplus* (= *Rhipicephalus microplus*) (8.8%), *Ixodes persulcatus* (3.4%), *Rhipicephalus sanguineus* (0.5%), *Argas vespertilionis* (0.2%), and 1 unidentified tick [13]. Later, Kim et al. (2008) reported 130 *H. longicornis* and 12 *Ixodes nipponensis* from 16 wild boars at Dongducheon, Gyeonggi-do (Province), for isolation and detection of tick-borne encephalitis virus [6]. Reports and studies of tick collections from wild large mammals are few, with most surveys limited to small mammals conducted as part of rodent-borne diseases surveillance programs [14-

•Received 4 February 2011, revised 3 May 2011, accepted 7 June 2011.

*Corresponding author (jschae@snu.ac.kr)

© 2011, Korean Society for Parasitology

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/3.0>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE JUN 2011		2. REPORT TYPE		3. DATES COVERED 00-00-2011 to 00-00-2011	
4. TITLE AND SUBTITLE Ticks Collected from Selected Mammalian Hosts Surveyed in the Republic of Korea During 2008-2009				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) 5th Medical Detachment, 168th Multifunctional Medical Battalion, 65th Medical Brigade, Unit 15247, APO, AP, 96205-5247				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT A tick survey was conducted to determine the relative abundance and distribution of ticks associated with selected mammals in the Republic of Korea (ROK) during 2008-2009. A total of 918 ticks were collected from 76 mammals (6 families, 9 species) captured at 6 provinces and 3 Metropolitan Cities in ROK. Haemaphysalis longicornis (54.4%) was the most frequently collected tick, followed by Haemaphysalis flava (28.5%), Ixodes nipponensis (7.6%), Ixodes pomerantzevi (4.8%), Ixodes persulcatus (4.6%), and Haemaphysalis japonica (0.1%). Adults (57.0%) and nymphs (28.7%) of Ixodes and Haemaphysalis spp. were collected most frequently from medium or large mammals in this survey, while few larvae (14.3%) were collected. Hydropotes inermis was the most frequently captured mammal (52.6%), with a 16.4 tick index and 5 of 6 species of ticks collected during this survey. H. longicornis (69.7%) was the predominant tick collected from H. inermis, followed by H. flava (22.2%), I. persulcatus (6.1%), I. nipponensis (1.8%), and H. japonica (0.2%).					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

16]. The purpose of the present study was to determine the relative abundance, infestation rates, and geographical distributions of ticks associated with *Hydropotes inermis* (Korean water deer) and other wild mammals in the ROK.

As part of The 8th US Army, 65th Medical Brigade tick-borne disease surveillance program, the 5th Medical Detachment collaborated with 1) The Conservation Genome Resource Bank for Korean Wildlife, Seoul National University (SNU), 2) National Institute of Biological Resources (NIBR), and 3) The Migratory Birds Center located on Hong Island, National Park Research Institute (NPRI), to collect ticks from wild mammals captured for necropsy under institutional approved animal use protocols (SNU, NIBR, and the NPRI). Ticks were removed from mammals captured from 6 provinces [Gyeonggi-do (Pochon), Gangwon-do (Chuncheon, Cheorwon, Inje), Jeollanam-do (Goheung, Gokseong, Gwangyang, Gurye, Hampyeong, Suncheon, Yeosu, Hong Island), Chungcheongbuk-do (Cheongwon), Gyeongsangbuk-do (Ulsan), and Jeju-do (Jeju, Seogwipo)], and 3 Metropolitan Cities (Seoul, Daejeon, and Ulsan) in the ROK (Table 1). Ticks were carefully removed with a fine forceps from mammals, placed in 2-ml cryovials with 80% ethyl alcohol, and transported to the Entomology Section, 5th Medical Detachment, where they were identified to species and developmental stage under a dissecting microscope using standard keys and current nomenclature [17-20].

A total of 918 ixodid ticks belonging to 2 genera (*Ixodes* and

Haemaphysalis) were collected from mammals (n=76; 6 families, 9 species) captured for surveillance from 6 provinces and 3 Metropolitan Cities in the ROK. *H. inermis* (52.6%) was the most frequently collected mammal, followed by *Felis catus* (feral cat, 27.6%), *Capreolus pygargus* (roe deer, 5.3%), *Nyctereutes procyonoides* (raccoon dog, 3.9%) and *Tamias sibiricus* (Siberian chipmunk, 3.9%) (Table 1). Only 1-2 ticks were collected from each of the remaining 4 species. Of the 6 species of ticks collected, *H. longicornis* (54.4%) was the most frequently collected, followed by *Haemaphysalis flava* (28.5%), *I. nipponensis* (7.6%), *Ixodes pomerantzevi* (4.8%), *I. persulcatus* (4.6%), and *Haemaphysalis japonica* (0.1%). The highest tick indices for selected hosts were recorded from *N. procyonoides* (38.0), followed by *H. inermis* (16.4), *T. sibiricus* (15.0), *C. pygargus* (9.0), and *Meles leucurus* (7.0). Tick indices for the remaining mammals were < 5.0 (Table 2).

