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Review of ticks (families: Ixodidae and Argasidae) in the Republic of Korea

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Ethics Approval
Not applicable.

Abstract

Ticks and tick-borne pathogens are among the main sources of interest in veterinary medicine and public health. This review aimed to cover published data on tick species and their geographical distribution in Korea. Over 143 articles regarding ticks were published between 1966 and 2022, and reporting at least 29 species belonging to the family Ixodidae and five belonging to the family Argasidae. Among these, *Haemaphysalis longicornis*, *H. flava*, and *Ixodes nipponensis* were the main genera distributed nationwide, whereas *Amblyomma* was mostly identified in the southern region. Conversely, only a limited number of Argasidae ticks were present, including the genera *Argas* and *Ornithodoros*. Considering the changes in tick distribution patterns due to global warming, continuous nationwide monitoring of ticks is required.

Keywords: ticks; *Haemaphysalis*; *Ixodes*; Ixodidae; Argasidae

INTRODUCTION

Ticks are obligate blood-sucking arthropods distributed in tropical and temperate regions of the world [1]. The life cycle of Ixodidae and Argasidae ticks consists of egg and three active developmental stages (larva, nymph, and adult). However, Argasidae ticks have multiple nymphal instars. Most species, larvae, and nymphs find hosts, feed, detach, and molt nymphs and adults, respectively. Female Ixodidae ticks seek hosts and feed only once until they are engorged, then lay many eggs and die. However, female Argasidae ticks feed on and oviposit several times [1]. During the blood-feeding periods, ticks transmit various pathogenic agents from host to host, thus threatening livestock.

The Republic of Korea (Korea) is a Northeast Asian country and is located between the 33°N and 43°N latitudes and between the 124°E and 132°E longitudes. Geographically, more than 70% of the Korean Peninsula is covered by mountains, which are mainly located in the northern and eastern regions, whereas plains comprise the southern and southwestern regions. The climate is considered temperate to subtropical and has a heavy rainy season in the summer. Administratively, Korea is divided into eight metropolitan cities (Seoul, Sejong, Daejeon, Busan, Daegu, Gwangju, Incheon, and Ulsan) and nine provinces (Gyeonggi, Gangwon, Chungbuk [Chungcheongbuk-do], Chungnam [Chungcheongnam-do], Gyeongbuk [Gyeongsangbuk-do], Gyeongnam [Gyeongsangnam-do], Jeonbuk [Jeollabuk-do], Jeonnam [Jeollanam-do], and Jeju) [2].

Different tick species are distributed throughout the country owing to climatic conditions that are favorable to tick survival. Moreover, recent global warming has facilitated changes in the distribution patterns of ticks in Korea. Many studies on ticks have been conducted regionally by individual researchers; therefore, these studies need to be summarized. In this review, we summarize the species diversity of ticks reported in Korea.

METHODOLOGY

A literature search was conducted from 25th October until 12th to November 2022. Scientific research publications in English and Korean were collected by using two major databases: "PubMed" (https://www.ncbi.nlm.nih.gov/) and "Web of science" (https://www.webofknowledge.com/) with extra website including the "Korean Journal of Parasitology" (https://www.parasitol.kr/), "Google scholar" (https://scholar.google.co.kr/), and "Korea Disease Control and Prevention Agency" (https://www.kdca.go.kr/). The main keywords for searching were "tick distribution south Korea", "tick bite cases in Korea", "tick Korea", "진드기 조사", and "진드기 분포". Furthermore, the following extra keyworks were used: "tick distribution in Korea", "tick bite cases in Korea" "*Haemaphysalis ornithophila*", and "*Haemaphysalis phasiana*".

