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REVIEW ARTICLE

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Detailed new insights about tick infestations in domestic ruminant groups: a global systematic review and meta-analysis

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Abstract The domestic ruminants such as buffaloes, cattle, goats, sheep, and camels all around the globe represent a significant part of the global economy. Although domestic ruminant group infestations by hard ticks are commonly reported worldwide. Because these localized reports have shown variable and unprocessed results. A comprehensive global meta-analysis of tick infestations that dealt with the global annually trend in the world countries, continents, hemispheres and tropical regions; animal age categories and sexes, attachment sites; tick life stages; and seasonal and monthly tick infestations in the world hemispheres and tropical regions in domestic ruminant groups, would be of particular importance and therefore performed. From 658 papers identified, 382 papers were selected to become parts of meta-analysis source, detailed results (329 papers) and systematic review (102 papers). The results indicate that the global tick infestations in the world countries, continents, hemispheres and tropical regions exhibited different values and ranges for domestic ruminant groups that are globally considerable amount of tick infestations to cause significant economical and medical damages. The global resultant trend of tick infestations in domestic ruminant groups exhibited predominantly an increasing trend in the world hemispheres, tropical regions, and globally in the world during the past decades. These valuable results suggest that the control measures to prohibit tick infestations in domestic ruminant groups have not been successful. Towards an effective and sustainable tick control, the control measures must be continued with more strength and intensity. The global tick infestations in domestic ruminant age categories and attachment sites of body parts exhibited different values. In other words, the levels of interest of ticks for blood feeding on domestic ruminant groups change with their age categories and attachment sites of body parts. These valuable results suggest that the all age categories of domestic ruminant groups are threatened by ticks. Ticks are predominantly tend to attach the females of domestic ruminant group as approximately twice as males. The females and males of ticks attack more domestic ruminant groups than nymphalid and larval life stages. The outcome of statistical analysis showed that there is difference between seasonal domestic ruminant tick infestation patterns in tropical regions and in the northern and southern hemispheres. Different significant degrees of tick infestations in domestic ruminant groups by analysis between tick and tick life stage infestations in relation to animal age categories, attachment sites of body parts, sexes, and seasonal and monthly tick infestations among years, countries, continents, hemispheres and tropical regions, show the temporal, spatial and epidemiological tick infestation values in different climatic, geographical and environmental conditions among countries, continents, hemispheres and tropical regions of the world.

Keywords Buffaloes · Camels · Cattle · Goats · Sheep · Domestic ruminants · Seasonal and monthly tick infestation · Tick attachment sites · Tick infestation

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Introduction

Ticks are globally considered as obligate hematophagous ectoparasitic arthropods that belong to the subclass of Acari and Ixodida order infesting humans and animals (Abera et al. 2010; Yassin et al. 2016; Cicculli et al. 2019; Balinandi et al. 2020). They are the most important pest of livestock in regions of tropics and subtropics of the world. Ticks are also one of the most important parasites among the factors that affect livestock health, performance and productivity by their causing to transmit agents of various diseases, blood loss, hypersensitivity, inflammation, irritation, reduction in live weight and milk production, affect appetite, body condition, blood composition, respiratory rates, damage to hide and udder, and open wounds leading to secondary infections. They can cause various clinical manifestations including tissue injury, body paralysis during feeding on their vertebrate hosts, and sometimes anemia during their massive infestations. Ticks are also considered to be the most common reservoirs and vectors of viral, bacterial and protozoan pathogenic microorganism causing severe infectious diseases of medical, zoonotic and veterinary importance in humans, and domestic and wild animals, and are the second most common vectors of human pathogens worldwide after mosquitoes. They can play a key role as an participant to emerge and/or reemerge tick-borne diseases such as anaplasmosis, babesiosis, ehrlichiosis, rickettsiosis, lyme, relapsing and Q-fever diseases, and life-threatening arboviruses (Greenfield 2011; Anderson et al. 2013; Lu et al. 2013; Kiros et al. 2014; Aydin et al. 2015; Abdullah et al. 2016; Yassin et al. 2016; Sajid et al. 2018; Batool et al. 2019; Cicculli et al. 2019; Guo et al. 2019; Balinandi et al. 2020).

The domestic ruminants such as buffaloes, cattle, goats, sheep (Artiodactyla: Bovidae), and camels (Artiodactyla: Camelidae) all around the globe represent a significant part of the global economy, particularly in the world developing countries. Thus, domestic ruminants provides energy, food, raw material, and manure for crops. Therefore, it is not surprising that the sector of domestic ruminants, especially the dairy sector, has emerged as an important economic source for a vast majority of the rural population and a target for agribusiness in the dairy, meat, and various other products in the processed foods sector. They provide a vital source of monetary income to the owners of poor-resources and small-holder dairy farms (Kabir et al. 2011; Al-Shaibani 2012; Ghafar et al. 2020b). Buffaloes and cattle are not only main source of animal proteins but their products such as bones, skins and goods made from their fetch are of great importance for humans (Kakar and Kakarsulemankhel 2008). Buffaloes are multipurpose animals as they have extensively been used for agricultural land preparation, racking, carting and transportation of goods, and threshing and crushing of sugarcane and oil seeds in the rural areas (Iqbal et al. 2013). Goats and sheep are one of the most affordable animals in the world and can be accommodated in any kind of weather conditions. Goats play an important and frequently under estimated role in a range of agricultural systems worldwide. Goat farming is generally favored by farmers in countries with a relatively arid and unpredictable climate where the goat's greater ability to convert poor quality forage into meat and milk makes it more valuable than other forms of livestock (Cornall and Wall 2015). Sheep continue to be important for wool and meat today, and are also occasionally raised for pelts, as dairy animals, or as model organisms for science. Sheep husbandry is practiced throughout the majority of the inhabited world, and has been fundamental to many civilizations.

Camels represent a vital contribution to food security and human welfare in vulnerable households of the world areas. They are important for milk, meat, and leather productions, transportation, draft power, entertainment like racing and dancing, and house hold income generations. The ability of the camels to survive in harsh areas of the world, their endurance in prolonged drought, and above all their high potential to convert the scanty resources of the desert into milk and meat makes them playing a pivotal role in the socioeconomic uplift of the community of deserts (Megersa et al. 2012; Taddese and Mustefa 2013; Qamar et al. 2019). Camels play an important role in the culture and agriculture of many countries. They are uniquely important working animals of the semi-arid and hot-arid ecosystem because of their unique adaptive physiological characteristics and hence, they support the survival of millions of people in these areas of the world. Many pastoral groups and communities are solely depending on camels in diverse ecozones throughout the world, the nomads are depending on camels for their livelihood in the wide deserted less rainfall areas makes the life scare in drinkable sweat water (Kiros et al. 2014; Feyera et al. 2017; Qamar et al. 2019).

A number of environmental factors such as diet, feeding regime, housing, climate, season, heat stress, disease status, and parasitic burden affect milk production of dairy domestic ruminants (Abbasi et al. 2017). Of all, various internal and external parasitic diseases have been reported to be the major problems affecting the health, productivity and performance of domestic ruminants (Kiros et al. 2014). Among many constraints, tick parasitism is thought to be a major hindrance in the population development of domestic ruminants (Abbasi et al. 2017). Beside their medical importance, the economical damages that ticks can cause are also significant. Tick infestations are the major problem for animal health that causes substantial economic losses to farming communities of poor-resources, particularly in regions of tropics and subtropics of the world. The annual global economic losses due to tick infestations have been expected US$14,000–18,000 million (Dehaghi et al. 2011; Dumitrache et al. 2012; Abbasi et al. 2017; Rehman et al. 2017; Sajid et al. 2018; Balinandi et al. 2020; Ghafar et al. 2020a). In addition, traveling to migratory bird habitats or tourism sites, such as forests, wetlands or recreational parks that identified as risky places with natural tourism attractions, and human activities in nature and animal husbandry facilitate higher contact with these infected vectors and pose a risk for the emergence of tick-borne diseases (Jameson et al. 2012; Nasirian 2013, 2014, 2019b; Nasirian et al. 2013, 2016; Leblebicioglu et al. 2014, 2015, 2016; Nasirian et al. 2014a, b, 2015a, b; Nasirian and Irvine 2017; Sharifah et al. 2020).

The livestock industry all around the globe is under economic threat due to ticks and tick-borne diseases (Sajid et al. 2018). In recent years many factors have changed the interactions among humans, animals and the environment and this has caused the emergence and reemergence of many diseases (Liyanaarachchi et al. 2015). Human tick-borne diseases are usually zoonotic and wild and domestic vertebrate hosts are the reservoir of infection, usually without themselves being apparently affected (Grech-Angelini et al. 2016). Prevalence of ectoparasites and their infestation on various parts of domesticated animals are issues of high importance in veterinary science (Abdullahi et al. 2018). It is important to know the prevalence of the ticks involved on the transmission as well as their geographical distribution for the control of tick and tick-borne diseases (Dehaghi et al. 2011). Access to knowledge concerning the distribution of hard ticks across different geographical regions is essential in controlling of tick populations and tick-borne diseases (Farahi et al. 2016). The tick infestations are the most common and considered to be economically important in a domestic ruminant groups, and reported studies conducted in different species such as buffaloes, camels, cattle, goats, and sheep (Abbasi et al. 2017).

Although domestic ruminant group infestations by hard ticks (Acari: Ixodida: Ixodidae) are commonly reported worldwide. Because these localized reports have shown variable results (Lotfollahzadeh et al. 2011) and often presented as unprocessed documents. Evidence or knowledge synthesis and knowledge translation are scientific methodological approaches used across different disciplines for combining results from individual studies, interpreting them based on the body of evidence and with the objective of supporting decision-making. Policymakers need to be well-informed in a timely manner, and for that, evidence must be synthesized using relevant highlighting decisive information to be applied in the decision-making process. 'Meta-analyses' comprise the statistical component of systematic reviews and quantitatively combine individual results into pooled effect sizes. Meta-analyses are performed to increase power and precision, to answer different research questions that were not included in the individual studies, and to assess issues that may have arisen from conflicting studies or generate new hypotheses. Systematic reviews and meta-analyses should be reassessed periodically to determine whether they are still up to date, as more new data or methods may become available, and given the continuing importance of the research question asked. Unbiased evidence synthesis and knowledge translation must be the modern standard for reviews because they can be used to inform decisions and therefore will have the greatest impact on policy (Oliveira et al. 2021). It seems like a comprehensive global meta-analysis study that deals with the global annually trend of tick infestations for each domestic ruminant group of buffaloes, camels, cattle, goats, sheep, and the global domestic ruminants in the world countries, continents, hemispheres and tropical regions; tick infestations in age categories of domestic ruminants; tick infestations in attachment sites of domestic ruminant group body parts; tick infestations in relation to domestic ruminant group sexes and tick life stages; and seasonal and monthly tick infestations in domestic ruminant groups in the world hemispheres and tropical regions, would be of particular importance. Therefore, this global systematic meta-analysis review summarizes the above-mentioned objectives about detailed new insights of tick infestations in domestic ruminant groups.

Materials and methods

Collection and selection of papers for review

To perform this global meta-analysis systematic review, the Preferred Reporting Items for Systematic Re-views and

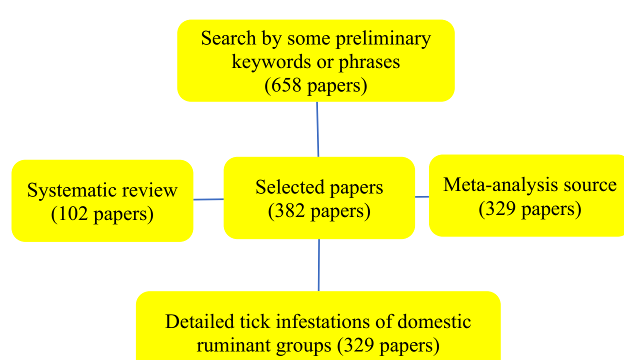

Fig. 1 Flow chart of the study process

Table 1 Tick infestations of domestic ruminant groups including buffaloes, camels, cattle, goats and sheep based on literature search

Country (province or state)	TI (%)	Sampling			References
		Location	n	Date	
Buffaloes					
Iraq	–	Across	9775	Apr-May 1965	Robson and Robb (1967)
India	–	Across	12,535	1975–1976	Miranpuri (1988)
Egypt (Ismailia)	33.3	Local	5515	Oct 1999-Feb 2000	Wahba (2001)
Thailand (Samut Prakan)	9.4	Local	1491	Mar 2000-Feb 2001	Nithikathkul et al. (2002)
Iraq (Basra)	48.3	Local	505	Jan-Dec 2004	Awad and Abudl-Hussein (2005)
Bangladesh	11.7	Across	6771	Jul 1999-Jun 2001	Islam et al. (2006)
Egypt	9.2	Across	1019	Jun 2002-Jul 2003	Loftis et al. (2006)
Pakistan	14.7	Across	4500	–	Ghosh et al. (2007)
Pakistan (Peshawar)	11.3	Local	–	Aug 2003-Feb 2004	Manan et al. (2007)
India (Kerala)	14.0	Local	–	May 1999-May 2002	Prakasan and Ramani (2007)
Iran (West Azerbaijan)	1.7	Local	799	Mar 2006-Feb 2007	Davoudi et al. (2008)
Pakistan (Quetta)	7.0	Local	–	Nov 2005-Apr 2006	Kakar and Kakarsulemankhel (2008)
Pakistan (Punjab)	40.1	Local	1793	–	Sajid et al. (2008)
India (Uttarkhand)	33.0	Local	–	Jan 2004-Dec 2004	Vatsya et al. (2008)
Pakistan	24.1	Local	–	Mar-Nov 2009	Farzana et al. (2010)
Bangladesh (Kurigram)	25.4	Local	–	Nov 2007-Oct 2008	Mamun et al. (2010)
Pakistan	24.1	Local	–	Mar 2009-Nov 2009	Perveen et al. (2010)
India (Punjab)	55.0	Local	–	Aug 2008-May 2009	Haque et al. (2011)
Egypt	15.2	Local	342	2009	Chisholm et al. (2012)
Brazil (Rio de Janeiro)	82.3	Local	–	Jun 2008-Dec 2009	Corrêa et al. (2012)
India (Nashik)	28.2	Local	–	–	Jawale et al. (2012)
Kenya	22.7	Local	1071	2010	Kariuki (2012)
Pakistan (Punjab)	34.0	Local	–	Jul-Aug 2007	Ali et al. (2013)
India (Vidarbha)	77.3	Local	–	–	Chavhan et al. (2013)
Pakistan (Punjab)	21.2	Local	352	Apr 2010-Mar 2011	Iqbal et al. (2013)
Pakistan	22.6	Across	–	Jul 2013-Sep 2013	Khan et al. (2013)
India (Villupuram)	58.1	Local	–	Mar-Feb 2011	Shobana et al. (2013)
Iraq	41.5	Across	785	Mar 2012-Feb 2013	Shubber et al. (2013)
India (Kerala)	12.8	Local	–	Jun 2010-Sep 2010	Shyma et al. (2013)
Egypt	17.8	Local	440	Nov 2012-Sep 2013	Asmaa et al. (2014)
India (Haryana)	42.2	Local	867	Aug 2011-Jan 2013	Chhillar et al. (2014)
Iraq (Wasit)	8.7	Local	–	2012	Hassan and Al-Zubaidi (2014)
Pakistan (Punjab)	84.3	Local	–	Oct 2012-Sep 2013	Mustafa et al. (2014)
Iraq	42.2	Across	–	Mar 2012-Feb 2013	Shubber et al. (2014)
Pakistan (Sindh)	24.8	Local	–	–	Soomro et al. (2014)
Pakistan (Multan)	52.5	Local	–	Sep 2009-Aug 2010	Zahida et al. (2014)
India (Jammu)	37.3	Local	–	Mar 2012-Feb 2013	Khajuria et al (2015)
Iraq	20.0	Across	–	–	Mohammad (2015)
India	51.8	Local	–	Jul 2010-Jun 2011	Patel et al. (2015)
Pakistan (Azad Jammu and Kashmir)	48.7	Local	699	Jul-Dec 2011	Sultana et al. (2015a)
Pakistan (Kashmir)	51.0	Local	–	Jun 2011-Nov 2011	Sultana et al. (2015b)
Pakistan	–	Local	682	Jan 2012-Dec 2012	Ali et al. (2016)
Pakistan (Khairpur)	26.6	Local	–	Apr-Sep 2015	Abbasi et al. (2017)
Pakistan (Khyber Pakhtunkhwa)	33.3	Local	1200	Jun-Sep 2015	Farooqi et al. (2017)
Pakistan	81.4	Across	3807	Sep 2013-Nov 2013	Rehman et al. (2017)

