



Species composition of hard ticks (Acari: Ixodidae) on domestic animals and their public health importance in Tamil Nadu, South India

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Received: 8 July 2020

Accepted: 4 November 2020

Available online: 27 January 2021

ABSTRACT: This study was carried out in Madurai district, Tamil Nadu State, South India. Ticks were collected from cows, dogs, goats, cats and fowls. The overall percentage of tick infestation in these domestic animals was 21.90%. The following ticks were identified: *Amblyomma integrum*, *Haemaphysalis bispinosa*, *Haemaphysalis paraturturis*, *Haemaphysalis turturis*, *Haemaphysalis intermedia*, *Haemaphysalis spinigera*, *Hyalomma anatolicum*, *Hyalomma brevipunctata*, *Hyalomma kumari*, *Rhipicephalus turanicus*, *Rhipicephalus haemaphysaloides* and *Rhipicephalus sanguineus*. The predominant species recorded from these areas is *R. sanguineus* (27.03%) followed by both *R. (B.) microplus* (24.12%) and *R. (B.) decoloratus* (18.82%). The maximum tick infestation rate was recorded in animals from rural areas (25.67%), followed by semi-urban (21.66%) and urban (16.05%) areas. This study proved the predominance of hard ticks as parasites on domestic animals and will help the public health personnel to understand the ground-level situation and to take up necessary control measures to prevent tick-borne diseases.

Keywords: Ticks, domestic animals, Ixodidae, prevalence.

Zoobank: <http://zoobank.org/D8825743-B884-42E4-B369-1F16183354C9>

INTRODUCTION

Hard ticks (Acari: Ixodidae) are involved in the transmission of a variety of disease pathogens of public health and veterinary importance (Arthur, 1962; Estrada-Pena and Jongejan, 1999; Parola and Raoult, 2001; Barandika et al., 2007; Brites-Neto et al., 2015; Liyannarachchi et al., 2015; Tonetti et al., 2020). Today, the order Ixodida includes 970 species of ticks known all over the world which are included in four families, being three extant Ixodidae (750 spp.), Argasidae (218 spp.), one Nuttallielidae and one extinct Deinoceritidae (Guglielmone et al., 2015; Dantas-Torres et al., 2019). In India, domestic animals are often infested heavily with multi-species of ticks transmitting different diseases such as theileriosis, babesiosis, and anaplasmosis (Ghosh and Nagar, 2014). Tick studies gained much significance after the Shimoga district of Karnataka state, reported Kyasanur Forest Disease (KFD) transmitted by *Haemaphysalis* spp. (Pattnaik, 2006). Crimean-Congo hemorrhagic fever (CCHFV) virus infection in domestic animals and humans were reported from different parts of the country (Shanmugan et al., 1976). So far in Madurai district, no tick surveillance was undertaken and no data is available about the distribution pattern of the ticks. Hence this study was undertaken to study the available tick species and to know about the prevalence of different vector species in Madurai district.

MATERIALS AND METHODS

Madurai district situated in the Tamil Nadu state of India is one of the 38 districts in the Tamil Nadu state. The latitude of Madurai, Tamil Nadu, India is 9.9533° N and the

longitude is 78.0195° E. The geographical area of this district is 147.97 km². The total population as per the 2011 census is 1,470,755. The average annual minimum temperature in Madurai is 23.9 °C, the average maximum is 34.5 °C, and the annual rainfall is 869.4 mm (34.23 inch). The study area of Madurai was grouped into three regions viz. urban, semi-urban, and rural environments (Fig. 1). In each habitat, 100 households were selected randomly. This study incorporated different household animals like cows, dogs, goats, cats and fowls. Ticks were collected with fine-tipped tweezers and kept separately for identification in sample vial containing 70% ethanol, location, host, and date of collection was noted. Ticks were identified using the available tick identification keys (Sharif, 1928; Geevarghese and Dhanda, 1987; Walker et al., 2003; Geevarghese and Mishra, 2011). Immature ticks were mounted with Hoyer's medium (Prakasan and Ramani, 2007). All collected specimens were deposited in Mosquito/Ectoparasite Museum, Entomology Laboratory of ICMR-Vector Control Research Centre Field Station, Tamil Nadu, India. The tick index and the tick infestation rate were calculated. The data analysis was performed using SPSS Ver. 15 (Statistics Package for Social Sciences).