We retrieved 146 studies published from 1966 to 2022 from the databases, and excluded duplications and unrelated studies (Fig. 1). In total, 143 studies were included. The title, year of publication, study region, and tick species were extracted from the selected studies. The geo-

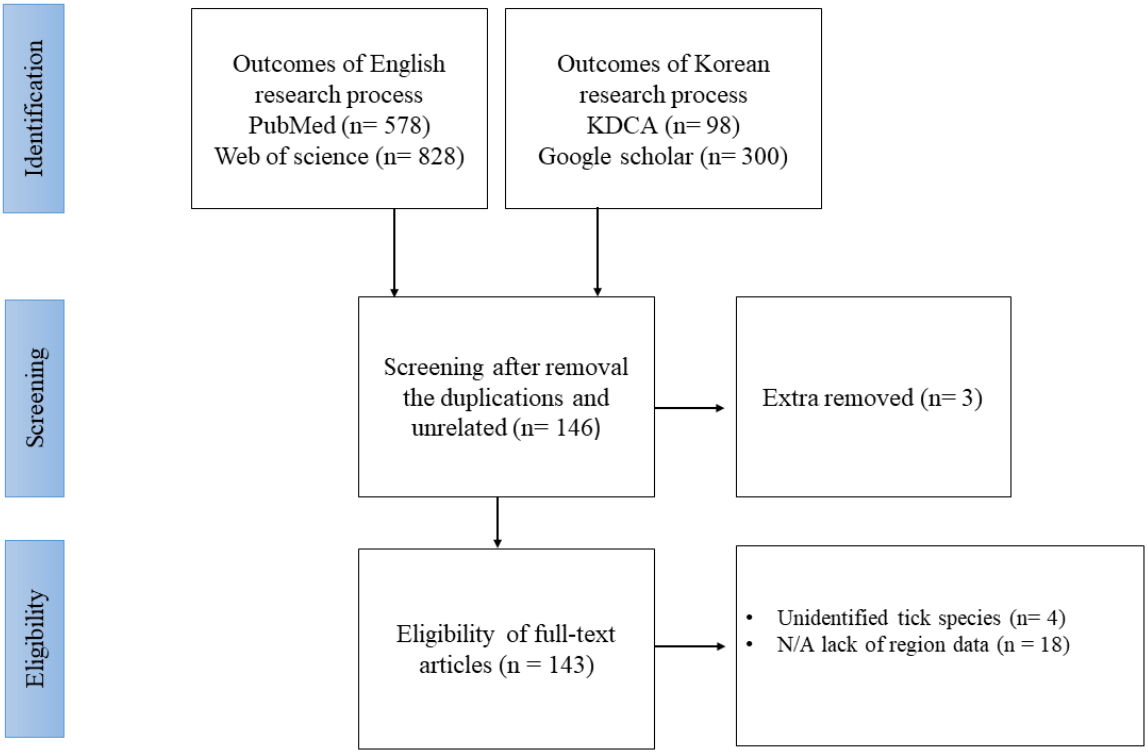

Fig. 1. Flow diagram of study screening and selection.

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graphical locations for tick collection were categorized into 10 groups, including Seoul and nine provinces, and the remaining metropolitan cities were included in the nearest provinces.

RESULTS

Previous studies have reported 29 tick species of Ixodidae (hard ticks) while Argasidae (soft ticks) have been represented by only five species (Table 1). *Haemaphysalis longicornis*, the Asian longhorned tick was the predominant species in Korea, followed by *H. flava*, *H. japonica*, *H. phasiana*, *H. ornithophila*, *H. concinna*, *H. punctata*, *H. formosensis*, and *H. campanulata*.

Sixteen species from the genus *Ixodes*, 16 species have been reported in Korea, including *I. nipponensis*, *I. persulcatus*, *I. turdus*, *I. granulatus*, *I. tanuki*, *I. pomeranzevi*, *I. uriae*, *I. signatus*, *I. angustus*, *I. ovatus*, *I. simplex*, *I. vespertilionis*, and *I. monospinosus*. Further, a few studies have identified minor tick species, including *Rhipicephalus sanguineus*, *R. microplus*, and *Amblyomma testudinarium*.

Conversely, limited records have been obtained on Argasidae ticks. Only *Argas vespertilionis*, *A. boueti*, *Ornithodoros sawaii*, *Ornithodoros* sp., and *O. capensis* were identified in the restricted regions.