H. japonica (100.0%) was collected only from the Korean water deer, while accounting for 95.2% of *I. persulcatus*, 91.8% of *H. longicornis*, 55.7% of *H. flava*, and 17.1% of *I. nipponensis*. *H. longicornis* (69.7%) was the predominant species collected from the Korean water deer, followed by *H. flava* (22.2%), *I. persulcatus* (6.1%), *I. nipponensis* (1.8%), and *H. japonica* (0.2%) (Table 1).

Tick-borne zoonoses pose a serious health threat to US and ROK military populations throughout Korea [1-9,14-16]. Identification of arthropod ectoparasites and isolation of patho-

Table 1. Number of ticks and collection sites for each mammal species in the Republic of Korea, 2008-2009

Host species	Number surveyed	Collection sites	HL	HF	HJ	IN	IPO	IPE	Total
<i>Tamias sibiricus</i>	3	Gyeonggi	0	1	0	0	44	0	45
<i>Mogera robusta</i>	1	Gyeonggi	0	0	0	0	0	0	0
<i>Nyctereutes procyonoides</i>	3	Gangwon	9	105	0	0	0	0	114
<i>Hydropotes inermis</i>	1	Seoul	0	5	0	0	0	0	5
	9	Gangwon	92	58	0	3	0	20	173
	2	Chungcheongbuk	0	3	0	0	0	4	7
	1	Daejeon	25	4	0	0	0	0	29
	2	Gyeongsangbuk	8	1	1	0	0	0	10
	18	Ulsan	331	30	0	9	0	3	373
	7	Jeollanam	2	45	0	0	0	13	60
<i>Capreolus pygargus</i>	2	Ulsan	19	10	0	0	0	0	29
	2	Jeju	6	0	0	1	0	0	7
<i>Prionolurus bengalensis</i>	2	Jeollanam	0	0	0	6	0	0	6
<i>Felis catus</i>	21	Jeollanam	0	0	0	48	0	2	50
<i>Mustela sibirica</i>	1	Jeollanam	0	0	0	3	0	0	3
<i>Meles leucurus</i>	1	Jeollanam	7	0	0	0	0	0	7
Total	76		499	262	1	70	44	42	918

^aHL, *Haemaphysalis longicornis*; HF, *Haemaphysalis flava*; HJ, *Haemaphysalis japonica*; IN, *Ixodes nipponensis*; IPO, *Ixodes pomerantzevi*; IPE, *Ixodes persulcatus*.

gens provide a descriptive analysis of the relative abundance of ticks, host associations, stages of development found on hosts, and relative distributions. Epidemiological data are critical to identify the prevalence, distribution, and disease risks of endemic and emerging zoonoses affecting animals and humans in the ROK. For US and ROK military populations, these data are central to the development of disease risk assessments and mitigation strategies (e.g., use of insecticide-impregnated uniforms) that reduce the impact of zoonotic diseases while increasing awareness among medical providers of potential arthropod-borne infections. *H. longicornis* is commonly collected on large mammals and from tall grass habitats with associated herbaceous vegetation and margins of forested hillsides and

mountains (unpublished data), while *H. flava* larvae and nymphs are often associated with small mammals (e.g., rodents and soricomorphs) and birds [17]. However, only 1 *H. flava* nymph was collected from 5,953 rodents and soricomorphs captured from 2004 to 2008 in Gyeonggi-do and Gangwon-do [16].