Table 1 continued

Country (province or state)	TI (%)	Sampling			References
		Location	n	Date	
Pakistan	58.5	Across	18,907	–	Sajid et al. (2017)
India (Uttar Pradesh)	53.3	Local	–	Feb 2016-May 2016	Singh and Mishra (2017)
Iraq (Basra)	42.5	Local	–	Jun 2016-May 2017	Al-Mayah and Hatem (2018)
Brazil (Pará)	7.9	Local	95	–	Batista et al. (2018)
Pakistan (Punjab)	44.5	Local	–	–	Khalil et al. (2018)
Zimbabwe	53.3	Across	1104	Jan-Apr 2016	Moyo et al. (2018)
India (Karur)	32.7	Local	–	–	Ravichandran (2018)
India (Punjab)	57.7	Local	–	Feb 2010-Aug 2011	Singh and Rath (2018)
Iraq	34.4	Across	749	Jun 2017-Feb 2018	Abed and Hasso (2019)
Pakistan	3.0	Local	–	Sep 2019	Ahmad et al. (2019)
Pakistan	79.0	Local	8641	Apr 2017-Mar 2018	Ali et al. (2019)
Iraq	49.1	Local	–	2011–2012	Al-Lahaibi and Al-Taee (2019)
Pakistan (Punjab)	37.5	Across	21,738	2016–2017	Batool et al. (2019)
India	29.5	Local	–	Oct 2016-May 2017	Chennuru et al. (2019)
Pakistan (Balochistan)	55.0	Local	913	Dec 2018-Dec 2019	Bibi et al. (2020)
Ethiopia (Hadiya)	42.2	Local	–	Nov 2017-Apr 2018	Fesseha and Mathewos (2020)
Pakistan	44.0	Across	774	Sep-Nov 2017	Ghafar et al. (2020a)
Pakistan (Punjab)	87.6	Local	200	Apr 2017-Sep 2017	Ramzan et al. (2020)
Camels					
Iraq	–	Across	9775	Apr-May 1965	Robson and Robb (1967)
Ethiopia	–	Across	28,768	1972–1977	Pegram et al. (1981)
Saudi Arabia	–	Local	373	–	Al-Asgah et al. (1985)
Saudi Arabia	70.0	Across	–	1991–1993	El-Azazy and Scrimgeour (1997)
Egypt (Sinai Peninsula)	22.8	Local	5468	Jan-Dec 1999	Diab et al. (2001)
Kenya and Ethiopia	50.0	Local	31,040	–	Dioli et al. (2001)
Nigeria (Borno and Yobe)	100	Across	13,058	–	James-Rugu and Jidayi (2004)
Ethiopia	–	Local	16,422	Dec 1997-Aug 1999	Zeleke and Bekele (2004)
Iraq (Basra)	15.7	Local	505	Jan-Dec 2004	Awad and Abudl-Hussein (2005)
Egypt	14.2	Across	1019	Jun 2002-Jul 2003	Loftis et al. (2006)
Nigeria (Sokoto)	91.3	Local	3465	–	Lawal et al. (2007)
Iran (West Azerbaijan)	10.2	Local	799	Mar 2006-Feb 2007	Davoudi et al. (2008)
Iraq	78.3	Local	–	Jul-Aug 2008	AL-Fatlawi and Hussein (2009)
Sudan	–	Across	51,253	2000–2001	Elghali and Hassan (2009)
Iran	–	Across	2170	2002–2004	Nabian et al. (2009)
Iran (Sistan and Baluchestan)	9.0	Local	331	Feb 2006-July 2007	Najarnezhad et al. (2009)
Ethiopia	61.5	Local	–	Nov 2007-Apr 2008	Dinka et al. (2010)
Sudan	26.4	Across	15,860	Mar 2006-Feb 2007	El Tigani and Mohammed (2010)
Pakistan	28.9	Local	–	Mar-Nov 2009	Farzana et al. (2010)
Egypt	40.9	Across	–	–	Hamed et al. (2010)
Pakistan	28.9	Local	–	Mar 2009-Nov 2009	Perveen et al. (2010)
Iran (Yazd)	14.8	Local	583	2008–2009	Salim Abadi et al. (2010)
Nigeria (Kano)	59.6	Local	10,178	Jan 2007-Dec 2007	Umar et al. (2010)
Egypt	27.9	Local	–	–	El-Seify et al. (2011)
Iran (Qeshm)	–	Local	2545	–	Nazifi et al. (2011)
Kenya	29.2	Local	8600	Apr-May 2008	Sang et al. (2011)

Table 1 continued

Country (province or state)	TI (%)	Sampling			References
		Location	n	Date	
Egypt	62.6	Local	342	2009	Chisholm et al. (2012)
Iran (Qom)	11.5	Local	744	2010–2011	Farzinnia et al. (2012)
Ethiopia	97.7	Local	6436	Oct 2009-May 2010	Megersa et al. (2012)
Iran (Kerman)	25.0	Local	426	Apr 2009-Mar 2010	Nourollahi Fard et al. (2012)
Ethiopia (Somali)	98.2	Local	1036	May 2006-Jan 2007	Tomassone et al. (2012)
Ethiopia	94.0	Local	11,774	Sep 2010-Mar 2011	Ayele et al. (2013)
Iran	85.5	Across	480	May 2012-Jan 2013	Champour et al. (2013)
Pakistan	83.0	Local	–	–	Gadahi et al. (2013)
Tunisia	90.6	Local	1630	Apr 2011-Mar 2012	Gharbi et al. (2013)
Ethiopia	94.0	Local	11,774	Sep 2010-Mar 2011	Taddese and Mustefa (2013)
Iran	19.2	Local	469	2012	Ganjali et al. (2014)
Ethiopia	96.6	Local	15,723	–	Kiros et al. (2014)
Kenya	22.1	Across	34,854	Apr 2007-Dec 2010	Lutomiah et al. (2014)
Iran (Golestan)	5.1	Local	255	Mar 2009-Feb 2010	Sarani et al. (2014)
Iraq	65.8	Across	–	Mar 2012-Feb 2013	Shubber et al. (2014)
Iran (Golestan)	69.3	Local	386	2010–2011	Sofizadeh et al. (2014)
Iraq	80.0	Across	–	–	Mohammad (2015)
Iran	59.3	Across	1122	Apr 2012-Mar 2013	Moshaverinia and Moghaddas (2015)
Ethiopia	35.4	Local	1347	–	Regassa et al. (2015)
China	–	Across	5257	2012–2014	Wang et al. (2015)
Egypt (Matrouh)	85.1	Local	740	May 2011-Apr 2013	Barghash et al. (2016)
Iran (Khorasan)	85.5	Local	480	May 2012-Jan 2013	Champour et al. (2016)
Iran (Sistan and Baluchestan)	53.9	Local	490	May 2014-Apr 2015	Ghashghaei et al. (2016)
Mexico (Yucatan)	23.0	Local	956	Jan 2009-Dec 2014	Rodríguez-Vivas et al. (2016)
Egypt	33.6	Across	5223	Jun 2014-Jul 2016	Yassin et al. (2016)
Somalia	97.0	Local	576	Mar 2017-May 2017	Farah Isse and Ali (2017)
Ethiopia (Somali)	78.6	Local	6793	Nov 2014-Apr 2015	Feyera et al. (2017)
Saudi Arabia	70.0	Local	1282	Jan-Mar 2016	Mohamed et al. (2017)
Iran (Qom)	–	Local	1265	Apr 2012-Mar 2013	Pasalary et al. (2017)
Iran (Golestan)	10.0	Local	1798	2014–2015	Sedaghat et al. (2017)
Nigeria (Kebbi)	35.6	Local	600	May 2014-Jun 2014	Abdullahi et al. (2018)
Iraq (Al Muthanna)	97.1	Local	1455	Feb 2017-Feb 2018	Al-Salihi et al. (2018)
Sudan	–	Across	9245	Nov 2014-Oct 2015	Bala et al. (2018)
Saudi Arabia (Riyadh)	–	Local	100	May 2014	Alajmi et al. (2019)
Saudi Arabia (Riyadh)	85.2	Local	10,832	Jan 2017-Dec 2017	Alanazi et al. (2019)
Pakistan	55.6	Across	7720	Nov 2010-Jul 2011	Qamar et al. (2019)
Tunisia	28.6	Across	327	2015–2017	Selmi et al. (2019)
Pakistan (Balochistan)	47.5	Local	913	Dec 2018-Dec 2019	Bibi et al. (2020)
Cattle					
Iraq	–	Across	9775	Apr-May 1965	Robson and Robb (1967)
Ethiopia	–	Across	28,768	1972–1977	Pegram et al. (1981)
South Africa	16.7	Local	5976	Mar 1988-Jan 1990	Fourie and Horak (1991)
Tunisia	–	Across	5097	Jun 1991-Jun 1992	Bouattour et al. (1996)
South Africa	16.7	Across	8220	May 1990-Oct 1991	Fourie et al. (1996)
Bangladesh (Chittagong)	65.5	Local	3203	Jul 1991-Jun 1992	Kamal et al. (1996)
Greece (Macedonia)	86.0	Across	11,620	1983–1986	Papadopoulos et al. (1996)

Table 1 continued

Country (province or state)	TI (%)	Sampling			References
		Location	n	Date	
South Africa (Free State)	11.1	Local	244,538	Sep 1995-Aug 1996	Dreyer et al. (1998)
Spain (Menorca)	–	Local	3624	1999–2000	Castellà et al. (2001)
Ethiopia (Borana)	–	Local	–	–	Regassa (2001)
Egypt (Ismailia)	33.3	Local	5515	Oct 1999-Feb 2000	Wahba (2001)
Ethiopia	–	Local	2790	May 1997-Apr 1998	Bekele (2002)
South Africa (North West)	10.0	Local	15,955	Sep 1991-Aug 1993	Bryson et al. (2002)
South Africa (Mpumalanga)	14.2	Local	767	Sep 1991-Aug 1993	Bryson et al. (2002)
South Africa	20.0	Local	–	May 1998-Apr 1999	Hlatshwayo et al. (2002)
West Africa (Côte d'Ivoire)	30.0	Local	–	Nov 1997-Jun1999	Knopf et al. (2002)
Thailand (Samut Prakan)	38.6	Local	1491	Mar 2000-Feb 2001	Nithikathkul et al. (2002)
Turkey (Burdur)	21.8	Local	3280	Sep 1999-Aug 2000	Yukari and Umur (2002)
Turkey (Elazig and Malatya)	44.0	Local	4581	Jul 1993-Jul 1995	Aktas et al. (2004)
Nigeria (Borno and Yobe)	81.8	Across	13,058	–	James-Rugu and Jidayi (2004)
Iraq (Basra)	55.2	Local	505	Jan-Dec 2004	Awad and Abudl-Hussein (2005)
Bangladesh	17.8	Across	6771	Jul 1999-Jun 2001	Islam et al. (2006)
Egypt	59.9	Across	1019	Jun 2002-Jul 2003	Loftis et al. (2006)
Turkey (Sivas)	29.6	Local	–	Oct 1999-Sep 2000	Mamak et al. (2006)
Iran (Mazandaran)	25.0	Local	696	–	Razavi and Seyfi (2006)
Italy	67.1	Local	6208	2002–2003	Torina et al. (2006)
Japan	14.3	Across	1001	Jun-Sep 2003	Yamane et al. (2006)
Rwanda	62.8	Across	12,814	Aug 2002-May 2003	Bazarusanga et al. (2007)
Pakistan	28.2	Across	4500	–	Ghosh et al. (2007)
Bangladesh	18.0	Across	12,778	Jul 1999-Jun 2000	Ghosh et al. (2007)
Turkey (Kayseri)	21.7	Local	866	Jun 2000-Oct 2001	Ica et al. (2007)
Tanzania	97.3	Across	175,472	1998–2001	Lynen et al. (2007)
Pakistan (Peshawar)	20.4	Local	–	Aug 2003-Feb 2004	Manan et al. (2007)
South Africa	12.5	Across	58,345	–	Nyangiwe and Horak (2007)
India (Kerala)	58.6	Local	–	May1999- May 2002	Prakasan and Ramani (2007)
Iran	62.0	Across	3200	Apr 2003-Mar 2005	Rahbari et al. (2007)
Iraq	48.2	Local	–	Jan 2002-Dec 2004	Tuama et al. (2007)
Ethiopia	9.1	Local	35,845	Jan-Oct 2002	Feleke et al. (2008)
Pakistan (Quetta)	10.1	Local	–	Nov 2005-Apr 2006	Kakar and Kakarsulemankhel (2008)
Pakistan	36.0	Local	–	–	Ramzan et al. (2008)
Pakistan (Punjab)	75.1	Local	1793	–	Sajid et al. (2008)
India (Uttarkhand)	37.3	Local	–	Jan 2004-Dec 2004	Vatsya et al. (2008)
Ethiopia	40.2	Local	2301	Nov 2006-Jun 2007	Yacob et al. (2008a)
Mozambique (Maputo)	65.5	Local	–	–	De Matos et al. (2009)
Pakistan (Punjab)	40.0	Local	–	–	Durrani and Shakoori (2009)
South Africa (Eastern Cape)	39.5	Local	5735	2004–2005	Horak et al. (2009)
Mozambique (Maputo)	36.6	Local	10,558	2004–2006	Horak et al. (2009)
Iran	–	Across	2170	2002–2004	Nabian et al. (2009)
Zimbabwe (Matabeleland South)	81.5	Local	8792	Jan-Apr 2007	Ndhlovu et al. (2009)
Ethiopia (Somali)	20.3	Local	10,055	Oct 2008-Mar 2009	Abebe et al. (2010)
Ethiopia (Bedelle)	97.8	Local	5507	Nov 2007-Apr 2008	Abera et al. (2010)
Pakistan	35.9	Local	–	Mar-Nov 2009	Farzana et al. (2010)
Iran (Mazandaran)	20.0	Local	323	–	Hosseini Vasoukolaei et al. (2010)

Table 1 continued

Country (province or state)	TI (%)	Sampling			References
		Location	n	Date	
Pakistan	35.9	Local	–	Mar 2009-Nov 2009	Perveen et al. (2010)
Bangladesh (Gazipur)	33.0	Local	–	Nov 2008-Oct 2009	Rony et al. (2010a)
Iran (Yazd)	47.2	Local	583	2008–2009	Salim Abadi et al. (2010)
Ethiopia (Oromia)	20.0	Local	6298	Oct 2007-May 2008	Tessema and Gashaw (2010)
Iraq (Najaf)	54.3	Local	612	2010	Al-Ramahi (2011)
Iran (Kerman)	3.5	Local	2179	2008–2009	Dehaghi et al. (2011)
Turkey (Sivas and Tokat)	66.1	Local	3125	Jun-Jul 2007	Gunes et al. (2011)
India (Punjab)	52.9	Local	–	Aug 2008-May 2009	Haque et al. (2011)
Bangladesh (Chittagong)	36.3	Local	280	Nov 2008-May 2009	Kabir et al. (2011)
Sudan (Equatoria)	30.7	Local	2322	Dec 2004-Jun 2005	Marcellino et al. (2011)
South Africa (Eastern Cape)	41.4	Local	1034	Aug 2007-Apr 2008	Marufu et al. (2011)
Bangladesh	46.4	Local	5855	–	Mohanta and Mondal (2011)
Afghanistan	84.6	Local	92	–	Mustafa et al. (2011)
Iran (East Azerbaijan)	13.0	Local	1668	Sep 2009-Aug 2010	Rezaei et al. (2011)
Kenya	55.6	Local	8600	Apr-May 2008	Sang et al. (2011)
Ethiopia	19.8	Local	–	Nov 2007-Apr 2008	Tadesse et al. (2011)
Ethiopia	25.6	Local	1831	Oct 2010-Mar 2011	Tiki and Addis (2011)
Iran	30.3	Across	5706	Mar 2007-Feb 2008	Yakhchali et al. (2011)
Pakistan	65.5	Local	1214	1996–2000	Ahmed et al. (2012)
Turkey	34.0	Across	2160	2007–2008	Aktas et al. (2012)
Ethiopia (Haramaya)	33.2	Local	1446	Nov 2010-Jun 2011	Asrate and Yalew (2012)
Egypt	20.5	Local	342	2009	Chisholm et al. (2012)
Iran (Kurdistan)	47.3	Local	–	May-Oct 2010	Fakoorziba et al. (2012)
Ethiopia	72.5	Local	3971	Nov 2009-Feb 2010	Fanos et al. (2012)
Iraq (Baghdad)	8.1	Local	521	Jan-Dec 2010	Hasson (2012)
India (Nashik)	62.0	Local	–	–	Jawale et al. (2012)
Kenya	32.0	Local	362	2010	Kariuki (2012)
Ethiopia (Amhara)	89.4	Local	2950	Nov 2009-Jun 2010	Kebede and Fetene (2012)
Hungary	84.0	Across	2163	Sep-Nov 2011	Hornok and Horváth (2012)
Tanzania (Mvomero)	16.7	Local	2462	–	Nonga Hezron et al. (2012)
Ethiopia	72.5	Local	3971	Nov 2009-Feb 2010	Tadesse et al. (2012)
Ethiopia (Somali)	81.5	Local	1036	May 2006-Jan 2007	Tomassone et al. (2012)
Nigeria (Nasarawa)	73.3	Local	2048	–	Tongjura et al. (2012)
Pakistan (Punjab)	70.0	Local	–	Jul-Aug 2007	Ali et al. (2013)
India (Vidarbha)	77.3	Local	–	–	Chavhan et al. (2013)
Pakistan	33.4	Across	–	Jul 2013-Sep 2013	Khan et al. (2013)
Nigeria	100	Across	5011	2010	Lorusso et al. (2013)
China	21.5	Across	2950	2010	Lu et al. (2013)
Iran (Mazandaran)	15.8	Local	1068	Sep 2009-Aug 2010	Motevalli Haghi et al. (2013)
Ethiopia	16.0	Local	–	Oct 2011-Apr 2012	Onu and Shiferaw (2013)
India (Mathura)	60.1	Local	–	Jul 2010-Jun 2011	Patel et al. (2013)
India (Villupuram)	35.1	Local	–	Mar-Feb 2011	Shobana et al. (2013)
India (Kerala)	22.4	Local	–	Jun 2010-Sep 2010	Shyma et al. (2013)
India (Punjab)	58.1	Local	–	Feb 2010-Aug 2011	Singh and Rath (2013)
Iran (Kermanshah)	24.6	Local	1031	May-Sep 2012	Sohrabi et al. (2013)
Ethiopia	62.0	Local	2439	Nov 2011-Apr 2012	Wasihun and Doda (2013)