DISCUSSION

Most Ixodidae ticks inhabit open environments such as grasslands, graves, forests, and mountain roads, whereas Argasidae ticks live in nests, caves, and burrows. For this reason, most studies have used dragging or flagging methods to collect ticks. *H. longicornis* and *H. flava* are the most commonly identified and widely distributed tick species in Korea [3], whereas *H. japonica* is mainly collected in Gangwon Province [4]. Moreover, *H. ornithophila*, *H. formosensis*, and *H. concinna* have been identified in migratory birds [5], while *H. campanulata*, *H. phasiana*, and *H. punctata* have been reported in a few studies [6–8].

The genus *Ixodes* is found worldwide. In particular, *I. ricinus* has a wider range of distribution, covering the European Union, North Africa, and Russia [9]. Interestingly, *I. nipponensis* is the main *Ixodes* species in Korea, followed by *I. persulcatus* and *I. granulatus* [4], and *I. ricinus* has not yet been reported.

A. testudinarium was mainly reported in Jeonbuk Province [4]; since the first record was in Jeju in 1981, many human bites have been reported in the southern regions of Korea. Jeju and the southern regions are considered to be warmer than the other regions, which may affect the distribution of *A. testudinarium* [10].

Most Argasidae ticks have specific hosts for feeding, such as bats and seabirds. Migratory birds play a critical role in the introduction of novel tick species from neighboring countries to Korea during the breeding season. *O. sawaii* was reported in migratory birds in 2016 [11], followed by *O. capensis* in 2017 [12], and *Ornithodoros* sp. in 2020 [13]. However, *A. vespertilionis* and *A. boueti* were recorded in Korea in 1966, and no additional studies have been

Table 1. Tick species with their geographical distribution and year of collection in Korea

Tick species	Year of collection	Region of collection	Reference
A. vespertilionis, A. boueti	1961–1965	Chungbuk	[14]
H. longicornis, B. microplus	1971–1972	Jeju	[17]
H. longicornis, B. microplus	1973	Gyeonggi	[18]
A. testudinarium	1981	Jeju	[19]
Ixodes species	1981	Gangwon	[20]
I. nipponensis	N/A	N/A	Refer to reference [41]
R. sanguineus	1984	Gyeonggi, Chungnam, Jeonbuk, Jeju	[21]
I. persulcatus	1982	Gangwon	[22]
B. microplus	1982–1984	Chungnam, Jeonbuk, Gyeongnam	[23]
I. nipponensis	1989	Gyeonggi	[24]
I. nipponensis	1984	Seoul	[25]
I. nipponensis	1991	Chungnam	[26]
I. ovatus, I. nipponensis	N/A	N/A	[27]
Ixodes	N/A	N/A	[28]
I. nipponensis	N/A	N/A	[29]
I. nipponensis	1995	Gyeonggi	[30]
H. flava	N/A	N/A	[31]
H. flava, I. tanuki	1995	Jeonbuk	[32]
I. nipponensis	N/A	N/A	[33]
I. nipponensis	1995	Gangwon	[34]
I. persulcatus	1995	Seoul	[35]
Ixodes spp., *Haemaphysalis* spp.	N/A	Gangwon	[36]
H. longicornis	N/A	N/A	[37]
I. monospinosus	N/A	N/A	[38]
I. nipponensis	N/A	N/A	[39]
I. nipponensis	N/A	N/A	[40]
I. nipponensis	1999 and 2001	N/A	[41]
H. longicornis	N/A	Chungbuk, Gyeonggi	[42]
H. longicornis, H. flava, Haemaphysalis sp.	N/A	Chungbuk	[43]
H. longicornis, H. flava, Haemaphysalis sp.	N/A	Chungbuk	[44]
H. longicornis	N/A	Chungbuk	[45]
H. longicornis, H. flava, I. turdus, I. persulcatus, I. nipponensis, Ixodes spp.	2001–2003	Gyeonggi	[46]
Ixodidae no-know species	2005	Seoul	[47]
H. phasiana, H. longicornis, H. flava, I. turdus	2007	Jeju, Gyeongnam, Jeonnam	[7]
H. longicornis, H. flava, I. nipponensis, I. turdus, I. persulcatus, Ixodes sp.	2001–2005	Gyeonggi, Seoul	[48]
H. longicornis, I. nipponensis	2005	Gyeonggi, Gangwon	[49]
H. flava, H. ornithophila, I. nipponensis, I. turdus	2008	Jeonnam	[50]
I. pomeranzevi, I. nipponensis	2008	Gyeonggi, Gangwon	[51]
H. longicornis, H. flava	2007–2008	Jeju	[52]
H. longicornis, H. flava, A. testudinarium, I. turdus, I. nipponensi, H. phasiana	2007	Jeju, Jeonnam, Gyeongbuk, Gyeongnam	[53]
H. punctata	N/A	Jeju	[8]
A. testudinarium	2009	Jeonnam	[54]
I. simplex, I. vespertilionis	2007–2009	Gangwon, Chungnam, Chungbuk, Gyeongbuk, Gyeongnam, Jeonbuk, Jeonnam, Jeju	[55]