RESULTS

This study showed the presence of ticks on 1,224 household animals cows (417), dogs (153), goats (465), cats (19), and fowl (170) belonged to 14 species and 5 genera. The following ticks were identified: *Amblyomma integrum* Karsch, 1879, *Haemaphysalis bispinosa*, Newmann, 1897, *Haemaphysalis paraturturis* Hoogstraal, Trapido and Re-bello, 1963, *Haemaphysalis turturis* Nuttall and

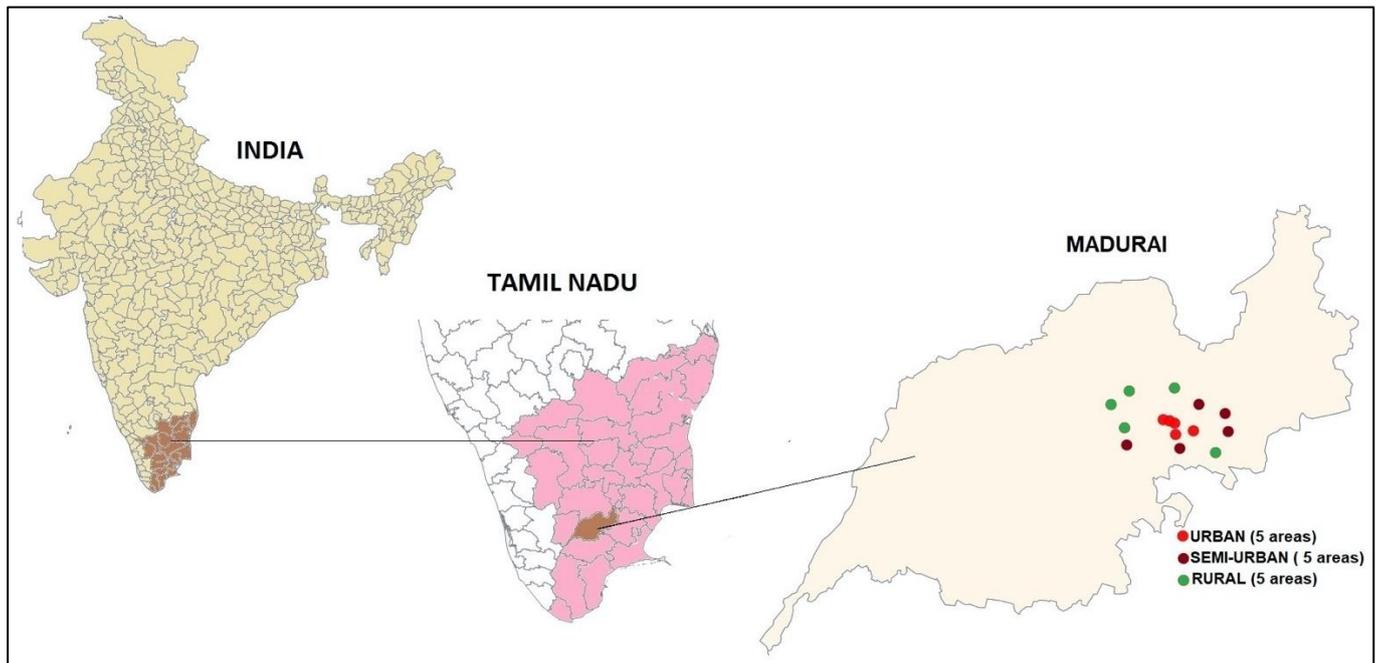


Figure 1. Localities where the field work was carried out in Madurai district.