Table 1 continued

Country (province or state)	TI (%)	Sampling			References
		Location	n	Date	
Ethiopia	85.3	Local	1444	Nov 2013-Apr 2014	Amante et al. (2014)
Egypt	60.5	Local	440	Nov 2012-Sep 2013	Asmaa et al. (2014)
Ethiopia (Oromia)	67.7	Local	10,440	Aug 2008-Apr 2009	Ayalew et al. (2014)
Ethiopia	84.7	Local	3117	Sep 2009-Mar 2010	Bedasso et al. (2014)
India (Haryana)	55.3	Local	867	Aug 2011-Jan 2013	Chhillar et al. (2014)
Iran	14.4	Local	469	2012	Ganjali et al. (2014)
Iraq (Wasit)	91.3	Local	–	2012	Hassan and Al-Zubaidi (2014)
Iran	15.0	Across	446	Jun 2012-May 2013	Jafarbekloo et al. (2014)
Tanzania	16.7	Local	203	2012	Kwak et al. (2014)
Kenya	56.4	Across	34,854	Apr 2007-Dec 2010	Lutomiah et al. (2014)
Iran (Mazandaran)	50.0	Local	1563	Apr-Sep 2011	Moghaddam et al. (2014)
North Macedonia	34.4	Local	–	2012	Pavlović et al. (2014)
Iran (Razavi Khorasan)	89.9	Local	612	Apr-Sep 2012	Riabi and Atarodi (2014)
Italy	20.7	Local	2179	May-Sep 2013	Rinaldi et al. (2014)
Iran (Golestan)	14.2	Local	498	Mar 2009-Feb 2010	Sarani et al. (2014)
Iraq	47.0	Across	–	Mar 2012-Feb 2013	Shubber et al. (2014)
Iran (Golestan)	75.8	Local	386	2010–2011	Sofizadeh et al. (2014)
Pakistan (Sindh)	22.4	Local	–	–	Soomro et al. (2014)
Ethiopia	56.2	Local	864	Nov 2014-Apr 2015	Admassu et al. (2015)
Ethiopia (Haramaya)	25.2	Local	1042	Nov 2013-Mar 2014	Desalegn et al. (2015)
Iran (Razavi Khorasan)	32.2	Local	–	May-Oct 2013	Fakoorziba et al. (2015)
Iran (Hamadan)	4.2	Local	1534	2010–2011	Gharekhani et al. (2015)
India (Lucknow)	58.7	Local	1412	Apr 2014-Mar 2015	Kaur et al. (2015)
India (Jammu)	47.1	Local	–	Mar 2012-Feb 2013	Khajuria et al. (2015)
Iran (Ilam)	43.0	Local	1316	Mar 2009-Aug 2009	Loui Monfared et al. (2015)
Iraq	62.0	Across	–	–	Mohammad (2015)
Sri Lanka	3.2	Across	30,461	Jan 2009-Aug 2011	Liyanaarachchi et al. (2015)
Ethiopia (Oromia)	13.5	Local	211	Oct 2013-Mar 2014	Regasa et al. (2015)
Pakistan (Azad Jammu and Kashmir)	55.5	Local	699	Jul-Dec 2011	Sultana et al. (2015a)
Pakistan (Kashmir)	55.4	Local	–	Jun 2011-Nov 2011	Sultana et al. (2015b)
Ethiopia (Oromia)	82.0	Local	1984	Nov 2014-Apr 2015	Tamerat et al. (2015)
China	–	Across	5257	2012–2014	Wang et al. (2015)
South Africa	34.9	Local	428	May-Nov 2011	Akuffo et al. (2016)
Pakistan	–	Local	682	Jan 2012-Dec 2012	Ali et al. (2016)
Iran (Isfahan)	61.1	Local	492	Jul 2014-Jun 2015	Biglari et al. (2016)
Turkey (Anatolia)	37.1	Local	1832	Apr 2008-Mar 2009	Deger et al. (2016)
French (Corsica)	63.2	Local	418	May 2014-May 2015	Grech-Angelini et al. (2016)
Iran (Golestan)	0.5	Local	2410	Oct 2014-Dec 2015	Farahi et al. (2016)
Iran (Fars)	2.0	Local	1245	Oct 2012-Sep 2013	Farhadpour et al. (2016)
India (Madhya Pradesh)	58.9	Local	–	–	Jayraw et al. (2016)
Ethiopia	93.8	Local	1984	–	Kemal et al. (2016a)
Ethiopia (Arbegona)	75.7	Local	2024	Oct 2014-Jun 2015	Kemal et al. (2016b)
Cameroon (Adamawa)	5.7	Local	680,387	–	Mamoudou et al. (2016)
Mexico (Yucatan)	37.9	Local	956	Jan 2009-Dec 2014	Rodríguez-Vivas et al. (2016)
Iran (Kermanshah)	10.5	Local	851	2012–2013	Mohammadian et al. (2016)
Egypt	59.0	Across	5223	Jun 2014-Jul 2016	Yassin et al. (2016)

Table 1 continued

Country (province or state)	TI (%)	Sampling			References
		Location	n	Date	
Ethiopia	77.6	Local	2418	May-Dec 2016	Bayou and Asegdew (2017)
West Africa (Ivory Coast)	63.6	Across	24,031	Apr 2014-May 2015	Boka et al. (2017)
Lebanon	50.4	Across	272	2014	Dabaja et al. (2017)
Iran (Lorestan)	39.5	Local	2460	Apr-Mar 2014	Davari et al. (2017)
India (Odisha)	40.3	Local	–	Feb 2016-Jan 2017	Dehuri et al. (2017)
Pakistan (Khyber Pakhtunkhwa)	33.3	Local	1200	Jun-Sep 2015	Farooqi et al. (2017)
Iran (Hamadan)	26.7	Local	259	2015–2016	Fayazkhoo et al. (2017)
Pakistan (Balochistan)	35.0	Local	200	–	Kakar et al. (2017)
Tanzania	60.5	Across	7705	–	Kerario et al. (2017)
Saudi Arabia	97.0	Local	1282	Jan-Mar 2016	Mohamed et al. (2017)
Nigeria (Borno)	59.8	Local	1879	–	Paul et al. (2017)
Pakistan (Balochistan)	66.0	Local	1649	Mar 2013-Mar 2014	Rafiq et al. (2017)
Pakistan	89.9	Across	3807	Sep 2013-Nov 2013	Rehman et al. (2017)
Pakistan	77.9	Across	18,907	–	Sajid et al. (2017)
Iran (Golestan)	24.0	Local	1798	2014–2015	Sedaghat et al. (2017)
Ethiopia (Gambella)	25.2	Local	2605	Dec 2016-Jun 2016	Yunus et al. (2017)
Nigeria (Kebbi)	44.4	Local	600	May 2014-Jun 2014	Abdullahi et al. (2018)
India (Bengal)	41.9	Local	–	Jul 2015-Jun 2016	Debbarma et al. (2018)
Iran (Kohgiluyeh and Boyer-Ahmad)	3.5	Local	1273	Jan 2015-Dec 2016	Fatemian et al. (2018)
Bangladesh (Mymensingh)	60.4	Local	2287	Feb-May 2014	Roy et al. (2018)
India (Kashmir)	24.6	Local	–	Mar 2016-Aug 2016	Tramboo et al. (2018)
Ethiopia	65.3	Local	3290	Nov 2016-Apr 2017	Abiso et al. (2019)
Pakistan	20.8	Local	–	Sep 2019	Ahmad et al. (2019)
Saudi Arabia (Riyadh)	69.2	Local	10,832	Jan 2017-Dec 2017	Alanazi et al. (2019)
Pakistan	87.2	Local	8641	Apr 2017-Mar 2018	Ali et al. (2019)
Pakistan (Punjab)	42.4	Across	21,738	2016–2017	Batool et al. (2019)
Korea	56.2	Across	1298	2014–2015	Chae et al. (2019)
France (Corsica)	88.8	Local	660	May-Sep 2016	Cicculli et al. (2019)
India (Mizoram)	63.4	Local	632	Apr 2017-Mar 2018	Ghosh et al. (2019)
Cameroon	14.2	Across	7091	Apr-Aug 2016	Silatsa et al. (2019)
Indonesia	33.3	Across	1575	–	Sahara et al. (2019)
Uganda	98.2	Across	4362	Sep-Nov 2017	Balinandi et al. (2020)
Pakistan (Balochistan)	65.0	Local	913	Dec 2018-Dec 2019	Bibi et al. (2020)
North America (Caribbean islands)	–	Across	1990	Jun 2016–2018	Charles et al. (2020)
Pakistan	47.9	Across	774	Sep-Nov 2017	Ghafar et al. (2020a)
Sudan (Gezira)	12.9	Local	1089	Jan, May, Aug 2014	Hayati et al. (2020)
India (Chhattisgarh)	49.4	Local	832	–	Jadhao et al. (2020)
Britain	6.2	Across	–	Nov 2017-Oct 2018	Lihou et al. (2020)
Ecuador	88.0	Across	461	Feb-Mar 2012	Maya-Delgado et al. (2020)
Pakistan (Punjab)	63.3	Local	200	Apr 2017-Sep 2017	Ramzan et al. (2020)
West Africa (Côte d'Ivoire)	4.2	Local	1120	Nov-Dec 2015	Yéo et al. (2020)
Goats					
Ethiopia	–	Across	28,768	1972–1977	Pegram et al. (1981)
South Africa	16.7	Local	5976	Mar 1988-Jan 1990	Fourie and Horak (1991)
Tanzania	78.0	Across	–	Sep 1993-Feb 1994	Kusiluka et al. (1995)
Bangladesh (Chittagong)	44.4	Local	3451	Jul 1991-Jun 1992	Kamal et al. (1996)

Table 1 continued

Country (province or state)	TI (%)	Sampling			References
		Location	n	Date	
Greece (Macedonia)	85.0	Across	11,620	1983–1986	Papadopoulos et al. (1996)
South Africa	21.6	Local	3764	–	Horak et al. (2001)
Turkey (Burdur)	15.8	Local	3280	Sep 1999-Aug 2000	Yukari and Umur (2002)
Turkey (Kayseri)	6.0	Local	–	Aug 1997-Oct 1999	Inci et al. (2003)
South Africa (Eastern Cape)	14.3	Local	65,179	Feb 1983-Jan 1984	Macivor and Horak (2003)
Nigeria (Borno and Yobe)	26.5	Across	13,058	–	James-Rugu and Jidayi (2004)
Iraq (Basra)	34.6	Local	505	Jan-Dec 2004	Awad and Abudl-Hussein (2005)
Bangladesh	21.3	Across	6771	Jul 1999-Jun 2001	Islam et al. (2006)
Turkey (Sivas)	19.9	Local	–	Oct 1999-Sep 2000	Mamak et al. (2006)
Iran (West Azerbaijan)	9.9	Local	849	Apr 2003-Mar 2004	Yakhchali and Hosseine (2006)
Pakistan	12.3	Across	4500	–	Ghosh et al. (2007)
Bangladesh	30.9	Across	12,778	Jul 1999-Jun 2000	Ghosh et al. (2007)
Turkey (Kayseri)	7.8	Local	1585	Jun 2000-Oct 2001	Ica et al. (2007)
Nigeria	10.0	Local	–	Feb-Nov 2005	Idris and Umar (2007)
Pakistan (Peshawar)	12.1	Local	–	Aug 2003-Feb 2004	Manan et al. (2007)
South Africa	12.5	Across	58,345	–	Nyangiwe and Horak (2007)
India (Kerala)	74.7	Local	–	May1999- May 2002	Prakasan and Ramani (2007)
Iran	57.0	Across	3200	Apr 2003-Mar 2005	Rahbari et al. (2007)
Ethiopia (Amhara)	56.4	Local	–	Nov 2003-Mar 2004	Sertse and Wossene (2007)
Iraq	23.0	Local	–	Jan 2002-Dec 2004	Tuama et al. (2007)
Zimbabwe	71.0	Across	2510	2005–2006	Hove et al. (2008)
Pakistan (Punjab)	51.6	Local	1793	–	Sajid et al. (2008)
Nigeria (Benue)	7.5	Local	–	Oct 2003-Mar 2004	Ofukwu et al. (2008)
Ethiopia	18.6	Local	–	Nov 2006-May2007	Yacob et al. (2008b)
Ethiopia (Oromia)	89.9	Local	4310	Nov 2007-Feb 2008	Abunna et al. (2009)
Mozambique (Maputo)	26.7	Local	–	–	De Matos et al. (2009)
South Africa (Eastern Cape)	32.1	Local	4484	2004–2005	Horak et al. (2009)
Mozambique (Maputo)	22.8	Local	2572	2004–2006	Horak et al. (2009)
Iran	–	Across	2170	2002–2004	Nabian et al. (2009)
Ethiopia (Bedelle)	94.4	Local	5507	Nov 2007-Apr 2008	Abera et al. (2010)
Pakistan	23.1	Local	–	Mar-Nov 2009	Farzana et al. (2010)
Iran (Mazandaran)	22.2	Local	323	–	Hosseini Vasoukolaei et al. (2010)
Pakistan (Islamabad)	41.5	Local	–	Feb-Nov 2009	Irshad et al. (2010)
Iraq (Al Anbar)	53.0	Local	–	–	Muhaidi et al. (2010)
Ethiopia (Tigray)	29.7	Local	–	Nov 2007-Apr 2008	Mulugeta et al. (2010)
Nigeria (Benue)	31.5	Local	–	Oct-Mar 2004	Ofukwu and Akwuobu (2010)
Pakistan	23.1	Local	–	Mar 2009-Nov 2009	Perveen et al. (2010)
Bangladesh (Gazipur)	32.3	Local	–	Nov 2008-Oct 2009	Rony et al. (2010b)
Iran (Yazd)	10.8	Local	583	2008–2009	Salim Abadi et al. (2010)
Bangladesh	72.8	Local	–	Dec 2006-Nov 2007	Sarkar et al. (2010)
Ethiopia	58.8	Local	–	Oct 2009-May 2010	Abebe et al. (2011)
Egypt	23.6	Local	–	–	El-Seify et al. (2011)
Ethiopia (Wolmera)	72.3	Local	–	Oct 2008-Apr 2009	Bekele et al. (2011)
Bangladesh	56.7	Local	5855	–	Mohanta and Mondal (2011)
Iran (East Azerbaijan)	18.9	Local	1668	Sep 2009-Aug 2010	Rezaei et al. (2011)
Kenya	6.2	Local	8600	Apr-May 2008	Sang et al. (2011)

Table 1 continued

Country (province or state)	TI (%)	Sampling			References
		Location	n	Date	
Ethiopia	4.5	Local	–	Nov 2007-Apr 2008	Tadesse et al. (2011)
Ethiopia (Amhara)	12.2	Local	–	Nov 2010-Mar 2011	Tesfaye et al. (2012)
Iran	29.5	Across	5706	Mar 2007-Feb 2008	Yakhchali et al. (2011)
Ethiopia (Oromia)	66.1	Local	3496	Nov 2010-Mar 2011	Abunna et al. (2012)
Ethiopia	23.9	Local	–	Nov 2011-Apr 2012	Amuamuta et al. (2012)
Turkey (Black Sea)	32.9	Local	2797	2010–2011	Aydin et al. (2012)
Iran (Kurdistan)	55.0	Local	–	May-Oct 2010	Fakoorziba et al. (2012)
Ethiopia (Amhara)	17.1	Local	–	Oct 2011-Mar 2012	Fentahun et al. (2012)
Iraq (Wasit)	20.3	Local	–	May-Aug 2010	Hasson and Al-Zubaidi (2012)
Hungary	51.2	Across	320	Jun-Aug 2011	Hornok et al. (2012)
Ethiopia (Somali)	53.4	Local	1036	May 2006-Jan 2007	Tomassone et al. (2012)
Nigeria (Nasarawa)	39.3	Local	2048	–	Tongjura et al. (2012)
Ethiopia (Amhara)	17.7	Local	–	Oct 2009-Apr 2010	Amare et al. (2013)
Ethiopia	57.6	Local	–	–	Fekadu et al. (2013)
China	3.0	Across	2950	2010	Lu et al. (2013)
Iran (Mazandaran)	35.8	Local	1068	Sep 2009-Aug 2010	Motevalli Haghi et al. (2013)
Serbia (Belgrade)	34.4	Local	–	Mar-Nov 2011	Pavlovic et al. (2013)
Ethiopia	23.7	Local	–	Oct 2010-May 2011	Shibeshi et al. (2013)
India (Villupuram)	41.9	Local	–	Mar-Feb 2011	Shobana et al. (2013)
Iran (Kermanshah)	25.3	Local	1031	May-Sep 2012	Sohrabi et al. (2013)
Iraq (Duhok)	34.9	Local	916	Jan-June 2010	Zangana et al. (2013)
Egypt	25.9	Local	440	Nov 2012-Sep 2013	Asmaa et al. (2014)
Ethiopia (Oromia)	27.3	Local	–	Oct 2009-Apr 2010	Beyecha et al. (2014)
Ethiopia	97.6	Across	7634	Feb 2013-Jul 2013	Eyob and Matios (2014)
Iran	38.6	Local	469	2012	Ganjali et al. (2014)
Pakistan (Punjab)	33.6	Local	804	Apr 2011-Mar 2012	Iqbal et al. (2014)
Iran	17.0	Across	446	Jun 2012-May 2013	Jafarbekloo et al. (2014)
Kenya	15.4	Across	34,854	Apr 2007-Dec 2010	Lutomiah et al. (2014)
Pakistan (Punjab)	86.5	Local	–	Oct 2012-Sep 2013	Mustafa et al. (2014)
Nigeria (Anambra)	12.7	Local	–	Aug-Oct 2011	Obi et al. (2014)
Iran (Razavi Khorasan)	6.4	Local	612	Apr-Sep 2012	Riabi and Atarodi (2014)
Iran (Golestan)	44.7	Local	498	Mar 2009-Feb 2010	Sarani et al. (2014)
Iraq	25.9	Across	–	Mar 2012-Feb 2013	Shubber et al. (2014)
Iran (Golestan)	77.3	Local	386	2010–2011	Sofizadeh et al. (2014)
India (Tamil Nadu)	72.7	Local	–	–	Soundararajan et al. (2014)
Ghana (Vunania)	8.7	Local	358	–	Angyiereyiri et al. (2015)
Ethiopia (Haramaya)	10.0	Local	1042	Nov 2013-Mar 2014	Desalegn et al. (2015)
Sri Lanka	70.8	Across	2628	Jun 2011-May 2013	Diyes and Rajakaruna (2015)
Iran (Razavi Khorasan)	18.4	Local	–	May-Oct 2013	Fakoorziba et al. (2015)
Sri Lanka	7.9	Across	30,461	Jan 2009-Aug 2011	Liyanaarachchi et al. (2015)
Iran (Ilam)	49.6	Local	1316	Mar 2009-Aug 2009	Loui Monfared et al. (2015)
Iraq	30.8	Across	–	–	Mohammad (2015)
Pakistan	73.7	Local	–	2011	Shah et al. (2015)
Pakistan (Azad Jammu and Kashmir)	48.3	Local	699	Jul-Dec 2011	Sultana et al. (2015a)
Pakistan (Kashmir)	48.0	Local	–	Jun 2011-Nov 2011	Sultana et al. (2015b)
Sudan (South Darfur)	20.2	Local	1530	Mar 2006-Feb 2007	Yagoub et al. (2015)
South Africa	0.7	Local	428	May-Nov 2011	Akuffo et al. (2016)