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Table 1. Continued

Tick species	Year of collection	Region of collection	Reference
H. longicornis, H. flava, I. persulcatus, I. nipponensis, H. japonica, I. pomerantzevi	2008–2009	Gangwon, Gyeonggi, Chungbuk, Gyeongbuk, Jeonnam, Jeju, Seoul	[56]
H. longicornis, H. flava, I. nipponensis, I. persulcatus	2011–2012	Gangwon, Gyeonggi, Chungnam, Chungbuk, Gyeongbuk, Gyeongnam Jeonbuk, Jeonnam, Jeju	[57]
I. nipponensis, I. pomerantzevi	2008	Gyeonggi, Gangwon	[58]
H. flava, H. longicornis, I. nipponensis, I. turdus	2008–2009	Jeonnam	[59]
H. longicornis, Ixodes spp.	2010–2011	Jeju, Gyeongbuk, Chungbuk, Jeonbuk, Jeonnam	[60]
A. testudinarium	N/A	Gyeongnam	[61]
H. longicornis, H. flava, I. nipponensis	2004–2005	Gyeonggi	[62]
H. longicornis, H. flava, I. nipponensis	2004–2005	Gyeonggi	[63]
I. nipponensis	2006	Jeonbuk, Jeonnam	[64]
I. nipponensis	2012	Gyeonggi	[65]
H. longicornis	N/A	N/A	[66]
A. testudinarium	2010	Jeonnam	[10]
H. longicornis, H. flava, A. testudinarium, H. japonica, H. formosensis, I. nipponensis	2012	Seoul, Gyeonggi, Chungbuk, Chungnam, Jeonbuk, Jeju	[67]
H. longicornis, H. flava, I. nipponensis	2013	Seoul	[68]
H. longicornis, H. flava, I. nipponensis	N/A	Gwangju	[69]
H. longicornis, H. flava, I. nipponensis	2014	Gyeonggi, Gangwon	[70]
H. longicornis, H. flava, I. nipponensis, I. granulatus, A. testidunarium, I. persulcatus, H. japonica douglasi, H. campanulata, R. sanguineus	2013–2015	N/A	[6]
H. longicornis, A. testidunarium	2014	Jeonnam	[71]
H. longicornis, I. nipponensis, A. testidunarium	2015	Jeonnam	[72]
I. nipponensis, A. testidunarium	N/A	N/A	[73]
H. longicornis, H. flava, I. nipponensis, A. testudinarium	2013	Gangwon, Gyeonggi, Chungnam, Chungbuk, Gyeongbuk, Gyeongnam, Jeonbuk, Jeonnam	[74]
A. testudinarium	N/A	Gyeongnam	[75]
A. testudinarium	N/A	Jeonnam	[76]
O. sawaii	2009	Jeonnam	[11]
H. flava, H. longicornis, I. nipponensis, A. testudinarium, H. phasiana, I. turdus	2014	Gyeonggi, Gangwon, Chungcheongnam, Gyeongsangbuk, Gyeongsangnam, Jeju, Seoul	[77]
H. longicornis	2009 and 2013	Jeju	[78]
H. longicornis, H. flava, I. nipponensis	2013	Gangwon, Gyeongnam, Jeonnam, Gyeonggi, Gyeongbuk	[79]
H. flava, H. longicornis, I. nipponensis, I. persulcatus	2008–2009	Seoul	[80]
I. nipponensis, A. testudinarium	2015	Gangwon, Chungbuk, Chungnam, Jeonbuk, Jeonnam, Gyeongnam	[81]
A. testudinarium, I. nipponensis	N/A	N/A	[82]
H. longicornis	2013 and 2015	Gyeongbuk	[83]
H. longicornis, H. flava, I. nipponensis, A. testudinarium, I. persulcatus, I. granulatus, H. japonica	2015	Gyeonggi, Gangwon, Chungnam, Chungbuk, Gyeongbuk, Gyeongnam, Jeonbuk, Jeonnam, Jeju, Seoul	[84]
I. nipponensis, H. flava, H. longicornis	2013	Jeonbuk, Jeonnam, Chungnam, Chungbuk	[85]
I. signatus, I. uriae	2016	Jeonnam	[86]
O. capensis, O. sawaii	2014–2015	Gyeongnam, Chungnam	[12]
H. longicornis, H. flava, I. nipponensis, I. turdus, A. testudinarium	2013	Gangwon, Gyeonggi, Chungbuk, Chungnam, Jeonbuk, Jeonnam, Gyeongbuk, Jeju	[87]