Warburton, 1915, *Haemaphysalis intermedia* Warburton and Nuttall, 1909, *Haemaphysalis spinigera* Neumann, 1897, *Hyalomma anatolicum* (Koch, 1844), *Hyalomma brevipunctata* Sharif, 1928, *Hyalomma kumari* Sharif, 1928, *Rhipicephalus (Boophilus) annulatus* (Say, 1821), *Rhipicephalus (B.) decoloratus* (Koch, 1844), *Rhipicephalus (B.) microplus* (Canestrini, 1887), *Rhipicephalus turanicus* Pomerantzev, 1940, *Rhipicephalus haemaphysaloides* Supino, 1897, and *Rhipicephalus sanguineus* complex (Latrielle 1806) (Table 1). A list of 15 tick species collected in this study and the detailed gender and life stage is shown in Table 1.

Prevalence and infestation details of tick species in domestic animals is furnished in Table 1 and 2. Among the three localities, the maximum collection was recorded from semi-urban areas. The total tick infestation rate was calculated to be 21.90% and the tick index was 0.922. In the rural areas 13 species of ticks were found, followed by 11 species of ticks recorded from semi-urban areas and eight from urban areas. The rural habitat showed a maximum number of tick species. The predominant species recorded from these areas was *R. sanguineus* complex (27.03%), followed by both *R. (B.) microplus* and *R. (B.) decoloratus* (24.12% and 18.82%), respectively. The maximum number of ticks were collected from cows (41.43% of the ticks), followed by dogs (18.02 %), goats (36.92%), cats (1.59%) and fowls (2.03%). Tick abundance rate concerning different host animals was 27.33% for cows, 22.88% for dogs, 19.35% for goats, 36.84% for cats, and 12.94% for fowl (Table 2). Ticks were collected mostly from ears followed by neck and udder of the animals. A list of 10 medically important tick vectors collected in this study is shown in Table 3.

There was a significant difference in the distribution of ticks among rural, semi-urban, and urban localities (F-5.465, df-2, p<0.05). Again there was a significant difference in the distribution of ticks among the five host ani-

mal groups (F-4.938, df-4, p<0.05). Finally, cross-analysis of three localities versus 5 host (15 species of ticks) showed a significant difference among the tick positivity (F-3.287, df-14, p<0.05).

DISCUSSION

The first major contribution to Indian tick fauna was by Sharif (1928), who reported 45 species of ticks preserved in the Zoological Survey of India (Indian Museum in Calcutta). Sen (1938) prepared a check-list for 50 species of Ixodid ticks found on the domestic stock. A check-list of different tick species on various vertebrate hosts and from many areas of the country was prepared by the National Institute of Virology in Pune (Geevarghese et al., 1997; Geevarghese and Mishra, 2011). In India, so far 109 tick species were reported of which 88 belong to the family Ixodidae (Geevarghese et al., 1997; Ghosh et al., 2007). Tick faunal studies from the eastern Himalayas recorded 14 different species of ixodid ticks belonging to seven genera with an abundant collection of *Amblyomma* spp. and *R. (B.) microplus* (Varma and Mahadevan, 1970). In Jammu and Kashmir 16 different species of ixodid ticks belonging to seven genera were recorded (Kaul et al., 1990). Ixodid ticks belonging to seven genera and 17 species were collected from North-East Frontier Agency, India (Dhanda and Ramachandrarao, 1964).

In Haryana, six different tick species from three genera of hard ticks were collected (Chhilar et al., 2014). A study conducted in Karnataka reported hard ticks infesting sheep and goats (Jagannath and Lokesh, 1988; Saxena, 1997). Kumar et al. (2002) reported the presence of hard ticks in Tamil Nadu. Similarly in Kerala Prakasan and Ramani (2003) reported hard ticks infestation in humans. The presence of hard ticks in different domestic animals was already reported from many states like Karnataka, Tamil Nadu and Assam (Jagannah et al., 1979; Latha et al., 2004; Miranpuri and Singh, 1978). Saxana et al. (1984) reported eight different species of ticks, and Kumar et al.

Table 1. Prevalence of tick species in domestic animals in Madurai, Tamil Nadu, India.