Table 1 continued

Country (province or state)	TI (%)	Sampling			References
		Location	n	Date	
Iran (Isfahan)	8.1	Local	492	Jul 2014-Jun 2015	Biglari et al. (2016)
Iran (Fars)	25.2	Local	1245	Oct 2012-Sep 2013	Farhadpour et al. (2016)
Iraq	56.3	Across	1865	Jan 2015-Dec 2015	Mohammad (2016)
Iran (Kermanshah)	5.3	Local	851	2012–2013	Mohammadian et al. (2016)
Serbia (Šabac)	16.9	Local	–	Mar 2010-Nov 2012	Pavlović et al. (2016)
Mexico (Yucatan)	0.31	Local	956	Jan 2009-Dec 2014	Rodríguez-Vivas et al. (2016)
French (Corsica)	50.0	Local	1938	May 2014-May 2015	Grech-Angelini et al. (2016)
India	1.8	Local	–	Nov 2015-Jan 2016	Ajith et al. (2017)
Lebanon	24.4	Across	272	2014	Dabaja et al. (2017)
Iran (Lorestan)	26.3	Local	2460	Apr-Mar 2014	Davari et al. (2017)
Greece	26.5	Local	59	Dec 2012-Aug 2013	Dimanopoulou et al. (2017)
Iran (Hamadan)	25.9	Local	259	2015–2016	Fayazkhoo et al. (2017)
India	72.1	Local	–	Mar 2016-Jun 2016	Gopalakrishnan et al. (2017)
Iran (West Azerbaijan)	14.3	Local	315	Jun-Sep 2014	Mohammadi et al. (2017)
Pakistan	60.0	Across	3807	Sep 2013-Nov 2013	Rehman et al. (2017)
Pakistan (Punjab)	43.6	Local	575	Jan 2013-Dec 2013	Riaz et al. (2017)
Pakistan	72.1	Across	18,907	–	Sajid et al. (2017)
Iran (Golestan)	32.0	Local	1798	2014–2015	Sedaghat et al. (2017)
Iran (Kohgiluyeh and Boyer-Ahmad)	22.2	Local	1273	Jan 2015-Dec 2016	Fatemian et al. (2018)
India	47.1	Across	2924	Apr 2015-Mar 2017	Rashid et al. (2018)
India	78.2	Local	–	–	Soundararajan et al. (2018)
India (Kashmir)	54.3	Local	–	Mar 2016-Aug 2016	Tramboo et al. (2018)
Saudi Arabia (Riyadh)	74.2	Local	10,832	Jan 2017-Dec 2017	Alanazi et al. (2019)
Pakistan	68.3	Local	8641	Apr 2017-Mar 2018	Ali et al. (2019)
Iraq (Najaf)	–	Local	411	Mar-Sep 2018	Al-Husseini (2019)
Pakistan (Punjab)	36.1	Across	21,738	2016–2017	Batool et al. (2019)
Korea	43.8	Across	1298	2014–2015	Chae et al. (2019)
Pakistan (Punjab)	40.0	Local	–	–	Ramzan et al. (2019)
Pakistan (Balochistan)	27.5	Local	913	Dec 2018-Dec 2019	Bibi et al. (2020)
Pakistan	57.7	Across	104	–	Ghafar et al. (2020b)
Pakistan (Sanghar)	74.3	Local	723	Jun-Sep 2017	Jariko et al. (2020)
South Africa (Mpumalanga)	20.0	Local	13,132	2013–2014	Jongejan et al. (2020)
Nigeria (Katsina)	11.8	Local	201	Mar-Jun 2019	Orpin et al. (2020)
Pakistan (Punjab)	40.3	Local	200	Apr 2017-Sep 2017	Ramzan et al. (2020)
Sheep					
Iraq	–	Across	9775	Apr-May 1965	Robson and Robb (1967)
Ethiopia	–	Across	28,768	1972–1977	Pegram et al. (1981)
South Africa	20.0	Local	5976	Mar 1988-Jan 1990	Fourie and Horak (1991)
Greece (Macedonia)	85.0	Across	11,620	1983–1986	Papadopoulos et al. (1996)
Brazil (SäoPaulo)	31.3	Local	–	–	Madeira et al. (2000)
Turkey (Burdur)	25.4	Local	3280	Sep 1999-Aug 2000	Yukari and Umur (2002)
Turkey (Kayseri)	32.0	Local	–	Aug 1997-Oct 1999	Inci et al. (2003)
Nigeria (Borno and Yobe)	43.0	Across	13,058	–	James-Rugu and Jidayi (2004)
Italy	31.4	Local	927	Sep-Dec 2000	Rinaldi et al. (2004)
Iraq (Basra)	40.0	Local	505	Jan-Dec 2004	Awad and Abudl-Hussein (2005)

Table 1 continued

Country (province or state)	TI (%)	Sampling			References
		Location	n	Date	
Egypt	5.5	Across	1019	Jun 2002-Jul 2003	Loftis et al. (2006)
Turkey (Sivas)	24.0	Local	–	Oct 1999-Sep 2000	Mamak et al. (2006)
Italy	2.1	Local	6208	2002–2003	Torina et al. (2006)
Iran (West Azerbaijan)	6.4	Local	849	Apr 2003-Mar 2004	Yakhchali and Hosseine (2006)
Pakistan	18.8	Across	4500	–	Ghosh et al. (2007)
Pakistan (Peshawar)	12.8	Local	–	Aug 2003-Feb 2004	Manan et al. (2007)
Sudan (Sennar)	20.0	Local	198	Jul 2002-May 2003	Mohammed and Hassan (2007)
India (Kerala)	10.0	Local	–	May1999- May 2002	Prakasan and Ramani (2007)
Iran	55.0	Across	3200	Apr 2003-Mar 2005	Rahbari et al. (2007)
Ethiopia (Amhara)	50.5	Local	–	Nov 2003-Mar 2004	Sertse and Wossene (2007)
Iraq	96.8	Local	–	Jan 2002-Dec 2004	Tuama et al. (2007)
Nigeria (Benue)	8.9	Local	–	Oct 2003-Mar 2004	Ofukwu et al. (2008)
Ethiopia	31.8	Local	–	Nov 2006-May2007	Yacob et al. (2008b)
Ethiopia (Oromia)	87.5	Local	4310	Nov 2007-Feb 2008	Abunna et al. (2009)
Iran	–	Across	2170	2002–2004	Nabian et al. (2009)
Ethiopia (Bedelle)	89.9	Local	5507	Nov 2007-Apr 2008	Abera et al. (2010)
Pakistan	27.3	Local	–	Mar-Nov 2009	Farzana et al. (2010)
Iran (Mazandaran)	28.3	Local	323	–	Hosseini Vasoukolaei et al. (2010)
Pakistan (Islamabad)	43.4	Local	–	Feb-Nov 2009	Irshad et al. (2010)
Iraq (Al Anbar)	57.0	Local	–	–	Muhaidi et al. (2010)
Ethiopia (Tigray)	16.0	Local	–	Nov 2007-Apr 2008	Mulugeta et al. (2010)
Iran (Ilam)	11.4	Local	1095	Apr 2007-Mar2008	Nasiri et al. (2010)
Nigeria (Benue)	40.7	Local	–	Oct-Mar 2004	Ofukwu and Akwuobu (2010)
Pakistan	27.3	Local	–	Mar 2009-Nov 2009	Perveen et al. (2010)
Iran	22.2	Local	1279	Apr-Mar 2008	Rasouli et al. (2010)
Iran (Hamadan)	24.9	Local	328	2007	Tahmasebi et al. (2010)
Iran (Yazd)	49.1	Local	583	2008–2009	Salim Abadi et al. (2010)
Ethiopia	48.0	Local	–	Oct 2009-May 2010	Abebe et al. (2011)
Ethiopia (Wolmera)	19.9	Local	–	Oct 2008-Apr 2009	Bekele et al. (2011)
Algeria	29.7	Local	761	Jan 2009-Dec 2010	Bouhous et al. (2011)
Turkey (Sivas and Tokat)	30.1	Local	3125	Jun-Jul 2007	Gunes et al. (2011)
Iran (Kerman)	1.9	Local	2179	2008–2009	Dehaghi et al. (2011)
Egypt	18.2	Local	–	–	El-Seify et al. (2011)
Iraq (Al Anbar)	–	Local	490	2004–2009	Mohammad and Jassim (2011)
Afghanistan	71.5	Local	40	–	Mustafa et al. (2011)
Iran (Khorasan Razvi)	–	Local	812	–	Razmi et al. (2011)
Iran (East Azerbaijan)	13.2	Local	1668	Sep 2009-Aug 2010	Rezaei et al. (2011)
Kenya	2.7	Local	8600	Apr-May 2008	Sang et al. (2011)
Ethiopia	12.6	Local	–	Nov 2007-Apr 2008	Tadesse et al. (2011)
Iran	31.4	Across	5706	Mar 2007-Feb 2008	Yakhchali et al. (2011)
Ethiopia (Oromia)	80.3	Local	3496	Nov 2010-Mar 2011	Abunna et al. (2012)
Yemen (Thamar)	43.4	Local	875	Dec 2010-May 2011	Al-Shaibani (2012)
Ethiopia	37.0	Local	–	Nov 2011-Apr 2012	Amuamuta et al. (2012)
Turkey (Black Sea)	30.8	Local	2797	2010–2011	Aydin et al. (2012)
Egypt	1.8	Local	342	2009	Chisholm et al. (2012)
Iran (Kurdistan)	39.4	Local	–	May-Oct 2010	Fakoorziba et al. (2012)

Table 1 continued

Country (province or state)	TI (%)	Sampling			References
		Location	n	Date	
Iran (Qom)	9.6	Local	744	2010–2011	Farzinnia et al. (2012)
Ethiopia (Amhara)	21.2	Local	–	Oct 2011-Mar 2012	Fentahun et al. (2012)
Iraq (Baghdad)	19.7	Local	521	Jan-Dec 2010	Hasson (2012)
Iraq (Wasit)	79.7	Local	–	May-Aug 2010	Hasson and Al-Zubaidi (2012)
Hungary	0.8	Across	320	Jun-Aug 2011	Hornok et al. (2012)
Iraq (Sulaymaniyah)	11.8	Local	1171	Mar 2009-Feb 2010	Kadir et al. (2012)
Ethiopia (Oromia)	11.4	Local	–	Oct 2009-Apr 2010	Kumsa et al. (2012)
Iran (East Azerbaijan)	40.0	Local	525	Apr-Sep 2011	Moshaverinia et al. (2012)
Ethiopia (Amhara)	31.4	Local	–	Nov 2010-Mar 2011	Tesfaye et al. (2012)
Ethiopia (Somali)	61.1	Local	1036	May 2006-Jan 2007	Tomassone et al. (2012)
Nigeria (Nasarawa)	49.5	Local	2048	–	Tongjura et al. (2012)
Ethiopia (Amhara)	3.9	Local	–	Oct 2009-Apr 2010	Amare et al. (2013)
Ethiopia	19.2	Local	–	Nov 2011-Mar 2012	Bayisa et al. (2013)
Ethiopia	18.8	Local	–	–	Fekadu et al. (2013)
China	3.6	Across	2950	2010	Lu et al. (2013)
Iran (Mazandaran)	48.3	Local	1068	Sep 2009-Aug 2010	Motevalli Haghi et al. (2013)
Serbia (Belgrade)	60.1	Local	–	Mar-Nov 2011	Pavlovic et al. (2013)
Ethiopia	25.4	Local	–	Oct 2010-May 2011	Shibeshi et al. (2013)
Iran (Kermanshah)	25.1	Local	1031	May-Sep 2012	Sohrabi et al. (2013)
Iran (Fars)	33.0	Local	–	2010–2011	Yaghfoori et al. (2013)
Iraq (Duhok)	46.7	Local	916	Jan-June 2010	Zangana et al. (2013)
Egypt	14.8	Local	440	Nov 2012-Sep 2013	Asmaa et al. (2014)
Ethiopia	69.9	Across	7634	Feb 2013-Jul 2013	Eyob and Matios (2014)
Iran	27.8	Local	469	2012	Ganjali et al. (2014)
Iran	26.0	Across	446	Jun 2012-May 2013	Jafarbekloo et al. (2014)
Kenya	6.1	Across	34,854	Apr 2007-Dec 2010	Lutomiah et al. (2014)
Nigeria (Anambra)	17.0	Local	–	Aug-Oct 2011	Obi et al. (2014)
North Macedonia	41.9	Local	–	2012	Pavlović et al. (2014)
Iran (Razavi Khorasan)	3.7	Local	612	Apr-Sep 2012	Riabi and Atarodi (2014)
Italy	20.2	Local	2179	May-Sep 2013	Rinaldi et al. (2014)
Iran (Golestan)	34.9	Local	498	Mar 2009-Feb 2010	Sarani et al. (2014)
Iraq	46.9	Across	–	Mar 2012-Feb 2013	Shubber et al. (2014)
Iran (Golestan)	72.1	Local	386	2010–2011	Sofizadeh et al. (2014)
Iran (Semnan)	56.9	Local	1505	May 2010-May 2011	Changizi (2015)
Ethiopia (Haramaya)	10.1	Local	1042	Nov 2013-Mar 2014	Desalegn et al. (2015)
Iran (Razavi Khorasan)	49.4	Local	–	May-Oct 2013	Fakoorziba et al. (2015)
Iran (Hamadan)	2.0	Local	1534	2010–2011	Gharekhani et al. (2015)
Sri Lanka	20.1	Across	30,461	Jan 2009-Aug 2011	Liyanaarachchi et al. (2015)
Iran (Ilam)	23.5	Local	1316	Mar 2009-Aug 2009	Loui Monfared et al. (2015)
Iraq	32.3	Across	–	–	Mohammad (2015)
Pakistan	66.7	Local	–	2011	Shah et al. (2015)
Pakistan (Azad Jammu and Kashmir)	54.7	Local	699	Jul-Dec 2011	Sultana et al. (2015a)
Pakistan (Kashmir)	54.7	Local	–	Jun 2011-Nov 2011	Sultana et al. (2015b)
China	–	Across	5257	2012–2014	Wang et al. (2015)
Sudan (South Darfur)	49.5	Local	1530	Mar 2006-Feb 2007	Yagoub et al. (2015)
South Africa	3.1	Local	428	May-Nov 2011	Akuffo et al. (2016)

Table 1 continued

Country (province or state)	TI (%)	Sampling			References
		Location	n	Date	
Iran (Isfahan)	30.6	Local	492	Jul 2014-Jun 2015	Biglari et al. (2016)
French (Corsica)	33.3	Local	1938	May 2014-May 2015	Grech-Angelini et al. (2016)
Iran (Golestan)	40.5	Local	3904	Oct 2014-Dec 2015	Farahi et al. (2016)
Iran (Fars)	72.8	Local	1245	Oct 2012-Sep 2013	Farhadpour et al. (2016)
Iraq	84.7	Across	1865	Jan 2015-Dec 2015	Mohammad (2016)
Iran (Kermanshah)	84.2	Local	851	2012–2013	Mohammadian et al. (2016)
Serbia (Šabac)	16.0	Local	–	Mar 2010-Nov 2012	Pavlović et al. (2016)
Mexico (Yucatan)	0.6	Local	956	Jan 2009-Dec 2014	Rodríguez-Vivas et al. (2016)
Egypt	7.4	Across	5223	Jun 2014-Jul 2016	Yassin et al. (2016)
Ethiopia (Oromia)	18.0	Local	–	Nov 2013-Jul 2014	Bedada et al. (2017)
Lebanon	25.3	Across	272	2014	Dabaja et al. (2017)
Iran (Lorestan)	34.2	Local	2460	Apr-Mar 2014	Davari et al. (2017)
Greece	25.6	Local	59	Dec 2012-Aug 2013	Dimanopoulou et al. (2017)
Iran (Hamadan)	16.1	Local	259	2015–2016	Fayazkhoo et al. (2017)
Pakistan	11.1	Across	3807	Sep 2013-Nov 2013	Rehman et al. (2017)
Pakistan (Punjab)	50.7	Local	575	Jan 2013-Dec 2013	Riaz et al. (2017)
Pakistan	81.5	Across	18,907	–	Sajid et al. (2017)
Iran (Golestan)	34.0	Local	1798	2014–2015	Sedaghat et al. (2017)
Mexico	51.9	Local	5013	Sep 2014-Sep 2015	Coronel-Benedett et al. (2018)
Tunisia (Siliana)	10.4	Local	722	Jun 2015-May 2016	Elati et al. (2018a)
Tunisia (Gafsa)	16.2	Local	560	Oct 2013-Sep 2014	Elati et al. (2018b)
Iran (Kohgiluyeh and Boyer-Ahmad)	36.8	Local	1273	Jan 2015-Dec 2016	Fatemian et al. (2018)
India	57.9	Across	2924	Apr 2015-Mar 2017	Rashid et al. (2018)
India	77.1	Local	–	–	Soundararajan et al. (2018)
India (Kashmir)	52.6	Local	–	Mar 2016-Aug 2016	Tramboo et al. (2018)
Saudi Arabia (Riyadh)	79.1	Local	10,832	Jan 2017-Dec 2017	Alanazi et al. (2019)
Pakistan	16.3	Local	8641	Apr 2017-Mar 2018	Ali et al. (2019)
Iraq (Najaf)	–	Local	411	Mar-Sep 2018	Al-Husseini (2019)
Pakistan (Punjab)	29.0	Across	21,738	2016–2017	Batool et al. (2019)
France (Corsica)	24.4	Local	660	May-Sep 2016	Cicculli et al. (2019)
Pakistan (Punjab)	68.0	Local	–	–	Ramzan et al. (2019)
Pakistan (Balochistan)	30.0	Local	913	Dec 2018-Dec 2019	Bibi et al. (2020)
Pakistan	42.3	Across	104	–	Ghafar et al. (2020b)
Britain	6.2	Across	–	Nov 2017-Oct 2018	Lihou et al. (2020)
Nigeria (Katsina)	8.1	Local	201	Mar-Jun 2019	Orpin et al. (2020)
Pakistan (Punjab)	50.0	Local	200	Apr 2017-Sep 2017	Ramzan et al. (2020)
West Africa (Côte d'Ivoire)	12.5	Local	1120	Nov-Dec 2015	Yéo et al. (2020)

n, sample size; and TI, tick infestations

Meta-Analyses (PRISMA) guidelines and unbiased approaches were followed (Moher et al. 2015; Oliveira et al. 2021). Several years of experience and comments from the journal editors and reviewers in writing and administering the papers and especially systematic and meta-analysis reviews played a key role to achieve and write this global systematic and meta-analysis review (Nasirian et al. 2006, 2011; Nasirian 2016, 2017a, b; Nasirian 2019a, b, c; Nasirian and Salehzadeh 2019a, b; Zahirnia et al. 2019a, b; Kakeh-Khani et al. 2020; Nasirian 2020; Salehzadeh et al. 2020; Kassiri and Nasirian 2021; Nasirian and Saghafipour 2021; Nasirian and Zahirnia 2021; Salavati et al. 2021; Zahirnia et al. 2021). The criteria for collection and selection of papers for this global

Table 2 Tick infestations in age category of domestic ruminant groups including buffaloes, camels, cattle, goats and sheep based on literature search