Table 1. Continued

Tick species	Year of collection	Region of collection	Reference
H. flava, H. longicornis, H. phasiana, I. nipponensis, I. persulcatus, A. testudinarium	2013	Chungbuk, Chungnam, Jeonbuk, Jeonnam	[88]
H. longicornis, H. flava, Haemaphysalis spp.	2015	Seoul	[89]
H. longicornis, H. flava, I. nipponensis, A. testidunarium	2016	Jeonbuk	[90]
Engorged female hard tick	2015	Gyeongbuk	[91]
I. nipponensis, H. flava, H. longicornis, A. testudinarium, H. phasiana, I. turdus	2014	Gyeongbuk, Gyeongnam	[92]
H. flava, H. longicornis	2003 and 2010	Gangwon, Gyeonggi, Chungbuk, Chungnam, Jeonbuk, Jeonnam, Gyeongbuk, Gyeongnam, Seoul	[93]
I. turdus, I. nipponensis, H. flava, H. longicornis, H. formosensis, H. ornithophila, H. concinna, A. testudinarium	2010–2011	Jeonnam	[5]
H. longicornis	2004 and 2015	Gyeonggi, Jeju	[94]
I. nipponensis, A. testudinarium	2016	Gyeonggi, Gangwon, Chungbuk, Chungnam, Jeonbuk, Jeonnam, Gyeongbuk, Gyeongnam	[95]
H. longicornis, H. flava, I. nipponensis, A. testudinarium, H. phasiana	2018	Gangwon, Gyeonggi, Chungnam, Jeonbuk, Jeonnam, Gyeongbuk, Jeju	[96]
H. longicornis, H. flava, H. japonica, A. testudinarium, I. nipponensis	N/A	Nationwide survey	[97]
H. flava, I. nipponensis, I. persulcatus, H. japonica, A. testudinarium, I. granulatus	2013–2017	Gangwon, Gyeonggi, Chungnam, Chungbuk, Gyeongbuk, Gyeongnam, Jeonbuk, Jeonnam, Jeju	[4]
H. longicornis, H. flava, I. nipponensis	2014–2015	Gangwon, Gyeonggi, Gyeongbuk, Chungnam, Jeonbuk, Jeonnam, Gyeongbuk, Gyeongnam, Jeju	[98]
H. longicornis, H. flava, Haemaphysalis spp.	2015–2017	Gyeonggi	[99]
I. nipponensis, H. flava, H. longicornis, A. testudinarium	2009	Gyeonggi, Gyeongbuk, Jeonbuk, Jeonnam	[100]
I. nipponensis	2007 and 2015	Gyeongbuk	[101]
H. longicornis, H. flava, I. nipponensis	2015–2018	Gyeonggi	[102]
H. longicornis, H. flava	N/A	Gangwon	[103]
H. longicornis, H. flava, I. nipponensis, A. testudinarium, H. japonica	2019	Nationwide survey	[104]
H. longicornis, H. flava, I. nipponensis	2019	Gyeongbuk	[105]
H. longicornis, H. flava, I. nipponensis, A. testudinarium	2014–2018	Jeollanam	[106]
H. longicornis, H. flava	2018	Jeju	[107]
H. longicornis, H. flava	2014–2016	Gangwon, Gyeongnam, Jeonnam	[108]
H. longicornis, H. flava, I. nipponensis, A. testudinarium, Haemaphysalis sp.	2019	Gangwon, Gyeonggi, Gyeongbuk, Chungnam, Jeollabuk, Jeollanam, Gyeongbuk, Gyeongnam	[109]
H. longicornis	2014–2018	Gangwon, Gyeonggi, Gyeongbuk, Chungnam, Jeollabuk, Jeollanam, Gyeongbuk, Gyeongnam	[110]
H. longicornis, H. flava, I. nipponensis, Haemaphysalis spp.	2010–2015	Gangwon, Gyeonggi, Gyeongbuk, Chungnam, Jeollabuk, Jeollanam, Gyeongbuk, Gyeongnam	[111]
H. longicornis, I. nipponensis, H. flava	2018	N/A	[112]
H. longicornis, H. flava, I. nipponensis	2015–2019	Gangwon, Gyeonggi, Gyeongbuk, Chungnam, Jeollabuk, Jeollanam, Gyeongbuk, Gyeongnam, Jeju	[113]
I. nipponensis, I. angustus, H. longicornis, Ixodes spp.	2017	Gangwon, Chungnam, Chungbuk, Jeonnam, Gyeongbuk, Gyeongnam, Jeju	[114]
I. nipponensis	2017	Jeonnam	[115]
O. sawaii, Ornithodoros sp.	2017–2018	Chungnam, Jeonnam, Jeju	[116]