Family	Genus	Species	Nymph	%	Male	%	Female	%	Total	%
Ixodidae	<i>Amblyomma</i>	<i>Amblyomma integrum</i>	3	0.27	1	0.09	10	0.88	14	1.24
		<i>Haemaphysalis bispinosa</i>	8	0.71	14	1.24	75	6.63	97	8.57
		<i>Haemaphysalis paraturturis</i>	0	0.00	0	0.00	9	0.80	9	0.80
	<i>Haemaphysalis</i>	<i>Haemaphysalis turturis</i>	8	0.71	2	0.18	21	1.86	31	2.74
		<i>Haemaphysalis intermedia</i>	7	0.62	12	1.06	34	3.00	53	4.68
		<i>Haemaphysalis spinigera</i>	0	0.00	2	0.18	14	1.24	16	1.41
	<i>Hyalomma</i>	<i>Hyalomma anatolicum</i>	0	0.00	0	0.00	12	1.06	12	1.06
		<i>Hyalomma brevipunctata</i>	2	0.18	0	0.00	9	0.80	11	0.97
		<i>Hyalomma kumari</i>	3	0.27	9	0.80	20	1.77	32	2.83
	<i>Rhipicephalus</i>	<i>Rhipicephalus (B.) annulatus</i>	3	0.27	0	0.00	14	1.24	17	1.50
		<i>Rhipicephalus (B.) decoloratus</i>	4	0.35	42	3.71	167	14.75	213	18.82
		<i>Rhipicephalus (B.) microplus</i>	1	0.09	84	7.42	188	16.61	273	24.12
		<i>Rhipicephalus turanicus</i>	2	0.18	11	0.97	26	2.30	39	3.45
		<i>Rhipicephalus haemaphysaloides</i>	0	0.00	2	0.18	7	0.62	9	0.80
		<i>Rhipicephalus sanguineus</i>	17	1.50	116	10.25	173	15.28	306	27.03
Total			58	5.12	295	26.06	779	68.82	1132	100

Table 2. Tick infestation rate and tick index in study areas.

Host	Total host examined	Host infested	Total ticks collected	Infestation (%)	Tick index
Cow	417	114	469	27.34	1.12
Dog	153	35	204	22.88	1.33
Goat	465	90	418	19.35	0.90
Cat	19	7	18	36.84	0.95
Fowl	170	22	23	12.94	0.14
Total	1,224	268	1,132	21.90	0.92

Table 3. List of medically important tick vectors collected in this study.

No	Vector	Disease	Parasite/pathogens	R
1	<i>Amblyomma integrum</i>	Otoacariasis	Otalgia	R1
2	<i>Haemaphysalis intermedia</i>	Ganjam virus	Nairobi sheep disease	R3
3	<i>Haemaphysalis spinigera</i>	Kyasanur Forest disease	Group B Toganvirus (Flaviviridae)	R2
4	<i>Haemaphysalis turturis</i>	Kyasanur Forest disease	KFD virus	R2
5	<i>Hyalomma anatolicum</i>	Crimean-Congo haemorrhagic fever	<i>Babesia equi</i>	R2
6	<i>Rhipicephalus (B.) annulatus</i>	Babesiosis	<i>Babesia</i> sp.	R2
7	<i>Rhipicephalus (B.) decoloratus</i>	Indian tick typhus	<i>Rickettsia conorii</i>	R2
8	<i>Rhipicephalus (B.) microplus</i>	Babesiosis	<i>Babesia bigemina</i> , <i>B. ovis</i>	R2
9	<i>Rhipicephalus sanguineus</i>	Indian tick typhus, ehrlichiosis	<i>Rickettsia conorii</i> , <i>Ehrlichia canis</i> , <i>E. equi</i>	R2
10	<i>Rhipicephalus turanicus</i>	Rickettsial disease	<i>Coxiella</i> , <i>Rickettsia</i>	R4

R-References: R1-Bandaranayaka et al. (2016), R2-Ghosh and Nagar (2014), R3-Geevarghese and Mishra (2011), R4-Chochlakakis et al. (2014).

(2014) reported 12 species of ticks on different domestic animals in Nilgiris hills situated in Tamil Nadu. A total of 14 species of ticks belonging to 5 genera infesting domestic animals in Villupuram district, Tamil Nadu were recorded Shobana et al. (2013). This study showed that more favourable conditions prevail in Madurai for the propaga-

tion of haematophagous ticks with richness in vegetation and animal fauna with special reference to rural areas. Similarly to the observations of Shobana et al. (2013) also in this study cats had a minimum number of ticks.