TI (%) in DRAC (Y)						Country (province or state)	Sampling			References
< 1	1–3	3–6	6–9	9–12	> 12		Location	n	Date	
Buffaloes										
20.8	20.0	6.3	–	–	–	Pakistan (Peshawar)	Local	–	Aug 2003-Feb 2004	Manan et al. (2007)
73.7	70.7	58.5	–	–	–	Bangladesh (Kurigram)	Local	–	Nov 2007-Oct 2008	Mamun et al. (2010)
–	–	62.8	31.6	5.5	–	Pakistan (Punjab)	Local	–	Oct 2012-Sep 2013	Mustafa et al. (2014)
–	27.6	15.2	22.9	18.1	16.2	Pakistan (Multan)	Local	–	Sep 2009-Aug 2010	Zahida et al. (2014)
91.0	35.6	–	–	–	–	India (Jammu)	Local	–	Mar 2012-Feb 2013	Khajuria et al. (2015)
–	45.7	23.7	–	–	–	India (Uttar Pradesh)	Local	–	Feb 2016-May 2016	Singh and Mishra (2017)
59.2	20.4	20.4	–	–	–	Brazil (Pará)	Local	95	–	Batista et al. (2018)
–	43.4	38.2	–	–	–	Pakistan (Punjab)	Local	–	–	Khalil et al. (2018)
21.0	79.0	–	–	–	–	India (Punjab)	Local	–	Feb 2010-Aug 2011	Singh and Rath (2018)
18.3	5.5	5.7	–	–	–	India	Local	–	Oct 2016-May 2017	Chennuru et al. (2019)
55.0	39.0	48.0	–	–	–	Pakistan	Across	774	Sep-Nov 2017	Ghafar et al. (2020a)
Camels										
15.4	–	–	50.0	–	34.6	Sudan	Across	15,860	Mar 2006-Feb 2007	El Tigani and Mohammed (2010)
–	77.8	44.1		–	33.6	Ethiopia	Local	6436	Oct 2009-May 2010	Megersa et al. (2012)
14.5	–	–	17.0	29.0	39.5	Iran (Khorasan)	Local	480	May 2012-Jan 2013	Champour et al. (2013)
–	16.3	23.1	22.0	20.1	18.5	Ethiopia	Local	15,723	–	Kiros et al. (2014)
–	–	22.1	34.4	–	43.5	Ethiopia	Local	1347	–	Regassa et al. (2015)
56.8	–	–	–	81.2	–	Somalia	Local	576	Mar 2017-May 2017	Farah Isse and Ali (2017)
24.5	–	–	59.5	13.2	2.8	Sudan	Across	9245	Nov 2014-Oct 2015	Bala et al. (2018)
23.1	48.5	62.4	–	51.1	–	Pakistan	Across	7720	Nov 2010-Jul 2011	Qamar et al. (2019)
–	74.8	25.2	–	–	–	Ethiopia	Local	11,774	Sep 2010-Mar 2011	Taddese and Mustefa (2013)
Cattle										
< 1	1–3	3–6	6–9	> 9	–					
24.5	20.5	19.2		–	–	Pakistan (Peshawar)	Local	–	Aug 2003-Feb 2004	Manan et al. (2007)
22.3	20.7	–	57.0	–	–	Ethiopia (Bedelle)	Local	5507	Nov 2007-Apr 2008	Abera et al. (2010)
21.2	–	54.5		24.2	–	Bangladesh (Gazipur)	Local	–	Nov 2008-Oct 2009	Rony et al. (2010a)
22.9	44.2	–	32.9	–	–	Ethiopia (Oromia)	Local	6298	Oct 2007-May 2008	Tessema and Gashaw (2010)
46.3	–	–	27.8	–	–	Bangladesh (Chittagong)	Local	280	Nov 2008-May 2009	Kabir et al. (2011)
16.6	33.3	23.4	–	29.7	–	Iran	Across	5706	Mar 2007-Feb 2008	Yakhchali et al. (2011)
17.2	30.6	52.2	–	–	–	Ethiopia (Haramaya)	Local	1446	Nov 2010-Jun 2011	Asrate and Yalew (2012)
16.5	29.9	–	53.6	–	–	Ethiopia	Local	3971	Nov 2009-Feb 2010	Fanos et al. (2012)
5.1	27.3	–	67.6	–	–	Ethiopia	Local	3971	Nov 2009-Feb 2010	Tadesse et al. (2012)
25.7	–	–	74.3	–	–	India (Punjab)	Local	–	Feb 2010-Aug 2011	Singh and Rath (2013)
2.0	30.0	38.0	–	30.0	–	Iran (Kermanshah)	Local	1031	May-Sep 2012	Sohrabi et al. (2013)
30.5	20.7	–	48.8	–	–	Egypt	Local	440	Nov 2012-Sep 2013	Asmaa et al. (2014)
–	20.4	28.3	–	51.3	–	Ethiopia	Local	3117	Sep 2009-Mar 2010	Bedasso et al. (2014)
12.1	62.9	–	25.0	–	–	Ethiopia	Local	864	Nov 2014-Apr 2015	Admassu et al. (2015)
–	39.2	–	60.8	–	–	Ethiopia (Haramaya)	Local	1042	Nov 2013-Mar 2014	Desalegn et al. (2015)
77.7	–	64.7	–	48.1	–	India (Lucknow)	Local	1412	Apr 2014-Mar 2015	Kaur et al. (2015)
91.0	–	–	35.6	–	–	India (Jammu)	Local	–	Mar 2012-Feb 2013	Khajuria et al. (2015)
15.9	–	–	4.1	–	–	Cameroon (Adamawa)	Local	680,387	–	Mamoudou et al. (2016)

Table 2 continued

TI (%) in DRAC (Y)						Country (province or state)	Sampling			References
< 1	1–3	3–6	6–9	9–12	> 12		Location	n	Date	
4.3	54.3	–	30.5	–	–	Pakistan (Balochistan)	Local	200	–	Kakar et al. (2017)
65.0	35.6	–	36.8	–	–	India (Bengal)	Local	–	Jul 2015-Jun 2016	Debbarma et al. (2018)
18.1	21.4	–	60.5	–	–	Sudan	Across	1098	2017	Elhaj et al. (2019)
42.7	–	73.4	–	61.9	–	India (Mizoram)	Local	632	Apr 2017-Mar 2018	Ghosh et al. (2019)
34.0	22.0	–	44.0	–	–	Sudan (Gezira)	Local	1089	Jan, May, Aug 2014	Hayati et al. (2020)
55.0	39.0	–	48.0	–	–	Pakistan	Across	774	Sep-Nov 2017	Ghafar et al. (2020a)
< 1	1–2	3–4	4–5	> 5	–					
Goats										
28.4	10.3	–	–	–	–	Pakistan (Peshawar)	Local	–	Aug 2003-Feb 2004	Manan et al. (2007)
51.4	–	–	48.6	–	–	Ethiopia (Bedelle)	Local	5507	Nov 2007-Apr 2008	Abera et al. (2010)
69.3	–	–	30.7	–	–	Bangladesh (Gazipur)	Local	–	Nov 2008-Oct 2009	Rony et al. (2010b)
20.1	23.3	24.7	–	32.3	–	Iran	Across	5706	Mar 2007-Feb 2008	Yakhchali et al. (2011)
17.4	63.0	10.9	–	8.7	–	Iran (Kermanshah)	Local	1031	May-Sep 2012	Sohrabi et al. (2013)
–	–	93.6	–	6.4	–	Pakistan (Punjab)	Local	–	Oct 2012-Sep 2013	Mustafa et al. (2014)
–	39.2	–	60.8	–	–	Ethiopia (Haramaya)	Local	1042	Nov 2013-Mar 2014	Desalegn et al. (2015)
24.0	33.1	–	42.9	–	–	Pakistan (Punjab)	Local	575	Jan 2013-Dec 2013	Riaz et al. (2017)
29.8	23.4	16.8	–	–	–	Nigeria (Katsina)	Local	201	Mar-Jun 2019	Orpin et al. (2020)
Sheep										
31.2	9.8	–	–	–	–	Pakistan (Peshawar)	Local	–	Aug 2003-Feb 2004	Manan et al. (2007)
46.8	–	–	53.2	–	–	Ethiopia (Bedelle)	Local	5507	Nov 2007-Apr 2008	Abera et al. (2010)
23.8	23.2	23.5	–	30.4	–	Iran	Across	5706	Mar 2007-Feb 2008	Yakhchali et al. (2011)
14.8	55.6	25.9	–	3.7	–	Iran (Kermanshah)	Local	1031	May-Sep 2012	Sohrabi et al. (2013)
24.0	33.1	–	42.9	–	–	Iran	Across	5706	Mar 2007-Feb 2008	Yakhchali et al. (2011)
15.3	46.9	22.6	–	15.3	–	Yemen (Thamar governorate)	Local	875	Dec 2010-May 2011	Al-Shaibani (2012)
32.2	–	–	67.8	–	–	Ethiopia (Oromia)	Local	–	Oct 2009-Apr 2010	Kumsa et al. (2012)
–	39.2	–	60.8	–	–	Ethiopia (Haramaya)	Local	1042	Nov 2013-Mar 2014	Desalegn et al. (2015)
24.2	52.4	23.5	–	–	–	Nigeria (Katsina)	Local	201	Mar-Jun 2019	Orpin et al. (2020)

DRAC, domestic ruminant age categories; n, sample size; TI, tick infestations; and Y, years

systematic meta-analysis review were the study objectives that dealt with the global annually trend of tick infestations for buffaloes, camels, cattle, goats, sheep, and the global domestic ruminants in the world countries, continents, hemispheres and tropical regions; tick infestations in age categories of domestic ruminants; tick infestations in attachment sites of domestic ruminant group body parts; tick infestations in relation to domestic ruminant group sexes and tick life stages; and seasonal and monthly tick infestations in domestic ruminant groups in the world hemispheres and tropical regions.

Papers about the study subjects were collected from websites including Web of Science, Springer, Scopus, PubMed, ScienceDirect, Google Scholar, Entomological Society of America publications, and Elsevier. As a first step, preliminary phrases or keywords including ticks infesting domestic ruminants, ticks feeding on domestic ruminants, ticks parasitizing domestic ruminants, ticks removed from domestic ruminants, tick infestations in age category of domestic ruminants, tick infestations in attachment sites of domestic ruminant group body parts, tick infestations in relation to sexes of domestic ruminants, tick life stage infestations, and seasonal and monthly tick infestations in domestic ruminants were used to search relevant papers about the study subjects. The above mentioned phrases were also used to search relevant papers separately for each ruminant group of buffaloes, camels, cattle, goats, and sheep. For the second step, new basic keywords were selected, based on a detailed reading of the initially searched papers. These new basic keywords were included in an additional search for supplementary papers about the study subjects. In addition, the references of all relevant searched papers were explored for supplementary relevant papers, if found were also included. To evaluate the collected papers, papers with high quality criteria (Fourie and Horak 1991; Bouattour et al. 1996;

Papadopoulos et al. 1996; Bekele 2002; Bryson et al. 2002; Zeleke and Bekele 2004; Bazarusanga et al. 2007; Omer et al. 2007; Yacob et al. 2008a, b; Abunna et al. 2009; De Matos et al. 2009; Sajid et al. 2009; Abera et al. 2010; Aktas et al. 2012; Iqbal et al. 2013; Lutomiah et al. 2014; Aydin et al. 2015; Cornall and Wall 2015; Yassin et al. 2016; Ajith et al. 2017; Dabaja et al. 2017; Moyo et al. 2018; Ahmad et al. 2019; Alajmi et al. 2019; Alanazi et al. 2019; Chae et al. 2019; Chennuru et al. 2019; Ghosh et al. 2019; Balinandi et al. 2020; Charles et al. 2020; Ramzan et al. 2020) were selected as the criteria to assess and select the other papers. There are many valuable papers that reported ticks infesting domestic ruminant groups but it is not possible to analyze the data that does not have the above mentioned objectives. Then after a preliminary review and careful reading of 658 identified and collected papers, 382 papers had the data of the study mentioned objectives.

Summary of the study approach

The study process is represented in Fig. 1. Among 658 papers collected, 382 papers were become parts of the study, including meta-analysis source (329 papers) (Tables 1, 2, 3, 4, 5, 6, 7), and followed by the section of detailed the global annually trend of tick infestations for buffaloes, camels, cattle, goats, sheep, and the global domestic ruminants in the world countries, continents, hemispheres and tropical regions; tick infestations in age categories of domestic ruminants; tick infestations in attachment sites of domestic ruminant group body parts; tick infestations in relation to domestic ruminant group sexes and tick life stages; and seasonal and monthly tick infestations in domestic ruminant groups in the world hemispheres and tropical regions (Figs. 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12; Tables 8, 9, 10), and section of study body text or systematic review (102 papers). All papers for meta-analysis source (Tables 1, 2, 3, 4, 5, 6, 7) and subsequent meta-analysis results have reported the data in a similar way by percent (Figs. 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12; Tables 8, 9, 10).

The related papers about the global tick infestations for buffaloes, camels, cattle, goats, sheep, and the global domestic ruminants in the world countries, continents, hemispheres and tropical regions; tick infestations in age categories of domestic ruminants; tick infestations in attachment sites of domestic ruminant group body parts; tick infestations in relation to domestic ruminant group sexes and tick life stages; and seasonal and monthly tick infestations in domestic ruminant groups in the world hemispheres and tropical regions, were read carefully. For extracting, categorizing and analyzing the data of the related papers, the methods following Nasirian, Nasirian and Salehzadeh, Kassiri and Nasirian, and Nasirian and Zahirnia (Nasirian 2016, 2017a, b, 2019a, b, c; Nasirian and Salehzadeh 2019a; Nasirian 2020; Kassiri and Nasirian 2021; Nasirian and Zahirnia 2021) were used. Based on the literature search, the results of tick infestations of domestic ruminant groups were primarily categorized and summarized according to tick infestations in buffaloes, camels, cattle, goats, and sheep (Table 1), age category tick infestations in buffaloes, camels, cattle, goats, and sheep (Table 2), attachment sites of body part tick infestations in buffaloes, camels, cattle, goats, and sheep (Table 3), tick infestations in relation to buffaloes, camels, cattle, goats, and sheep sexes (Table 4), tick infestations by life stages in buffaloes, camels, cattle, goats, and sheep (Table 5), and seasonal (Table 6) and monthly (Table 7) tick infestations in buffaloes, camels, cattle, goats, and sheep. All data which were represented in Tables 1, 2, 3, 4, 5, 6 and 7 subsequently entered into statistical analysis for estimating the global annually trend of tick infestations for buffaloes, camels, cattle, goats, sheep, and the global domestic ruminants in the world countries, continents, hemispheres and tropical regions (Figs. 2, 3, 4, 5, 6, 7), tick infestations in age categories of domestic ruminant groups (Fig. 8), tick infestations in attachment sites of domestic ruminant group body parts (Fig. 9), tick infestations in relation to animal sexes and tick life stages (Fig. 10), and seasonal and monthly tick infestations in domestic ruminant groups in the world hemispheres and tropical regions (Figs. 11 and 12).

Figures 2, 3, 4, 5, 6, 7 show the global annually trend of tick infestations for each domestic ruminant group of buffaloes, camels, cattle, goats, sheep, and global domestic ruminants in the world countries, continents, hemispheres and tropical regions, based on the literature search. Figure 8 shows tick infestations in age categories of domestic ruminant groups, based on the literature search. Figure 9 shows tick infestations in attachment sites of domestic ruminant group body parts, based on the literature search. Figure 10 shows tick infestations in relation to animal sexes and tick life stages in domestic ruminant groups, based on the literature search. Figures 11 and 12 show the seasonal and monthly tick infestations in domestic ruminant groups in the world hemispheres and tropical regions, based on the literature search. Tables 8, 9 and 10 show tick and tick life stage infestation analysis in domestic ruminant groups by analysis of variance (ANOVA) and post hoc tests (Tukey) among domestic ruminants, domestic ruminant age categories, attachment sites of domestic ruminant body parts, and seasonal and monthly tick infestations in relation to the world hemispheres and tropical regions, continents, countries, and years.