In our survey, 262 (28.5%) *H. flava* ticks were collected, with nymphs and adults found on a variety of small and large mammals (Table 3). *I. nipponensis*, larvae and nymphs, was the predominant tick (98.9%) collected from 5,953 small mammals captured (e.g., rodents and soricomorphs) in Gyeonggi-do and Gangwon-do [16]. In other reports, *I. nipponensis* was the most frequently collected tick from small mammals captured in

Table 2. Number of mammals captured and number of ticks collected, by stage of development, for each mammal species in the Republic of Korea, 2008-2009

Family	Host species	Number surveyed	Tick species	Larvae	Nymphs	Adult male	Adult female	Total	Index ^a
Sciuridae	<i>Tamias sibiricus</i>	1	<i>Ixodes pomerantzevi</i>	24	5	0	15	44	15.0
		2	<i>Haemaphysalis flava</i>	0	1	0	0	1	
Talpidae	<i>Mogera robusta</i>	1	-	0	0	0	0	0	0.0
Canidae	<i>Nyctereutes procyonoides</i>	3	<i>Haemaphysalis longicornis</i>	0	0	0	9	9	38.0
			<i>Haemaphysalis flava</i>	14	43	32	16	105	
Cervidae	<i>Hydropotes inermis</i>	40	<i>Haemaphysalis longicornis</i>	77	179	116	86	458	16.4
			<i>Haemaphysalis flava</i>	15	29	65	37	146	
			<i>Haemaphysalis japonica</i>	0	0	1	0	1	
			<i>Ixodes persulcatus</i>	1	0	15	24	40	
			<i>Ixodes nipponensis</i>	0	0	6	6	12	
			<i>Haemaphysalis longicornis</i>	0	7	6	12	25	9.0
	<i>Capreolus pygargus</i>	4	<i>Haemaphysalis flava</i>	0	0	6	4	10	
			<i>Ixodes nipponensis</i>	0	0	0	1	1	
Felidae	<i>Prionailurus bengalensis</i>	2	<i>Ixodes nipponensis</i>	0	0	2	4	6	3.0
	<i>Felis catus</i>	21	<i>Ixodes persulcatus</i>	0	0	0	2	2	2.4
			<i>Ixodes nipponensis</i>	0	0	14	34	48	
Mustelidae	<i>Mustela sibirica</i>	1	<i>Ixodes nipponensis</i>	0	0	1	2	3	3.0
	<i>Meles leucurus</i>	1	<i>Haemaphysalis longicornis</i>	0	0	1	6	7	7.0
Total		76		131	264	265	258	918	12.1

^a Index = Total numbers of tick collected/total numbers of mammals collected.

Table 3. Total number, percent, and stage of development for ticks collected from mammals, Republic of Korea, 2008-2009

Tick species	Larvae	Nymph	Male	Female	Total (%)
<i>Haemaphysalis longicornis</i>	77 (15.4) ^a	186 (37.3) ^a	123 (47.3) ^b	113 (54.4) ^c	499
<i>Haemaphysalis flava</i>	29 (11.0)	73 (27.9)	103 (61.1)	57 (28.5)	262
<i>Haemaphysalis japonica</i>	0 (0.0)	0 (0.0)	1 (100.0)	0 (0.1)	1
<i>Ixodes nipponensis</i>	0 (0.0)	0 (0.0)	23 (100.0)	47 (7.6)	70
<i>Ixodes pomerantzevi</i>	24 (54.5)	5 (11.4)	0 (34.1)	15 (4.8)	44
<i>Ixodes persulcatus</i>	1 (2.4)	0 (0.0)	15 (97.6)	26 (4.6)	42
Total	131 (14.3)	264 (28.7)	265 (57.0)	258 (100.0)	918

^a Percent of total ticks collected from mammals by species and stage of development; ^b Percent of both male and female ticks collected from mammals; ^c Percent of ticks for all stages of development and species collected from mammals.

Gyeonggi-do, while *I. persulcatus* was more commonly collected in Gangwon-do [14]. In our survey, this species was predominantly collected from *F. catus* at Hong Island, Jeollanam-do, and accounted for 96.0% of the total collected from feral cats. Larvae and nymphs of *I. nipponensis* prefers to blood feed on small mammals, while adults are more commonly found on large mammals.

Recent studies indicate that *I. nipponensis* plays an important role in the transmission of tick-borne pathogens to humans in the ROK, as human tick bites are reported more frequently for this species among patients seen at medical clinics in the ROK [21-24]. However, the number of reports may be not only due to increased propensity to bite humans, but due to greater allergic reactions to bites by this species than others. *Ixodes persulcatus* was collected most frequently from *H. inermis*, which was associated with dense forested habitats in the Taebaek mountain range (20/42; 47.6%) and Sobaek mountain range (13; 31.0%). *I. pomerantzevi* is an uncommonly collected tick, with all previous collection records of this species collected from small mammals (*Myodes regulus*, *Tscherskia triton*, *T. sibiricus*, and *Apodemus agrarius*) while conducting routine rodent-borne disease surveillance [18,25,26]. In this survey, *T. sibiricus* was the primary host of *I. pomerantzevi*, with 24 larvae, 5 nymphs, and 15 female adults collected from 1 *T. sibiricus* collected in northern Gyeonggi-do. Only 1 male (0.1%) *H. japonica* was collected from a Korean water deer, and it has been infrequently recorded in other collections, e.g., tick drags, rodents, and birds.