A study about the tick fauna in the Shimoga district of Karnataka showed the presence of *H. spinigera* on dogs which facilitate the maintenance of the Kyasanur Forest disease (KFD) virus (Kumar et al., 2008). In Shimla hills species like *Hyalomma* spp., *R. sanguineus complex*, *R. haemaphysaloides*, *Haemaphysalis* spp. and *Ixodes* spp. with their role in disease transmission (Mehta, 1937). The presence of *Hyalomma* species in the region confirms the presence of the CCHF virus in Gujarat (Gandhi et al., 2011). A large number of the species infesting the different livestock were recorded as vectors of different pathogens (Liyannaarachchi et al., 2015; Tonetti et al., 2020). Tick-borne diseases like KFD and CCHF are of public health importance and the KFD virus was isolated from tickssuch as *H. spinigera*, *H. turturis*, and *H. bispinosa* in India. This present study showed the prevalence of the different species of ticks and the pattern of infestation on different domestic animal hosts namely cows, goats, dogs, cats, and fowl. In this study we have also observed the presence of 10 species tick vectors and the disease they cause as shown in Table 2.

This study showed for the first time the species of ticks existing on livestock in the region of Madurai district. Further studies are required to understand the epidemiology of those ticks, their vectorial potential for pathogenic microorganisms as well as the seroprevalence of tick-borne diseases in the human population. Tick control methods are to be adopted to keep the tick abundance in check at regular intervals to prevent the spread of tick-borne diseases.

Authors' contributions

Krishnamoorthi Ranganathan: Collection of the specimens, processing of the specimens, identification and preservation. **Govindarajan Renu:** Collection of the specimens, processing of the specimens, identification, preservation, review and editing. **Elango Ayyanar:** Identification, verification, data curation. **Rajamannar Veeramanoohan:** Data analysis, visualization, software programming. **Philip Samuel Paulraj:** Conceptualization, supervision and project administration.

Statement of ethics approval

This study was approved by the Institutional Animal Ethics Committee (IAEC) of ICMT-Vector Control Research Centre, Puducherry.

Funding

This work was supported by the Indian Council of Medical Research (ICMR-VCRC/IM1710).

Conflict of interest

None of declare.

Acknowledgment

We are thankful to our Director, Dr. Ashwani Kumar, ICMR-VCRC, Puducherry, and the previous Director Dr. Jambulingam, ICMR-VCRC, Puducherry for providing all

the necessary facilities, constant encouragement, guidance and useful suggestions for undertaking this study. We want to express our deep sense of gratitude to all our departmental colleagues of ICMR-VCRC Field station (erstwhile ICMR-CRME), Madurai.

REFERENCES

- Arthur, D.R. 1962. Ticks and disease. Pergamon Press, Oxford, UK, 445 pp.
- Bandaranayaka, K.O., Apanaskevich, D.A. and Rajakaruna, R.S. 2016. Life cycle of *Amblyomma integrum* (Acari: Ixodidae) under laboratory conditions. *Experimental and Applied Acarology*, 69: 335-345. doi: 10.1007/s10493-016-0034-5
- Barandika, J.F., Hurtado, A., Garcia-Esteban, C., Gil, H., Escudero, R., Barral, M., Jado, I., Juste, R.A., Anda, P. and Garcia-Perez, A.L. 2007. Tick-borne zoonotic bacteria in wild and domestic small mammals in Northern Spain. *Applied and Environmental Microbiology*, 73 (19): 6166-6171. doi: 10.1128/AEM.00590-07
- Brites-Neto, J., Roncato Duarte, K.M. and Martins, T.F. 2015. Tick-borne infections in human and animal population worldwide. *Veterinary World* 8 (3):301-315. doi: 10.14202/vetworld.2015.301-315
- Chhillar, S., Chhillar, J.S. and Kaur, H. 2014. Investigations on some hard ticks (Acari: Ixodidae) infesting domestic buffalo and cattle from Haryana, India. *Journal of Entomology and Zoology Studies*, 2: 99-104.
- Chochlakis, D., Loannou, I., Papadopoulos, B., Tselentis, Y. and Psaroulaki, A. 2014. *Rhipicephalus turanicus*: from low numbers to complete establishment in Cyprus. Its possible role as a bridge vector. *Parasites & Vectors*, 7: 8-11. doi: 10.1186/1756-3305-7-S1-P11
- Dantas-Torres, F., Martins, T.F., Munoz-Lealb, S., Onofrio, V.C. and Barros-Battesti, D.M. 2019. Ticks (Ixodida: Argasidae, Ixodidae) of Brazil: Updated species checklist and taxonomic keys. *Ticks and Tick-borne Diseases*, 10 (6):1-45. doi: 10.1016/j.ttbdis.2019.06.012
- Dhanda, V. and Ramachandrarao. T. 1964. A report on collection of ixodid ticks made in North East Frontier Agency India. *Indian Journal of Medical Research*, 52: 1139-1153.
- Estrada-Pena, A. and Jongejan, F. 1999. Ticks feeding on humans: a review of records on human-biting Ixodoidea with special references to pathogen transmission. *Experimental and Applied Acarology*, 23: 685-715. doi: 10.1023/a:1006241108739
- Gandhi, S., Dave, P., Patel, G.C., Khatri, H.J., Shah, N. and Mishra, U. 2011. An epidemiological investigation of a multisource outbreak of Congo Crimean Haemorrhagic