Table 3 Tick infestations in attachment sites of domestic ruminant group body parts including buffaloes, camels, cattle, goats and sheep based on literature search

TI (%) in AS						Country (province or state)	Sampling			References
DS	ER	ND	TAR	TA	SU		Location	n	Date	
Buffaloes										
–	14.8	4.7	45.7	14.5	20.3	Iraq (Basra)	Local	505	Jan-Dec 2004	Awad and Abudl-Hussein (2005)
–	–	–	3.7	60.9	34.8	Iran (West Azerbaijan)	Local	799	Mar 2006-Feb 2007	Davoudi et al. (2008)
	11.8	3.6	51.3	8.0	25.3	Kenya	Local	1071	2010	Kariuki (2012)
5.3	17.0	6.3	78.8	24.8	–	Egypt	Local	440	Nov 2012-Sep 2013	Asmaa et al. (2014)
8.1	–	19.0	26.3	11.1	19.7	Pakistan (Lahore)	Local	682	Jan 2012-Dec 2012	Ali et al. (2016)
–	–	1.5	11.1	2.8	11.3	Pakistan (Khairpur)	Local	–	Apr-Sep 2015	Abbasi et al. (2017)
–	3.7	22.2	9.3	–	64.8	India (Karur)	Local	–	–	Ravichandran (2018)
–	34.0	36.0	48.0	17.0	65.0	Pakistan (Punjab)	Local	200	Apr 2017-Sep 2017	Ramzan et al. (2020)
Camels										
–	14.8	4.7	45.7	14.5	20.3	Iraq (Basra)	Local	505	Jan-Dec 2004	Awad and Abudl-Hussein (2005)
1.6	–	6.4	6.6	5.1	21.1	Sudan	Across	51,253	2000–2001	Elghali and Hassan (2009)
–	6.3	–	91.1	2.6	–	Iran (Kerman)	Local	426	Apr 2009-Mar 2010	Nourollahi Fard et al. (2012)
1.2	19.1	11.0	27.6	28.1	12.9	Ethiopia	Local	11,774	Sep 2010-Mar 2011	Taddese and Mustefa (2013)
12.9	35.7	–	29.8	–	21.6	Iran (Golestan)	Local	255	Mar 2009-Feb 2010	Sarani et al. (2014)
–	15.8	21.5	19.5	11.6	31.8	Somalia	Local	576	Mar 2017-May 2017	Farah Isse and Ali (2017)
19.6	11.9	20.4	8.9	39.3	–	Nigeria (Kebbi)	Local	600	May 2014-Jun 2014	Abdullahi et al. (2018)
Cattle										
–	14.8	4.7	45.7	14.5	20.3	Iraq (Basra)	Local	505	Jan-Dec 2004	Awad and Abudl-Hussein (2005)
3.0	20.0	–	77.0	–	–	Iraq (Dohuk)	Local	6500	Mar 2005-Feb 2006	Omer et al. (2007)
–	–	–	30.1	50.3	19.6	Iran (West Azerbaijan)	Local	799	Mar 2006-Feb 2007	Davoudi et al. (2008)
–	10.8	7.6	48.2	6.2	26.9	Zimbabwe (Matabeleland South)	Local	8792	Jan-Apr 2007	Ndhlovu et al. (2009)
–	4.4	1.1	74.4	20.1	–	Iran (Kerman)	Local	2179	2008–2009	Dehaghi et al. (2011)
–	24.8	17.9	20.5	33.3	21.4	Bangladesh (Chittagong)	Local	280	Nov 2008-May 2009	Kabir et al. (2011)
–	6.0	29.1	15.8	20.7	21.8	Ethiopia	Local	1831	Oct 2010-Mar 2011	Tiki and Addis (2011)
–	38.6	38.6	8.2	58.7	33.8	Iran	Across	5706	Mar 2007-Feb 2008	Yakhchali et al. (2011)
0.35	1.6	17.2	44.4	6.0	34.0	Ethiopia	Local	3971	Nov 2009-Feb 2010	Fanos et al. (2012)
–	–	–	–	–	41.0	Iraq (Baghdad)	Local	521	Jan-Dec 2010	Hasson (2012)
–	35.6	18.0	22.6	6.4	17.4	Kenya	Local	362	2010	Kariuki (2012)
0.42	1.9	17.2	44.4	6.7	34.0	Ethiopia	Local	3971	Nov 2009-Feb 2010	Tadesse et al. (2012)
4.6	13.5	11.8	21.3	9.8	38.9	Iran (Mazandaran)	Local	1068	Sep 2009-Aug 2010	Motevalli Haghi et al. (2013)
1.4	2.0	38.8	25.8	5.3	26.7	Ethiopia	Local	2439	Nov 2011-Apr 2012	Wasihun and Doda (2013)
27.0	14.6	11.7	41.7	65.9	–	Egypt	Local	440	Nov 2012-Sep 2013	Asmaa et al. (2014)
–	19.0	7.6	66.4	7.0	–	Iran (Sistan and Baluchestan)	Local	2883	2010–2011	Mirzaei and Khedri (2014)
–	5.0	–	15.0	70.0	5.0	Iran (Razavi Khorasan)	Local	612	Apr-Sep 2012	Riabi and Atarodi (2014)
12.9	35.7	–	29.8	–	21.6	Iran (Golestan)	Local	255	Mar 2009-Feb 2010	Sarani et al. (2014)
–	2.0	30.0	21.0	10.0	–	Iran (Ilam)	Local	1316	Mar 2009-Aug 2009	Loui Monfared et al. (2015)
–	16.6	35.1	10.4	–	37.9	Ethiopia (Oromia)	Local	–	Oct 2013-Mar 2014	Regasa et al. (2015)
–	2.8	26.2	36.5	18.6	15.9	Ethiopia (Oromia)	Local	1984	Nov 2014-Apr 2015	Tamerat et al. (2015)
9.4	–	4.7	24.0	19.3	42.7	Pakistan (Lahore)	Local	682	Jan 2012-Dec 2012	Ali et al. (2016)
–	25.3	–	64.1	10.7	–	Egypt (Matrouh)	Local	740	May 2011-Apr 2013	Barghash et al. (2016)
–	6.5	26.8	17.9	18.9	29.9	Ethiopia (Arbegona)	Local	2024	Oct 2014-Jun 2015	Kemal et al. (2016b)

Table 3 continued

TI (%) in AS						Country (province or state)	Sampling			References
DS	ER	ND	TAR	TA	SU		Location	n	Date	
13.4	7.1	8.4	12.1	27.6	35.0	India (Odisha)	Local	–	Feb 2016-Jan 2017	Dehuri et al. (2017)
19.8	38.9	27.7	–	3.3	10.2	Pakistan (Balochistan)	Local	1649	Mar 2013-Mar 2014	Rafiq et al. (2017)
23.9	14.2	20.0	5.5	36.4	–	Nigeria (Kebbi)	Local	600	May 2014-Jun 2014	Abdullahi et al. (2018)
–	3.2	34.0	22.6	10.7	29.5	Ethiopia	Local	3290	Nov 2016-Apr 2017	Abiso et al. (2019)
17.9	13.8	14.6	17.2	36.5	–	India (Mizoram)	Local	632	Apr 2017-Mar 2018	Ghosh et al. (2019)
–	34.0	36.0	48.0	17.0	65.0	Pakistan (Punjab)	Local	200	Apr 2017-Sep 2017	Ramzan et al. (2020)
Goats										
–	14.8	4.7	45.7	14.5	20.3	Iraq (Basra)	Local	505	Jan-Dec 2004	Awad and Abudl-Hussein (2005)
6.9	2.0	–	86.7	–	4.4	Iran (West Azerbaijan)	Local	849	Apr 2003-Mar 2004	Yakhchali and Hosseine (2006)
5.1	85.0	–	–	–	9.8	Iraq (Dohuk)	Local	6500	Mar 2005-Feb 2006	Omer et al. (2007)
–	27.0	–	24.1	45.2	58.7	Iran	Across	5706	Mar 2007-Feb 2008	Yakhchali et al. (2011)
2.6	22.9	7.7	37.7	10.9	18.1	Iran (Mazandaran)	Local	1068	Sep 2009-Aug 2010	Motevalli Haghi et al. (2013)
–	60.8	26.1	13.0	10.9	–	Egypt	Local	440	Nov 2012-Sep 2013	Asmaa et al. (2014)
–	71.4	–	–	–	28.6	Iran (Razavi Khorasan)	Local	612	Apr-Sep 2012	Riabi and Atarodi (2014)
12.9	35.7	–	29.8	–	21.6	Iran (Golestan)	Local	255	Mar 2009-Feb 2010	Sarani et al. (2014)
–	63.0	–	17.0	13.0	7.0	Iran (Ilam)	Local	1316	Mar 2009-Aug 2009	Loui Monfared et al. (2015)
2.1	53.6	9.4	21.9	2.1	5.2	India	Local	–	Mar 2016-Jun 2016	Gopalakrishnan et al. (2017)
25.0	62.0	20.0	14.0	1.0	5.0	India	Across	2924	Apr 2015-Mar 2017	Rashid et al. (2018)
2.6	42.3	21.9	24.4	–	9.0	Pakistan (Sanghar)	Local	723	Jun-Sep 2017	Jariko et al. (2020)
–	34.0	36.0	48.0	17.0	65.0	Pakistan (Punjab)	Local	200	Apr 2017-Sep 2017	Ramzan et al. (2020)
Sheep										
–	14.8	4.7	45.7	14.5	20.3	Iraq (Basra)	Local	505	Jan-Dec 2004	Awad and Abudl-Hussein (2005)
5.1	1.3	–	70.9	–	22.8	Iran (West Azerbaijan)	Local	849	Apr 2003-Mar 2004	Yakhchali and Hosseine (2006)
5.1	85.0	–	–	–	9.8	Iraq (Dohuk)	Local	6500	Mar 2005-Feb 2006	Omer et al. (2007)
–	78.5	–	14.0	4.7	2.9	Pakistan (Islamabad)	Local	–	Feb-Nov 2009	Irshad et al. (2010)
–	63.3	–	23.1	9.5	4.1	Iran	Local	1279	Apr-Mar 2008	Rasouli et al. (2010)
–	28.3	2.2	55.1	14.4	–	Iran (Kerman)	Local	2179	2008–2009	Dehaghi et al. (2011)
–	20.3	–	50.6	11.4	47.0	Iran	Across	5706	Mar 2007-Feb 2008	Yakhchali et al. (2011)
16.6	36.9	–	15.1	–	26.9	Yemen (Thamar governorate)	Local	875	Dec 2010-May 2011	Al-Shaibani (2012)
–	7.0	–	13.0	–	–	Iraq (Baghdad)	Local	521	Jan-Dec 2010	Hasson (2012)
9.0	42.0	1.7	17.7	9.6	20.0	Iraq (Sulaymaniyah)	Local	1171	Mar 2009-Feb 2010	Kadir et al. (2012)
–	–	5.7	42.7	27.4	24.2	Iran (East Azerbaijan)	Local	525	Apr-Sep 2011	Moshaverinia et al. (2012)
–	55.7	7.9	20.2	2.2	14.0	Iran (Mazandaran)	Local	1068	Sep 2009-Aug 2010	Motevalli Haghi et al. (2013)
–	87.5	–	–	15.6	–	Egypt	Local	440	Nov 2012-Sep 2013	Asmaa et al. (2014)
–	20.6	5.3	65.2	8.9	–	Iran (Sistan and Baluchestan)	Local	2883	2010–2011	Mirzaei and Khedri (2014)
–	25.0	–	75.0	–	–	Iran (Razavi Khorasan)	Local	612	Apr-Sep 2012	Riabi and Atarodi (2014)
12.9	35.7	–	29.8	–	21.6	Iran (Golestan)	Local	255	Mar 2009-Feb 2010	Sarani et al. (2014)
–	42.0	2.0	30.0	8.0	18.0	Iran (Ilam)	Local	1316	Mar 2009-Aug 2009	Loui Monfared et al. (2015)
–	–	26.5	2.4	17.2	73.9	Mexico	Local	5013	Sep 2014-Sep 2015	Coronel-Benedett et al. (2018)
–	91.3	–	–	20.0	20.0	India	Across	2924	Apr 2015-Mar 2017	Rashid et al. (2018)
–	34.0	36.0	48.0	17.0	65.0	Pakistan (Punjab)	Local	200	Apr 2017-Sep 2017	Ramzan et al. (2020)

AS, attachment sites of domestic ruminant group body parts; DS, dorsal surface; ER, ear region; n, sample size; ND, neck and dewlap, TAR, tail and anal region; TA, thigh and abdomen; TI, tick infestations; and SU, scrotum or udder

Statistical analysis

Microsoft Excel and SPSS were used for analyzing the data represented in Tables 1, 2, 3, 4, 5, 6 and 7. To calculate and estimate the global annually trend of tick infestations for each domestic ruminant group of buffaloes, camels, cattle, goats, sheep, and the global domestic ruminants in relation to the world countries, continents, hemispheres and tropical regions (Figs. 2, 3, 4, 5, 6, 7), tick infestations in age categories of domestic ruminant groups (Fig. 8), tick infestations in attachment sites of domestic ruminant group body parts (Fig. 9), tick infestations of domestic ruminant groups in relation to animal sexes and tick life stages (Fig. 10), and seasonal and monthly tick infestations in domestic ruminant groups in the world hemispheres and tropical regions (Figs. 11, 12), the methods following Nasirian, Nasirian and Salehzadeh, Kassiri and Nasirian, and Nasirian and Zahirnia (Nasirian 2016, 2017a, b, 2019a, b, c; Nasirian and Salehzadeh 2019a; Nasirian 2020; Kassiri and Nasirian 2021; Nasirian and Zahirnia 2021) were used. An analysis of variance (ANOVA) and post hoc tests (Tukey) were used to compare tick and tick life stage infestations among domestic ruminant groups, domestic ruminant age categories, attachment sites of domestic ruminant group body parts, and seasonal and monthly tick infestations in relation to the world hemispheres and tropical regions, continents, countries, and years (Tables 8, 9, 10).

Attempt to obtained statistically adjusted pooled estimates

All papers that were allocated to the meta-analysis Sect. (329 papers) have been published in high quality international journals that 49.7% of them (162 papers) have distinct high journal volumes up to 20 volumes and 17.5% (57 papers) between 10 and 20 volumes. The 32.8% (107 papers) of them have been published in journals below 10 volumes that currently all are well-known journals. In these papers the sample size of collected ticks on domestic ruminant groups ranges between 40 and 680,387 ticks (Tables 1, 2, 3, 4, 5, 6, 7).

Results

Summary of the papers used for the meta-analysis

Based on the literature search among the papers that became part of meta-analysis section, 316 papers were allocated to tick infestations in buffaloes, camels, cattle, goats, and sheep domestic ruminant groups. The sample size of tick infestations of domestic ruminants ranged between 40 and 680,387 ticks. Places in which tick infestations of domestic ruminants include 44 countries, Afghanistan, Algeria, Bangladesh, Brazil, Britain, Cameroon, China, Côte d'Ivoire, Ecuador, Egypt, Ethiopia, France, Ghana, Greece, Hungary, India, Indonesia, Iran, Iraq, Italy, Japan, Kenya, Korea, Lebanon, Mexico, Mozambique, Nigeria, North Macedonia, Pakistan, Rwanda, Saudi Arabia, Serbia, Somalia, South Africa, Spain, Sri Lanka, Sudan, Tanzania, Thailand, Tunisia, Turkey, Uganda, Yemen, and Zimbabwe. Tick infestations of domestic ruminant groups were reported from 1967 to 2020 (Table 1). Forty six papers were allocated to tick infestations in age category of buffaloes, camels, cattle, goats, and sheep. The sample size of tick infestations in age category of domestic ruminant groups ranged between 95 and 680,387 ticks. Places in which tick infestations in age category of domestic ruminant groups include 12 countries, Bangladesh, Brazil, Cameroon, Egypt, Ethiopia, India, Iran, Nigeria, Pakistan, Somalia, Sudan, and Yemen. Tick infestations in age category of domestic ruminants were reported from 2007 to 2020 (Table 2).

Forty six papers were allocated to tick infestations in attachment sites of domestic ruminant group body parts of buffaloes, camels, cattle, goats, and sheep. The sample size of tick infestations in attachment sites of domestic ruminant group body parts ranged between 200 and 51,253 ticks. Places in which tick infestations in attachment sites of domestic ruminant groups body parts include 14 countries, Bangladesh, Egypt, Ethiopia, India, Iran, Iraq, Kenya, Mexico, Nigeria, Pakistan, Somalia, Sudan, Yemen, and Zimbabwe. Tick infestations in attachment sites of domestic ruminant group body parts were reported from 2005 to 2020 (Table 3). Seventy six papers were allocated to tick infestations in relation to sex of buffaloes, camels, cattle, goats, and sheep. The sample size of tick infestations in relation to sex of domestic ruminants ranged between 200 and 680,387 ticks. Places in which tick infestations in relation to sex of domestic ruminant groups include 12 countries, Bangladesh, Cameroon, Egypt, Ethiopia, India, Iran, Iraq, Nigeria, Pakistan, Somalia, Sudan, and Yemen. Tick infestations in relation to sex of domestic ruminant groups were reported from 2004 to 2020 (Table 4).

Ninety five papers were allocated to tick life stage infestation in buffaloes, camels, cattle, goats, and sheep. The sample size of tick life stage infestation in domestic ruminants ranged between 59 and 680,387 ticks. Places in which tick life stage infestation in age category of domestic ruminants include 31 countries, Argentina, Bangladesh, Brazil, Cameroon, China, Ecuador, Ethiopia, France, Greece, Hungary, India, Iran, Iraq, Italy, Japan, Kenya, Korea, Nigeria, Pakistan, Rwanda, Saudi Arabia, Somalia, South Africa, Spain, Sri Lanka, Sudan, Tanzania, Tunisia, Turkey, Yemen, and Zimbabwe. Tick life stage infestation

Table 4 Tick infestations in relation to sex of domestic ruminant groups including buffaloes, camels, cattle, goats and sheep based on literature search

ASI (%)		Country (province or state)	Sampling			References
Females	Males		Location	n	Date	
Buffaloes						
76.3	23.7	Pakistan (Punjab)	Local	1793	–	Sajid et al. (2009)
69.6	30.4	Pakistan (Punjab)	Local	352	Apr 2010-Mar 2011	Iqbal et al. (2013)
80.8	19.2	Iraq	Across	785	Mar 2012-Feb 2013	Shubber et al. (2013)
80.2	19.8	Pakistan (Punjab)	Local	–	Oct 2012-Sep 2013	Mustafa et al. (2014)
16.2	83.8	Pakistan (Multan)	Local	–	Sep 2009-Aug 2010	Zahida et al. (2014)
82.1	17.9	Pakistan (Lahore)	Local	682	Jan 2012-Dec 2012	Ali et al. (2016)
63.6	36.4	Pakistan	Across	18,907	–	Sajid et al. (2017)
56.5	42.8	India (Uttar Pradesh)	Local	–	Feb 2016-May 2016	Singh and Mishra (2017)
42.7	55.2	Pakistan (Punjab)	Local	–	–	Khalil et al. (2018)
97.2	2.8	India (Punjab)	Local	–	Feb 2010-Aug 2011	Singh and Rath (2018)
60.0	40.0	Iraq	Across	749	Jun 2017-Feb 2018	Abed and Hasso (2019)
46.5	45.0	Pakistan	Across	774	Sep-Nov 2017	Ghafar et al. (2020a)
Camels						
34.1	65.9	Nigeria (Borno and Yobe)	Across	13,058	–	James-Rugu and Jidayi (2004)
29.0	71.0	Nigeria (Sokoto)	Local	3465	–	Lawal et al. (2007)
64.1	35.9	Sudan	Across	51,253	2000–2001	Elghali and Hassan (2009)
36.4	63.6	Ethiopia	Local	–	Nov 2007-Apr 2008	Dinka et al. (2010)
31.2	67.6	Ethiopia	Local	6436	Oct 2009-May 2010	Megersa et al. (2012)
77.5	22.5	Iran (Khorasan)	Local	480	May 2012-Jan 2013	Champour et al. (2013)
59.0	41.0	Ethiopia	Local	11,774	Sep 2010-Mar 2011	Taddese and Mustefa (2013)
25.2	74.8	Ethiopia	Local	15,723	–	Kiros et al. (2014)
60.0	40.0	Iran (Golestan)	Local	255	Mar 2009-Feb 2010	Sarani et al. (2014)
83.9	16.1	Ethiopia	Local	1347	–	Regassa et al. (2015)
76.9	23.1	Egypt (Matrouh Governorate)	Local	740	May 2011-Apr 2013	Barghash et al. (2016)
87.2	12.8	Somalia	Local	576	Mar 2017-May 2017	Farah Isse and Ali (2017)
80.5	19.5	Ethiopia (Somali)	Local	6793	Nov 2014-Apr 2015	Feyera et al. (2017)
56.4	43.6	Iran (Qom)	Local	1265	Apr 2012-Mar 2013	Pasalary et al. (2017)
92.9	4.3	Iraq (Al Muthanna)	Local	1455	Feb 2017-Feb 2018	Al-Salihi et al. (2018)
82.7	17.3	Sudan	Across	9245	Nov 2014-Oct 2015	Bala et al. (2018)
78.0	22.0	Pakistan	Across	7720	Nov 2010-Jul 2011	Qamar et al. (2019)
Cattle						
39.4	60.6	Nigeria (Borno and Yobe)	Across	13,058	–	James-Rugu and Jidayi (2004)
61.7	38.3	Pakistan (Punjab)	Local	1793	–	Sajid et al. (2009)
44.1	55.9	Ethiopia (Bedelle)	Local	5507	Nov 2007-Apr 2008	Abera et al. (2010)
62.9	37.1	Bangladesh (Gazipur)	Local	–	Nov 2008-Oct 2009	Rony et al. (2010a)
54.8	45.2	Iran	Across	5706	Mar 2007-Feb 2008	Yakhchali et al. (2011)
54.3	45.7	Ethiopia (Haramaya)	Local	1446	Nov 2010-Jun 2011	Asrate and Yalew (2012)
68.1	31.9	Ethiopia	Local	3971	Nov 2009-Feb 2010	Fanos et al. (2012)
5.6	2.5	Iraq (Baghdad)	Local	521	Jan-Dec 2010	Hasson (2012)
49.0	51.0	Ethiopia (Amhara)	Local	2950	Nov 2009-Jun 2010	Kebede and Fetene (2012)
70.3	29.7	Ethiopia	Local	3971	Nov 2009-Feb 2010	Tadesse et al. (2012)
96.8	3.2	India (Punjab)	Local	–	Feb 2010-Aug 2011	Singh and Rath (2013)
54.0	46.0	Iran (Kermanshah)	Local	1031	May-Sep 2012	Sohrabi et al. (2013)
43.7	56.3	Ethiopia	Local	2439	Nov 2011-Apr 2012	Wasihun and Doda (2013)
53.6	46.4	Ethiopia	Local	1444	Nov 2013-Apr 2014	Amante et al. (2014)
58.7	41.5	Egypt	Local	440	Nov 2012-Sept 2013	Asmaa et al. (2014)
53.9	46.1	Ethiopia	Local	3117	Sep 2009-Mar 2010	Bedasso et al. (2014)