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Table 1. Continued

Tick species	Year of collection	Region of collection	Reference
I. turdus, H. flava, H. longicornis, I. nipponensis, H. formosensis, H. ornithophila, H. phasiana, H. concinna, A. testudinarium	2010–2011 and 2016	Chungnam, Jeonnam	[117]
H. longicornis	2013–2019	Jeju	[118]
H. longicornis, H. flava,	2017-2018	Gyeonggi	[119]
Ixodes spp., *I. nipponensis, I. angustus*	2017	Gangwon, Gyeongbuk, Gyeongnam, Jeonnam, Jeju,	[120]
H. longicornis, H. flava, I. nipponensis, A. testudinarium	2019	Chungnam	[121]
H. longicornis, H. flava, I. nipponensis, H. phasiana, I. turdus, A. testudinarium, H. japonica, I. persulcatus	2004–2016	Gangwon, Gyeonggi, Gyeongbuk, Chungnam, Jeollabuk, Jeollanam, Gyeongbuk, Gyeongnam, Jeju, Seoul	[3]
H. longicornis, H. flava, H. japonica, Haemaphysalis spp., *I. nipponensis, Ixodes* spp., *A. testudinarium*	2020	Gangwon, Gyeonggi, Gyeongbuk, Chungnam, Jeollabuk, Jeollanam, Gyeongbuk, Gyeongnam, Jeju	[122]
H. longicornis, H. flava, I. nipponensis, A. testudinarium, Haemaphysalis spp.	2021	Gyeongbuk, Chungnam, Jeollabuk, Jeollanam, Gyeongbuk, Gyeongnam	[123]
I. nipponensis, H. flava, H. longicornis, H. phasiana, R. sanguineus	2015–2016, and 2017	Gyeonggi, Gangwon, Gyeongbuk, Jeju	[124]
H. longicornis, H. flava, Haemaphysalis spp., *I. nipponensis,*	2018	Gyeongbuk	[125]
H. longicorni, I. nipponensis	2016–2017	Gyeonggi, Gangwon, Jeollabuk, Jeollanam, Gyeongbuk, Gyeongnam, Jeju	[126]
I. nipponensis, A. testudinarium, H. longicornis	2018	Jeollanam	[127]
H. longicornis, I. nipponensis, H. flava, A. testudinarium	2013	Gyeongnam, Jeollabuk, Chungnam	[128]
H. longicornis, I. nipponensis, H. flava	2017–2018	Gangwondo, Gyeonggi, Jeollabuk, Chungnam, Jeollanam, Gyeongbuk, Gyeongnam, Jeju	[129]
H. longicornis	2020	Gangwon	[130]
A. testudinarium, H. longicornis, I. nipponensis	2014 and 2017	Jeollanam	[131]
H. longicornis	N/A	Jeju	[132]
H. longicornis, H. flava, I. nipponensis	2013–2017	Gangwon, Gyeonggi, Gyeongbuk, Chungnam, Jeollabuk, Jeollanam, Gyeongbuk, Gyeongnam	[133]
H. longicornis, H. flava, I. nipponensis	2016–2020	Gyeongbuk	[134]
H. longicornis, H. flava, I. nipponensis	2020	Chungnam	[135]
H. longicornis, I. angustus, I. nipponesis, Ixodes sp.	N/A	N/A	[136]
H. longicornis, H. flava, I. nipponensis	2019–2020	Gyeonggi	[137]