- fever (CCHF). *Journal of Communicable Diseases*, 43: 161-167.
- Geevargheese, G. and Mishra, A.C. 2011. *Haemaphysalis* ticks of India. Elsevier, London, UK, 253 pp.
- Geevargheese, G., Fernandes, S. and Kulkarani, S.M. 1997. A checklist of Indian ticks (Acari: Ixodidae). *Indian Journal of Animal Science*, 67: 566-574.
- Geevargheese, G. and Dhanda, V. 1987. The Indian *Hyalomma* ticks (Ixodoidea: Ixodidae). *Indian Council of Agricultural Research*, New Delhi, India, 119 pp.
- Ghosh, S., Azhahianambi, P. and Yadav, M.P. 2007. Upcoming and future strategies of tick control: a review. *Journal of Vector Borne Diseases*, 44: 79-89.
- Guglielmone, A.A., Sánchez, M.E., Franco, L.G., Nava, S., Rueda, L.M. and Robbins, R.G. 2015. Hard ticks (Acari: Ixodida: Ixodidae). A non-profit open-access web portal for original descriptions of tick species (valid and invalid), dubious and uncertain names, and selected *nomina nuda*. Available <http://rafaela.inta.gov.ar/nombresgarrapatas/> (Last accessed: 18 August 2020).
- Jagannath, M.S., Muraleedharan, K. and Hiregoudar, L.S. 1979. Prevalence of ixodid ticks of cattle at Bangalore. *Indian Journal of Animal Science*, 49: 890-894.
- Jagannath, M.S. and Lokesh, V.V. 1988. Incidence of ixodid ticks of sheep and goats in Kolar district. *Indian Journal of Animal Sciences*, 58: 72-76.
- Kaul, H.N., Shetty, P.S., Ghalsasi, G.R. and Dhanda, V. 1990. Survey of ticks (Acarina: Ixodidae) for Crimean haemorrhagic fever virus activity in Jammu and Kashmir state, India. *Indian Journal of Medical Sciences*, 91: 5-8.
- Kumar, K., Balakrishnan, N., Katayal, R. and Gill, K.S. 2002. Prevalence of ixodid ticks in Nilgiri district of Tamil Nadu State (India). *Journal of Communicable Diseases*, 34: 124-127.
- Kumar, K., Sexena, V.K. and Lal, S. 2008. Prevalence of vectors of scrub typhus, plague and KFD in district Shimoga, Karnataka state, India. In: *Vector borne diseases: Epidemiology and control*. Tyagi, B.K. (Ed.). Scientific Publishers, Jodhpur, India, 205-211.
- Latha, B.R., Aiyasami, S.S., Pattabiraman, G., Sivaraman, T. and Rajavelu, G. 2004. Seasonal activity of ticks on small ruminants in Tamil Nadu State, India. *Tropical Animal Health and Production*, 36: 121-133. doi: 10.1023/B:TROP.0000012108.42526.11
- Liyanaarachchi, D.R., Rajakaruna, R.S., Dikkumbura, A.W. and Rajapakse, R.P.V.J. 2015. Ticks infesting wild and domestic animals and humans of Sri Lanka with new host records. *Acta Tropica*, 142: 64-70. doi: 10.1016/j.actatropica.2014.11.001
- Mehta, D.R. 1937. Studies on typhus in the Simla hills part viii ectoparasites of rats and shrews with special reference to their possible role in the transmission of typhus. *Indian Journal of Medical Sciences*, 25: 353-365.
- Miranpuri, G.S. and Singh, J. 1978. Ticks and mites from domestic animals in Assam, India and their possible role in transmission of diseases. *Indian Journal of Parasitology*, 2: 11-14.