Table 4 continued

ASI (%)		Country (province or state)	Sampling			References
Females	Males		Location	n	Date	
61.6	38.4	Iran (Golestan)	Local	255	Mar 2009-Feb 2010	Sarani et al. (2014)
44.0	56.0	Ethiopia	Local	864	Nov 2014-Apr 2015	Admassu et al. (2015)
58.8	41.2	Ethiopia (Haramaya)	Local	1042	Nov 2013-Mar 2014	Desalegn et al. (2015)
63.6	50.8	India (Lucknow)	Local	1412	Apr 2014-Mar 2015	Kaur et al. (2015)
51.9	48.1	Ethiopia (Oromia)	Local	211	Oct 2013-Mar 2014	Regasa et al. (2015)
56.4	43.6	Ethiopia (Oromia)	Local	1984	Nov 2014-Apr 2015	Tamerat et al. (2015)
83.3	16.7	Pakistan (Lahore)	Local	682	Jan 2012-Dec 2012	Ali et al. (2016)
74.2	25.8	Ethiopia (Arbegona)	Local	2024	Oct 2014-Jun 2015	Kemal et al. (2016b)
6.0	5.4	Cameroon (Adamawa)	Local	680,387	–	Mamoudou et al. (2016)
57.4	42.6	Ethiopia	Local	2418	May-Dec 2016	Bayou and Asegdew (2017)
70.0	30.0	Iran (Hamadan)	Local	259	2015–2016	Fayazkhoo et al. (2017)
77.1	22.9	Pakistan (Balochistan)	Local	200	–	Kakar et al. (2017)
63.6	36.4	Pakistan	Across	18,907	–	Sajid et al. (2017)
43.3	35.7	India (Bengal)	Local	–	Jul 2015-Jun 2016	Debbarma et al. (2018)
56.0	44.0	Ethiopia	Local	3290	Nov 2016-Apr 2017	Abiso et al. (2019)
85.2	14.8	Sudan	Across	1098	2017	Elhaj et al. (2019)
66.4	48.8	India (Mizoram)	Local	632	Apr 2017-Mar 2018	Ghosh et al. (2019)
48.7	51.3	Ethiopia (Hadiya)	Local	–	Nov 2017-Apr 2018	Fesseha and Mathewos (2020)
46.5	45.0	Pakistan	Across	774	Sep-Nov 2017	Ghafar et al. (2020a)
72.0	28.0	Sudan (Gezira)	Local	1089	Jan, May, Aug 2014	Hayati et al. (2020)
Goats						
20.3	79.7	Nigeria (Borno and Yobe)	Across	13,058	–	James-Rugu and Jidayi (2004)
78.1	21.9	Iran (West Azerbaijan)	Local	849	Apr 2003-Mar 2004	Yakhchali and Hosseine (2006)
8.8	11.3	Nigeria	Local	–	Feb-Nov 2005	Idris and Umar (2007)
83.9	16.1	Ethiopia (Oromia)	Local	4310	Nov 2007-Feb 2008	Abunna et al. (2009)
41.7	58.3	Ethiopia (Bedelle)	Local	5507	Nov 2007-Apr 2008	Abera et al. (2010)
68.8	31.2	Ethiopia (Amhara)	Local	–	Oct 2011-Mar 2012	Fentahun et al. (2012)
63.2	36.8	Bangladesh (Gazipur)	Local	–	Nov 2008-Oct 2009	Rony et al. (2010b)
60.5	39.5	Pakistan (Punjab)	Local	1793	–	Sajid et al. (2011)
51.6	48.4	Iran	Across	5706	Mar 2007-Feb 2008	Yakhchali et al. (2011)
71.0	29.0	Ethiopia (Oromia)	Local	3496	Nov 2010-Mar 2011	Abunna et al. (2012)
65.2	34.8	Iran (Kermanshah)	Local	1031	May-Sep 2012	Sohrabi et al. (2013)
68.0	32.0	Ethiopia (Oromia)	Local	–	Oct 2009-Apr 2010	Beyecha et al. (2014)
78.0	22.0	Pakistan (Punjab)	Local	–	Oct 2012-Sep 2013	Mustafa et al. (2014)
66.7	33.3	Iran (Golestan)	Local	255	Mar 2009-Feb 2010	Sarani et al. (2014)
58.8	41.2	Ethiopia (Haramaya)	Local	1042	Nov 2013-Mar 2014	Desalegn et al. (2015)
42.1	57.9	Sudan (South Darfur)	Local	1530	Mar 2006-Feb 2007	Yagoub et al. (2015)
66.0	34.0	Iran (Hamadan)	Local	259	2015–2016	Fayazkhoo et al. (2017)
83.0	17.0	Pakistan (Punjab)	Local	575	Jan 2013-Dec 2013	Riaz et al. (2017)
63.6	36.4	Pakistan	Across	18,907	–	Sajid et al. (2017)
79.2	20.8	India	Local	–	–	Soundararajan et al. (2018)
82.8	56.3	Pakistan (Sanghar)	Local	723	Jun-Sep 2017	Jariko et al. (2020)
Sheep						
65.6	34.4	Nigeria (Borno and Yobe)	Across	13,058	–	James-Rugu and Jidayi (2004)
78.1	21.9	Iran (West Azerbaijan)	Local	849	Apr 2003-Mar 2004	Yakhchali and Hosseine (2006)
57.9	42.1	Ethiopia	Local	–	Nov 2006-May2007	Yacob et al. (2008b)
83.9	16.1	Ethiopia (Oromia)	Local	4310	Nov 2007-Feb 2008	Abunna et al. (2009)
63.3	36.7	Ethiopia (Bedelle)	Local	5507	Nov 2007-Apr 2008	Abera et al. (2010)
68.8	31.2	Ethiopia (Amhara)	Local	–	Oct 2011-Mar 2012	Fentahun et al. (2012)

Table 4 continued

ASI (%)		Country (province or state)	Sampling			References
Females	Males		Location	n	Date	
59.1	40.9	Iran	Across	5706	Mar 2007-Feb 2008	Yakhchali et al. (2011)
71.0	29.0	Ethiopia (Oromia)	Local	3496	Nov 2010-Mar 2011	Abunna et al. (2012)
70.0	30.0	Yemen (Thamar governorate)	Local	875	Dec 2010-May 2011	Al-Shaibani (2012)
4.9	14.8	Iraq (Baghdad)	Local	521	Jan-Dec 2010	Hasson (2012)
75.8	24.2	Ethiopia (Oromia)	Local	–	Oct 2009-Apr 2010	Kumsa et al. (2012)
58.1	41.9	Ethiopia	Local	–	Nov 2011-Mar 2012	Bayisa et al. (2013)
59.3	40.7	Iran (Kermanshah)	Local	1031	May-Sep 2012	Sohrabi et al. (2013)
54.5	45.5	Iran (Golestan)	Local	255	Mar 2009-Feb 2010	Sarani et al. (2014)
58.8	41.2	Ethiopia (Haramaya)	Local	1042	Nov 2013-Mar 2014	Desalegn et al. (2015)
57.6	42.4	Sudan (South Darfur)	Local	1530	Mar 2006-Feb 2007	Yagoub et al. (2015)
58.6	41.4	Ethiopia (Oromiya)	Local	–	Nov 2013-Jul 2014	Bedada et al. (2017)
55.0	45.0	Iran (Hamadan)	Local	259	2015–2016	Fayazkhoo et al. (2017)
63.6	36.4	Pakistan	Across	18,907	–	Sajid et al. (2017)

n, sample size; and ASI, animal sex infestations

of domestic ruminants were reported from 1985 to 2020 (Table 5). Twenty eight papers were allocated to seasonal tick infestations in buffaloes, camels, cattle, goats, and sheep. The sample size of seasonal tick infestations in domestic ruminant groups ranged between 200 and 21,738 ticks. Places in which seasonal tick infestations of domestic ruminant groups include 9 countries, Bangladesh, Egypt, Ethiopia, India, Iran, Iraq, Italy, Pakistan, and Sudan. Seasonal tick infestations of domestic ruminant groups were reported from 2005 to 2019 (Table 6). Twenty three papers were allocated to monthly tick infestations in buffaloes, camels, cattle, goats, and sheep. The sample size of monthly tick infestations in the global domestic ruminants ranged between 320 and 51,253 ticks. Places in which monthly tick infestations in the global domestic ruminants include 11 countries, Argentina, Greece, Hungary, Iran, Iraq, Kenya, Pakistan, Sudan, Tunisia, Turkey, and Yemen. Monthly tick infestations in the global domestic ruminants were reported from 1996 to 2020 (Table 7).

Global mean and annually trend of tick infestations in domestic ruminant groups in the world countries, continents, hemispheres and tropical regions

Global mean of tick infestations in domestic ruminant groups in the world countries, continents, hemispheres and tropical regions.

Based on the literature search, the global means of tick infestations in the world countries, continents, hemispheres and tropical regions exhibited different values for buffaloes (Fig. 2b, d, f), camels (Fig. 3b, d, e), cattle (Fig. 4a, c, g), goats (Fig. 5a, e, g), sheep (Fig. 6b, d, f), and the global domestic ruminants (Fig. 7b, d, e). The global domain means of tick infestations in the world countries ranged 1.7–53.3, 23.0–97.0, 3.2–98.2, 0.3–78.0, 0.8–79.1, and 6.2–98.2% for buffaloes (Fig. 2b), camels (Fig. 3b), cattle (Fig. 4a), goats (Fig. 5a), sheep (Fig. 6a), and the global domestic ruminants (Fig. 7a), respectively. One-way ANOVA did not reveal a significant difference between tick infestations in buffaloes and sheep among the world countries ($1.119 \leq F \leq 1.496$; $10 \leq df \leq 28$; $0.075 \leq P \leq 0.368$). One-way ANOVA revealed a significant difference between tick infestations in camels, cattle, goats, and the global domestic ruminants among the world countries ($2.731 \leq F \leq 3.643$; $8 \leq df \leq 33$; $0.0001 \leq P \leq 0.017$) (Table 8). There was a significant difference between tick infestations in camels between Ethiopia and Iran (Mean difference = 46.8; SEM = 12.2; $P = 0.012$), cattle between Nigeria and Ethiopia with South Africa and Iran; goats between India and South Africa ($38.5 \leq$ Mean difference ≤ 50.2; $6.3 \leq$ SEM ≤ 12.5; $0.012 \leq P \leq 0.047$), and the global domestic ruminants between Saudi Arabia with China, South Africa, Kenya, Turkey, Egypt and Iran; Ethiopia, India, Iraq and Pakistan with South Africa; and Ethiopia, India and Pakistan with Iran ($13.6 \leq$ Mean difference ≤ 67.2; $3.4 \leq$ SEM ≤ 16.7; $0.0001 \leq P \leq 0.031$) by post hoc tests (Tukey) (Table 9).

The global domain means of tick infestations in the world continents ranged 27.7–45.1, 23.0–60.5, 37.9–88.0, 32.3–44.0, 26.3–38.2 and 22.7–52.4% for buffaloes (Fig. 2d), camels (Fig. 3d), cattle (Fig. 4c), goats (Fig. 5e), sheep (Fig. 6c), and the global domestic ruminants (Fig. 7b), respectively. The global domain means of tick infestations in the world hemispheres and tropical regions ranged 36.3–53.3, 31.9–55.8, 33.1–46.7, 23.8–43.3, 11.6–34.1 and 28.8–41.8% for buffaloes (Fig. 2f), camels

Table 5 Tick life stage infestations of domestic ruminant groups including buffaloes, camels, cattle, goats and sheep based on literature search

TLSI (%)				Country (province or state)	Sampling			References
Females	Males	Nymphs	Larvae		Location	n	Date	
Buffaloes								
40.7	59.3	1.7	–	Iraq (Basra)	Local	505	Jan-Dec 2004	Awad and Abudl-Hussein (2005)
56.5	43.5	–	–	Kenya	Local	1071	2010	Kariuki (2012)
32.9	67.1	1.8	1.3	Iraq	Across	785	Mar 2012-Feb 2013	Shubber et al. (2013)
80.2	2.0	4.2	–	Pakistan (Khyber Pakhtunkhwa)	Local	1200	Jun-Sep 2015	Farooqi et al. (2017)
50.5	49.5	25.0	–	Pakistan	Across	3807	Sep 2013-Nov 2013	Rehman et al. (2017)
64.9	33.0	1.1	1.1	Brazil (Pará)	Local	95	–	Batista et al. (2018)
67.4	32.6	–	–	Zimbabwe	Across	1104	Jan-Apr 2016	Moyo et al. (2018)
64.9	35.1	–	11.1	Pakistan	Local	8641	Apr 2017-Mar 2018	Ali et al. (2019)
60.6	39.4	17.8	7.8	Pakistan (Balochistan)	Local	913	Dec 2018-Dec 2019	Bibi et al. (2020)
48.8	51.2	3.4	–	Pakistan	Across	774	Sep-Nov 2017	Ghafar et al. (2020a)
Camels								
26.8	73.2	–	–	Saudi Arabia	Local	373	–	Al-Asgah et al. (1985)
24.6	74.2	1.2	–	Kenya and Ethiopia	Local	31,040	–	Dioli et al. (2001)
32.9	67.1	9.9	–	Iraq (Basra)	Local	505	Jan-Dec 2004	Awad and Abudl-Hussein (2005)
31.2	68.8	–	–	Sudan	Across	51,253	2000–2001	Elghali and Hassan (2009)
24.4	75.6	–	–	Ethiopia	Local	6436	Oct 2009-May 2010	Megersa et al. (2012)
33.8	66.2	–	–	Iran (Kerman)	Local	426	Apr 2009-Mar 2010	Nourollahi Fard et al. (2012)
27.8	72.2	–	–	Iran (Khorasan)	Local	480	May 2012-Jan 2013	Champour et al. (2013)
26.2	73.8	–	–	Ethiopia	Local	11,774	Sep 2010-Mar 2011	Taddese and Mustefa (2013)
42.4	57.6	–	–	Iran (Golestan)	Local	1059	2010–2011	Sofizadeh et al. (2014)
50.9	49.1	–	–	China	Across	5257	2012–2014	Wang et al. (2015)
39.7	60.3	–	–	Somalia	Local	576	Mar 2017-May 2017	Farah Isse and Ali (2017)
49.1	50.9	23.6	12.3	Pakistan (Balochistan)	Local	913	Dec 2018-Dec 2019	Bibi et al. (2020)
47.7	52.3	–	–	Tunisia	Across	327	2015–2017	Selmi et al. (2019)
Cattle								
36.0	64.0	–	–	Tunisia	Across	5097	Jun 1991-Jun 1992	Bouattour et al. (1996)
55.9	44.1	–	–	South Africa	Across	8220	May 1990-Oct 1991	Fourie et al. (1996)
51.4	48.6	11.8	3.2	Greece (Macedonia)	Across	11,620	1983–1986	Papadopoulos et al. (1996)
49.1	50.9	12.1	–	Spain (Menorca)	Local	3624	1999–2000	Castellà et al. (2001)
43.0	57.0	–	–	Turkey (Elazig and Malatya)	Local	4581	Jul 1993-Jul 1995	Aktas et al. (2004)
45.5	54.5	1.8	–	Iraq (Basra)	Local	505	Jan-Dec 2004	Awad and Abudl-Hussein (2005)
85.5	14.5	8.1	1.2	Japan	Across	1001	Jun-Sep 2003	Yamane et al. (2006)
43.1	56.9	–	11.3	Rwanda	Across	12,814	Aug 2002-May 2003	Bazarusanga et al. (2007)
72.1	27.9	11.7	–	Iran (Mazandaran)	Local	873	2004–2005	Razmi et al. (2007)
42.8	57.2	–	–	Ethiopia (Somali)	Local	10,055	Oct 2008-Mar 2009	Abebe et al. (2010)
46.4	53.6	–	–	Ethiopia (Bedelle)	Local	5507	Nov 2007-Apr 2008	Abera et al. (2010)
64.0	36.0	–	–	Iran (Mazandaran)	Local	323	–	Hosseini Vasoukolaei et al. (2010)
51.3	48.7	–	–	Iraq (Najaf)	Local	612	2010	Al-Ramahi (2011)
60.2	39.8	–	–	Iran (Kerman)	Local	2179	2008–2009	Dehaghi et al. (2011)
59.4	35.8	–	–	Bangladesh (Chittagong)	Local	280	Nov 2008-May 2009	Kabir et al. (2011)
34.7	65.3	–	–	Sudan (Equatoria)	Local	2322	Dec 2004-Jun 2005	Marcellino et al. (2011)
33.7	66.3	–	–	Ethiopia (Haramaya)	Local	1446	Nov 2010-Jun 2011	Asrate and Yalew (2012)