Adults (57.0%) and nymphs (28.7%) of *Ixodes* and *Haemaphysalis* spp. were mostly collected from medium/large mammals in this survey, while larval ticks only accounted for 14.3% of all ticks collected (Table 3). In contrast, larvae (82.8%) and nymphs (17.2%) were collected from small mammals, 5,397 *A. agrarius* in Gyeonggi-do and Gangwon-do during 2004-2008, while adults accounted for <0.1% of all ticks collected [16].

The changing ecology, particularly reforestation, and associated increases in wildlife populations provide for increased proximal host contact associated with the wide distribution of blood-feeding ectoparasites in the ROK. Further studies of tick-host relationships are necessary to better understand tick species distributions and population dynamics, the distribution and prevalence of tick-borne pathogens, and their potential effects on human and animal health.

ACKNOWLEDGEMENTS

We thank the commanders and soldiers of the 5th Medical Detachments, 168th Multifunctional Medical Battalion, 65th Medical Brigade for their assistance in conducting tick-borne disease surveillance. Funding for this research was provided by the Armed Forces Health Surveillance Center (AFHSC), Global Emerging Infections Surveillance and Response System (GEIS), Silver Spring, MD, the National Center for Medical Intelligence, Fort Detrick, MD, and through the BK21 Program for Veterinary Science, Seoul National University, Seoul, Korea.

Disclaimer: The opinions expressed herein are those of the authors and are not to be construed as official or reflecting the views of the US Department of the Army, Department of Defense, or the US Government.

REFERENCES

1. Lee JH, Park HS, Jung KD, Jang WJ, Koh SE, Kang SS, Lee IY, Lee WJ, Kim BJ, Kook YH, Park KH, Lee SH. Identification of the spotted fever group rickettsiae detected from *Haemaphysalis longicornis* in Korea. *Microbiol Immunol* 2003; 47: 301-304.
2. Chae JS, Kim CM, Kim EH, Hur EJ, Klein TA, Kang TK, Lee HC, Song JW. Molecular epidemiological study for tick-borne disease (*Ehrlichia* and *Anaplasma* spp.) surveillance at selected U.S. military training sites/installations in Korea. *Annals NY Acad Sci* 2003; 990: 118-125.
3. Kim CM, Kim IY, Yi YH, Lee MJ, Cho MR, Shah DH, Klein TA, Kim HC, Song JW, Chong ST, O'Guinn ML, Lee JS, Lee IY, Park JH, Chae JS. Detection of *Bartonella* species from ticks, mites and small mammals in Korea. *J Vet Sci* 2005; 6: 327-334.
4. Park KH, Lee SH, Won WJ, Jang WJ, Chang WH. Isolation of *Borrelia burgdorferi*, the causative agent of Lyme Disease, from *Ixodes* ticks in Korea. *J Korean Soc Microbiol* 1992; 27: 307-312.
5. Kee S, Hwang KJ, Oh HB, Kim MB, Shim JC, Ree HI, Park KS. Isolation and identification of *Borrelia burgdorferi* in Korea. *J Korean Soc Microbiol* 1994; 29: 301-310.
6. Kim SY, Yun SM, Han MG, Lee IY, Lee NY, Jeong YE, Lee BC, Ju YR. Isolation of tick-borne encephalitis viruses from wild rodents, South Korea. *Vector borne Zoonotic Dis* 2008; 8: 7-13.
7. Kim SY, Jeong YE, Yun SM, Lee IY, Han MG, Ju YR. Molecular evidence for tick-borne encephalitis virus in ticks in South Korea. *Med Vet Entomol* 2009; 23: 15-20.
8. Ko S, Kang JG, Kim SY, Klein TA, Kim HC, Chong ST, Sames WJ, Yun SM, Ju YR, Chae JS. Prevalence of tick-borne encephalitis virus in ticks from southern Korea. *J Vet Sci* 2010; 11: 197-203.
9. Jang WJ, Kim JH, Choi YJ, Jung KD, Kim YC, Lee SH, Choi MS, Kim IS, Walker DH, Park KH. First serologic evidence of human