- Parola, P. and Raoult, D. 2001. Ticks and tick borne bacterial diseases in humans: An emerging infectious threat. *Clinical Infectious Diseases*, 32: 897-928. doi: 10.1086/319347
- Pattanaik, P. 2006. Kyasanur forest disease: an epidemiological view in India. *Reviews in Medical Virology*, 16: 151-165. doi: 10.1002/rmv.495
- Prakasan, K. and Ramani, N. 2007. Tick parasites of domestic animals of Kerala, South India. *Asian Journal of Animal and Veterinary Advances*, 2: 74-80. doi: 10.3923/ajava.2007.74.80
- Saxena, V.K., Kaushal, K. and Rajagopal, R. 1984. Vertical distribution of ticks of domestic animals in Nilgiri hills (Tamil Nadu). *Journal of Communicable Diseases*, 16: 323-325.
- Saxena, V.K. 1997. Ixodid ticks infesting rodents and sheep in diverse biotopes of South-India. *Journal of Parasitology*, 83: 766-767. doi: 10.2307/3284262
- Sen, P. 1938. A checklist and host list of Ixodidae (ticks) occurring in India. *Indian Journal of Veterinary Science Animal Husbandary*, 8: 133-149.
- Shanmugam, J., Smirnova, S.E. and Chumakov, M. P. 1976. Presence of antibody to arboviruses of the Crimean Haemorrhagic Fever Congo (CHF Congo) group in human beings and domestic animals in India. *Indian Journal of Medical Research*, 64: 1403-1413.
- Sharrif, M. 1928. A revision of Indian Ixodidae with special reference to the collections in the Indian Museum. *Records of the Indian Museum*, 30: 217-344.
- Shobana, G., Gunasekaran, C. and Lena, M. 2013. A survey on ticks parasites in domestic animals of Villupuram district, South India. *Research Journal of Animal, Veterinary and Fishery Sciences*, 1 (5): 21-23.
- Ghosh, S. and Nagar, G. 2014. Problem of tick and tick borne disease in India with special emphasis progress in control research: a review. *Journal of Vector Borne Diseases*, 51: 259-270.
- Tonetti, N., Berggoetz, M., Ruhle, C., Pretorius, A.M. and Gern, L. 2009. Ticks and tick-borne pathogens from wildlife in the Free State province. *South Africa. Journal of Wildlife Diseases*, 45 (2): 437-446. doi: 10.7589/0090-3558-45.2.437
- Varma, R.N. and Mahadevan, B. 1970. Ixodid ticks collected in the Eastern Himalayas and their potential dis-

ease relationships. Indian Journal of Medical Science, 58 (6): 693-706.

Walker, A.R., Bouattour, A., Camicas, J.L., Estrada-Pena, A., Horak, I.G., Latif, A.A., Pegram, R.G. and Preston, P.M. 2003. Ticks of domestic animals in Africa: a guide to

identification of species. Bioscience Reports, Edinburgh Scotland, UK, 221 pp.

Edited by: Salih Doğan

Reviewed by: Three anonymous referees

Citation: Ranganathan, K., Renu, G., Ayyanar, E., Veeramano-Haran, R. and Paulraj, P.S. 2021. Species composition of hard ticks (Acari: Ixodidae) on domestic animals and their public health importance in Tamil Nadu, South India. Acarological Studies, 3 (1): 16-21.