H. longicornis, H. flava, H. phasiana, H. japonica, I. nipponensis	2018–2019	Gyeonggi	[138]
H. longicornis, H. flava, I. nipponensis, I. ovatus	2016–2018	Jeollabuk	[139]
H. longicornis	2019	Gangwon, Gyeonggi, Gyeongbuk, Chungnam, Jeollabuk, Jeollanam, Gyeongbuk, Gyeongnam, Jeju	[140]
H. longicornis, H. flava, A. testudinarium, I. nipponensis, H. japonica	2021	N/A	[141]
H. longicornis, A. testudinarium, I. nipponensis, H. flava, I. persulcatus	2020	Gangwon, Gyeonggi, Gyeongbuk, Chungnam, Jeollanam, Gyeongbuk, Gyeongnam, Jeju, Seoul	[142]
H. longicornis, H. flava, H. phasiana, I. nipponensis, I. persulcatus	2019–2020	Gyeonggi, Gangwon	[143]
H. longicornis, H. flava, I. nipponensis	2019	Gangwon, Jeju	[144]
I. turdus, H. flava	2008–2009	Jeonnam	[145]
H. flava, H. formosensis, H. longicornis, H. phasiana, I. nipponensis, I. turdus, A. testudinarium	2010–2011 and 2016	Jeonnam	[146]
H. longicornis, H. flava, I. nipponensis, H. phasiana, H. japonica, A. testudinarium	2020–2021	Gyeonggi, Gangwon, Chungnam, Gyeongbuk, Gyeongnam, Jeonbuk	[147]

N/A, not available.

conducted on these species in Korea [14].

The tick distribution and abundance change from year to year depending on various factors, such as region, climate, and seasonal change. The climate in Korea has gradually changed from temperate to subtropical, which affects the density and distribution of ticks. Previous studies have shown that ticks are more active in early and late autumn. In particular, nymphs peak from April to June and larvae predominate from July to October [15]. Some Argasidae ticks depend more on migratory hosts than on seasonal patterns.

Most studies have identified tick species based on their morphological characteristics. However, morphological identification is difficult in species differentiation among close tick species. For example, the larvae of *H. longicornis* and *H. flava* are morphologically identical and are regarded as *Haemaphysalis* spp. [16]. Future studies should consider the use of molecular methods to identify tick species.

In conclusion, this review summarizes the distribution of ticks in Korea, published between 1966 and 2022. Studies have reported 29 species of Ixodidae ticks and five Argasidae ticks in Seoul and nine geographic provinces in Korea.

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