- spotted fever group rickettsiosis in Korea. J Clin Microbiol 2004; 42: 2310-2313.
10. Choi YJ, Jang WJ, Kim JH, Ryu JS, Lee SH, Park KH, Paik HS, Koh YS, Choi MS, Kim IS. Spotted fever group and typhus group rickettsioses in humans, South Korea. Emerg Infect Dis 2005a; 11: 237-244.
 11. Choi YJ, Lee SH, Park KH, Koh YS, Lee KH, Baik HS, Choi MS, Kim IS, Jang WJ. Evaluation of PCR-based assay for diagnosis of spotted fever group rickettsiosis in human serum samples. Clin Diagn Lab Immunol 2005b; 12: 759-763.
 12. Kang JG, Ko SJ, Kim YJ, Yang HJ, Lee H, Shin NS, Choi KS, Chae JS. New genetic variants of *Anaplasma phagocytophilum* and *Anaplasma bovis* from Korean water deer (*Hydropotes inermis argyropus*). Vector borne Zoonotic Dis 2011; 11: 929-938.
 13. Kang YB. Studies on tick eradication in Korea (1982-1984). Special project for animal health. Ann Rep Inst Vet Res, Rural Develop Admin 1984: 269-305.
 14. Shim JC, Yoon YH, Kim JL, Shin EH, Yang YC, Cho YB, Lee JY. Studies on the vector of Lyme disease (*Borrelia burgdorferi*) (I) Geographical distribution and seasonal prevalence. Rep NIH Korea 1992; 29: 123-130.
 15. Shim JC, Yoon YH, Kim CL, Cho YB, Lee JY, Shin EH, Yang YC, Baik MK, Yu WH, Yu HS, Park KH, Kim KH. Studies on vector potential of ticks (Ixodidae) in transmitting Lyme disease (*Borrelia burgdorferi*) (II) Vector incrimination and seasonal occurrence of *Ixodes granulatus*. Rep NIH Korea 1993; 30: 131-136.
 16. Kim HC, Chong ST, Sames WJ, Nunn PV, Wolf SP, Robbins RG, Klein TA. Tick surveillance of small mammals captured in Gyeonggi and Gangwon Provinces, Republic of Korea, 2004-2008. Sys Applied Acarol 2010; 15: 100-108.
 17. Yamaguti N, Tipton VJ, Keegan HL, Toshioka S. Ticks of Japan, Korea and the Ryukyu Islands. Brigham Young University Science Bulletin, Biological Series 1971; 15: 1-226.
 18. Robbins RG, Keirans JE. Systematics and Ecology of the Subgenus *Ixodiopsis* (Acari: Ixodidae: *Ixodes*). Thomas Say Foundation Monograph XIV. Entomological Society of America, Lanham, Maryland, USA. 1992, viii + 159 pp.
 19. Horak IG, Camicas JL, Keirans JE. The Argasidae, Ixodidae and Nuttalliellidae (Acari: Ixodida): A world list of valid tick names. Exp Applied Acarol 2002; 28: 27-54.
 20. Guglielmone AA, Richard G, Robbins, Apanaskevich DA, Petney TN, Estrada-Pena A, Horak IG, Shao R. and Barker SC. The Argasidae, Ixodidae and Nuttalliellidae (Acari: Ixodida) of the world; A list of valid species names. Zootaxa 2010; (2528): 1-28.
 21. Lee SH, Chai JY, Kho WG, Hong SJ, Chung YD. A human case of tick bite by *Ixodes nipponensis* on the scalp. Korean J Parasitol 1989; 27: 67-69.
 22. Ryu JS, Lee JU, Ahn MH, Min DY, Ree HI. A human case of tick bite *Ixodes nipponensis*. Korean J Parasitol 1998; 36: 59-41.
 23. Ko JH, Cho DY, Chung BS, Kim SI. Two human cases of tick bite caused by *Ixodes nipponensis*. Korean J Parasitol 2002; 40: 199-203.
 24. Chang SH, Park JH, Kwak JE, Joo M, Kim HS, Chi JG, Hong ST, Chai JY. A case of histologically diagnosed tick infestation on the scalp of a Korean child. Korean J Parasitol 2006; 44: 157-161.
 25. Anonymous. List of Animals in Korea (excluding insects). The Korean Society of Systematic Zoology, Academy Press, Seoul, Korea. 1997, pp 1-489.
 26. Kim HC, Kim JH, Jo YS, Chong ST, Sames WJ, Klein TA, Robbins RG. Records of *Ixodes pomerantzzevi* Serdyukova, 1941 (Acari: Ixodidae) from small mammals in northern Gyeonggi and Gangwon Provinces, Republic of Korea. Sys Applied Acarol 2009; 14: 129-135.