Table 5 continued

TLSI (%)				Country (province or state)	Sampling			References
Females	Males	Nymphs	Larvae		Location	n	Date	
27.9	72.1	–	–	Ethiopia	Local	3971	Nov 2009-Feb 2010	Fanos et al. (2012)
41.8	58.2	–	–	Kenya	Local	362	2010	Kariuki (2012)
59.6	40.4	–	–	Iran (Qazvin)	Local	228	Apr-Aug 2010	Shemshad et al. (2012)
27.9	72.1	–	–	Ethiopia	Local	3971	Nov 2009-Feb 2010	Tadesse et al. (2012)
61.4	38.6	–	–	Nigeria	Across	5011	2010	Lorusso et al. (2013)
40.5	59.5	9.1	–	Iran (Mazandaran)	Local	1068	Sep 2009-Aug 2010	Motevalli Haghi et al. (2013)
42.0	58.0	–	–	Ethiopia	Local	1444	Nov 2013-Apr 2014	Amante et al. (2014)
21.2	78.8	–	–	Tanzania	Local	203	2012	Kwak et al. (2014)
54.7	45.3	–	–	Iran (Sistan and Baluchestan)	Local	2883	2010–2011	Mirzaei and Khedri (2014)
58.2	41.8	–	–	Iran (Razavi Khorasan)	Local	612	Apr-Sep 2012	Riabi and Atarodi (2014)
42.4	57.6	–	–	Iran (Golestan)	Local	1059	2010–2011	Sofizadeh et al. (2014)
54.0	46.0	–	–	Ethiopia (Haramaya)	Local	1042	Nov 2013-Mar 2014	Desalegn et al. (2015)
32.7	67.3	–	–	Iran (Hamadan)	Local	1534	2010–2011	Gharekhani et al. (2015)
42.0	58.0	–	–	India (Lucknow)	Local	1412	Apr 2014-Mar 2015	Kaur et al. (2015)
57.5	42.5	–	–	Ethiopia (Oromia)	Local	1984	Nov 2014-Apr 2015	Tamerat et al. (2015)
44.1	55.9	–	–	China	Across	5257	2012–2014	Wang et al. (2015)
54.5	45.4	–	–	Iran (Isfahan)	Local	492	Jul 2014-Jun 2015	Biglari et al. (2016)
57.4	42.6	–	–	Ethiopia	Local	1984	–	Kemal et al. (2016a)
51.2	48.8	–	–	Cameroon (Adamawa)	Local	680,387	–	Mamoudou et al. (2016)
47.4	52.6	–	–	Ethiopia	Local	2418	May-Dec 2016	Bayou and Asegdew (2017)
51.6	48.4	–	–	Iran (Lorestan)	Local	459	Apr-Mar 2014	Davari et al. (2017)
80.2	2.0	4.2	–	Pakistan (Khyber Pakhtunkhwa)	Local	1200	Jun-Sep 2015	Farooqi et al. (2017)
17.2	18.9	–	–	Iran (Hamadan)	Local	259	2015–2016	Fayazkhoo et al. (2017)
24.8	75.2	–	–	Ethiopia (Somali)	Local	6793	Nov 2014-Apr 2015	Feyera et al. (2017)
36.0	32.0	–	–	Pakistan (Balochistan)	Local	200	–	Kakar et al. (2017)
27.5	72.5	–	–	Tanzania	Across	7705	–	Kerario et al. (2017)
60.2	39.8	–	–	Nigeria (Borno)	Local	–	–	Paul et al. (2017)
46.9	53.1	–	–	Pakistan (Balochistan)	Local	1649	Mar 2013-Mar 2014	Rafiq et al. (2017)
51.4	48.6	35.2	–	Pakistan	Across	3807	Sep 2013-Nov 2013	Rehman et al. (2017)
67.9	19.6	12.3	0.13	Bangladesh (Mymensingh)	Local	2287	Feb-May 2014	Roy et al. (2018)
52.1	19.3	8.9	19.7	Argentina (Yungas)	Local	972	Jan 2012- Jun 2017	Saracho-Bottero et al. (2018)
51.8	48.2	–	–	Ethiopia	Local	3290	Nov 2016-Apr 2017	Abiso et al. (2019)
58.6	41.4	–	10.4	Pakistan	Local	8641	Apr 2017-Mar 2018	Ali et al. (2019)
89.3	10.7	0.27	–	Korea	Across	1298	2014–2015	Chae et al. (2019)
38.6	55.5	5.9	–	France (Corsica)	Local	660	May-Sep 2016	Cicculli et al. (2019)
44.5	55.5	–	–	Cameroon	Across	7091	Apr-Aug 2016	Silatsa et al. (2019)
54.5	45.5	22.4	10.6	Pakistan (Balochistan)	Local	913	Dec 2018-Dec 2019	Bibi et al. (2020)
40.3	59.7	2.1	–	Pakistan	Across	774	Sep-Nov 2017	Ghafar et al. (2020a)
58.6	41.4	–	–	India (Chhattisgarh)	Local	832	–	Jadhao et al. (2020)
64.3	35.7	9.1	1.1	Ecuador	Across	461	Feb-Mar 2012	Maya-Delgado et al. (2020)
–	–	41.0	–	Korea	Across	576	2014–2018	Seo et al. (2020)
Goats								
48.5	51.5	–	–	South Africa	Local	5976	Mar 1988-Jan 1990	Fourie and Horak (1991)
44.5	55.5	23.2	71.0	South Africa (Eastern Cape)	Local	14,814	1986–1987	Horak et al. (1991a)

Table 5 continued

TLSI (%)				Country (province or state)	Sampling			References
Females	Males	Nymphs	Larvae		Location	n	Date	
51.4	48.6	11.8	3.2	Greece (Macedonia)	Across	11,620	1983–1986	Papadopoulos et al. (1996)
33.7	66.3	21.3	56.9	South Africa	Local	3764	–	Horak et al. (2001)
37.6	62.4	31.7	62.5	South Africa (Eastern Cape)	Local	65,179	Feb 1983-Jan 1984	Macivor and Horak (2003)
45.0	55.0	1.8	–	Iraq (Basra)	Local	505	Jan-Dec 2004	Awad and Abudl-Hussein (2005)
39.2	60.8	–	31.4	Zimbabwe	Across	4735	Feb-Apr 2001, 2005–2006	Hove et al. (2008)
55.9	44.1	–	–	Ethiopia	Local	–	Nov 2006-May2007	Yacob et al. (2008b)
67.2	32.8	–	–	Ethiopia (Oromia)	Local	4310	Nov 2007-Feb 2008	Abunna et al. (2009)
59.2	40.8	–	–	Ethiopia (Bedelle)	Local	5507	Nov 2007-Apr 2008	Abera et al. (2010)
64.0	36.0	–	–	Iran (Mazandaran)	Local	323	–	Hosseini Vasoukolaei et al. (2010)
85.6	14.4	16.3	28.2	Hungary	Across	320	Jun-Aug 2011	Hornok et al. (2012)
59.6	40.4	–	–	Iran (Qazvin)	Local	228	Apr-Aug 2010	Shemshad et al. (2012)
40.5	59.5	9.1	–	Iran (Mazandaran)	Local	1068	Sep 2009-Aug 2010	Motevalli Haghi et al. (2013)
68.5	31.5	–	–	Ethiopia	Across	7634	Feb 2013-Jul 2013	Eyob and Matios (2014)
42.4	57.6	–	–	Iran (Golestan)	Local	1059	2010–2011	Sofizadeh et al. (2014)
54.0	46.0	–	–	Ethiopia (Haramaya)	Local	1042	Nov 2013-Mar 2014	Desalegn et al. (2015)
41.6	58.4	25.9	3.3	Sri Lanka	Across	2628	Jun 2011-May 2013	Diyes and Rajakaruna (2015)
54.5	45.4	–	–	Iran (Isfahan)	Local	492	Jul 2014-Jun 2015	Biglari et al. (2016)
44.1	55.9	7.2	1.2	Iraq	Across	1865	Jan 2015-Dec 2015	Mohammad (2016)
51.6	48.4	–	–	Iran (Lorestan)	Local	459	Apr-Mar 2014	Davari et al. (2017)
32.2	67.8	–	–	Greece	Local	59	Dec 2012-Aug 2013	Dimanopoulou et al. (2017)
19.0	15.4	–	–	Iran (Hamadan)	Local	259	2015–2016	Fayazkhoo et al. (2017)
37.5	62.5	–	–	Iran (West Azerbaijan)	Local	315	Jun-Sep 2014	Mohammadi et al. (2017)
48.1	51.9	57.0	–	Pakistan	Across	3807	Sep 2013-Nov 2013	Rehman et al. (2017)
73.4	26.6	65.2	–	Iraq (Najaf)	Local	411	Mar-Sep 2018	Al-Husseini (2019)
61.5	38.5	–	4.4	Pakistan	Local	8641	Apr 2017-Mar 2018	Ali et al. (2019)
30.5	69.5	6.7	–	Korea	Across	1298	2014–2015	Chae et al. (2019)
55.6	44.4	17.8	10.0	Pakistan (Balochistan)	Local	913	Dec 2018-Dec 2019	Bibi et al. (2020)
Sheep								
51.4	48.6	11.8	3.2	Greece (Macedonia)	Across	11,620	1983–1986	Papadopoulos et al. (1996)
35.4	64.6	5.7	91.6	South Africa	Across	139,064	Nov 1982-Mar 1984	Horak et al. (1991b)
50.1	49.9	–	–	Italy	Local	927	Sep-Dec 2000	Rinaldi et al. (2004)
30.0	70.0	–	–	Sudan	Local	2229	–	Ahmed et al. (2005)
42.5	57.5	0.88	–	Iraq (Basra)	Local	505	Jan-Dec 2004	Awad and Abudl-Hussein (2005)
32.3	67.7	–	–	Sudan (Sennar)	Local	198	Jul 2002-May 2003	Mohammed and Hassan (2007)
52.0	43.1	5.2	–	Iran	Local	1279	Apr-Mar 2008	Rasouli et al. (2010)
55.9	44.1	–	–	Ethiopia	Local	–	Nov 2006-May2007	Yacob et al. (2008b)
67.2	32.8	–	–	Ethiopia (Oromia)	Local	4310	Nov 2007-Feb 2008	Abunna et al. (2009)
43.8	56.2	–	–	Ethiopia (Bedelle)	Local	5507	Nov 2007-Apr 2008	Abera et al. (2010)
64.0	36.0	–	–	Iran (Mazandaran)	Local	323	–	Hosseini Vasoukolaei et al. (2010)
52.1	47.9	–	–	Iran (Kerman)	Local	2179	2008–2009	Dehaghi et al. (2011)
53.7	46.3	–	–	Iran (Khorasan Razvi)	Local	812	–	Razmi et al. (2011)
59.8	40.2	–	–	Yemen (Thamar governorate)	Local	875	Dec 2010-May 2011	Al-Shaibani (2012)

Table 5 continued

TLSI (%)				Country (province or state)	Sampling			References
Females	Males	Nymphs	Larvae		Location	n	Date	
94.4	5.6	5.3	–	Hungary	Across	320	Jun-Aug 2011	Hornok et al. (2012)
70.6	29.4	–	–	Iraq (Sulaymaniyah)	Local	1171	Mar 2009-Feb 2010	Kadir et al. (2012)
39.2	60.8	–	–	Iran (East Azerbaijan)	Local	525	Apr-Sep 2011	Moshaverinia et al. (2012)
59.6	40.4	–	–	Iran (Qazvin)	Local	228	Apr-Aug 2010	Shemshad et al. (2012)
40.5	59.5	9.1		Iran (Mazandaran)	Local	1068	Sep 2009-Aug 2010	Motevalli Haghi et al. (2013)
68.5	31.5	–	–	Ethiopia	Across	7634	Feb 2013-Jul 2013	Eyob and Matios (2014)
52.7	47.3	–	–	Iran (Sistan and Baluchestan)	Local	2883	2010–2011	Mirzaei and Khedri (2014)
42.4	57.6	–	–	Iran (Golestan)	Local	1059	2010–2011	Sofizadeh et al. (2014)
42.9	57.1	–	–	Iran (Semnan)	Local	1505	May 2010-May 2011	Changizi (2015)
54.0	46.0	–	–	Ethiopia (Haramaya)	Local	1042	Nov 2013-Mar 2014	Desalegn et al. (2015)
40.3	59.7	–	–	Iran (Hamadan)	Local	1534	2010–2011	Gharekhani et al. (2015)
42.1	57.9	–	–	China	Across	5257	2012–2014	Wang et al. (2015)
54.5	45.4	–	–	Iran (Isfahan)	Local	492	Jul 2014-Jun 2015	Biglari et al. (2016)
38.3	61.7	7.0	0.46	Iraq	Across	1865	Jan 2015-Dec 2015	Mohammad (2016)
51.6	48.4	–	–	Iran (Lorestan)	Local	459	Apr-Mar 2014	Davari et al. (2017)
32.2	67.8	–	–	Greece	Local	59	Dec 2012-Aug 2013	Dimanopoulou et al. (2017)
63.8	65.7	–	–	Iran (Hamadan)	Local	259	2015–2016	Fayazkhoo et al. (2017)
52.0	48.0	15.3	–	Pakistan	Across	3807	Sep 2013-Nov 2013	Rehman et al. (2017)
56.7	43.3	–	–	Tunisia (Gafsa)	Local	560	Oct 2013-Sep 2014	Elati et al. (2018b)
73.4	26.6	65.2	–	Iraq (Najaf)	Local	411	Mar-Sep 2018	Al-Husseini (2019)
63.9	36.1	–	7.5	Pakistan	Local	8641	Apr 2017-Mar 2018	Ali et al. (2019)
51.0	33.0	–	–	France (Corsica)	Local	660	May-Sep 2016	Cicculli et al. (2019)
68.8	31.2	10.6	5.0	Pakistan (Balochistan)	Local	913	Dec 2018-Dec 2019	Bibi et al. (2020)

n, sample size; and TLSI, tick life stage infestations

(Fig. 3e), cattle (Fig. 4g), goats (Fig. 5g), sheep (Fig. 6d), and the global domestic ruminants (Fig. 7c), respectively. One-way ANOVA did not reveal a significant difference between tick infestations in buffaloes, camels, cattle, goats, sheep, and the global domestic ruminants among the world continents ($0.802 \leq F \leq 2.35$; $2 \leq df \leq 4$; $0.159 \leq P \leq 0.524$), and hemispheres and tropical regions ($0.289 \leq F \leq 2.855$; $1 \leq df \leq 2$; $0.058 \leq P \leq 0.75$) (Table 8).

The global means of tick infestations were 36.9, 54.0, 45.0, 35.8, 33.7, and 40.1% in buffaloes, camels, cattle, goats, sheep, and the global domestic ruminants, respectively (Fig. 7d). One-way ANOVA revealed a significant difference between tick infestations in the global domestic ruminants ($F = 9.105$; $df = 4$; $P = 0.0001$) (Table 8). There was a significant difference between the global tick infestations between camels with sheep, goats, and buffaloes; and cattle with sheep, and goats ($9.1 \leq$ Mean difference ≤ 20.3; $2.9 \leq SEM \leq 4.1$; $0.0001 \leq P \leq 0.015$) by post hoc tests (Tukey) (Table 9).

Global annually trend of tick infestations in domestic ruminant groups in the world hemispheres and tropical regions.

Based on the literature search, the global trend of tick infestations in buffaloes (Fig. 2a, c, e) in the northern hemisphere, tropical regions, and the global world were gradually increased during the past decades. The global trend of tick infestations in camels (Fig. 3a, c) in the northern hemisphere and the global world were gradually increased during the past decades. The global trend of tick infestations in cattle (Fig. 4d, e, f) in the southern hemisphere, tropical regions, and the global world were gradually increased during the past decades. The global trend of tick infestations in sheep (Fig. 6b, f) in tropical regions and the global world were gradually increased during the past decades. The global trend of tick infestations in global domestic ruminants (Fig. 7e, f, h) in the northern and southern hemispheres, and the global world were gradually increased during the past decades.

The global trend of tick infestations in cattle (Fig. 4b) and sheep (Fig. 6e) in the northern hemisphere, and in the global domestic ruminants (Fig. 7g) in tropical regions

Table 6 Seasonal tick infestations of domestic ruminant groups including buffaloes, camels, cattle, goats and sheep based on literature search

STI (%)				Country (province or state)	Sampling			References
Spring	Summer	Autumn	Winter		Location	n	Date	
Buffaloes								
21.4	37.7	29.1	11.7	Iraq (Basra)	Local	505	Jan-Dec 2004	Awad and Abudl-Hussein (2005)
–	43.3	53.0	7.2	India (Uttarkhand)	Local	–	Jan 2004-Dec 2004	Vatsya et al. (2008)
–	8.1	–	14.4	Bangladesh (Kurigram)	Local	–	Nov 2007-Oct 2008	Mamun et al. (2010)
19.7	37.0	13.0	30.3	Pakistan (Lahore)	Local	682	Jan 2012-Dec 2012	Ali et al. (2016)
–	40.4	33.1	26.5	India (Punjab)	Local	–	Feb 2010-Aug 2011	Singh and Rath (2018)
Camels								
16.7	50.0	33.3	–	Iraq (Basra)	Local	505	Jan-Dec 2004	Awad and Abudl-Hussein (2005)
34.6	36.5	16.1	12.7	Iran (Yazd)	Local	583	2008–2009	Salim Abadi et al. (2010)
30.4	47.8	13.0	8.7	Iran (Qom)	Local	744	2010–2011	Farzinnia et al. (2012)
29.8	44.8	17.2	8.2	Iran (Kerman)	Local	426	Apr 2009-Mar 2010	Nourollahi Fard et al. (2012)
35.7	45.9	13.3	5.1	Iran (Golestan)	Local	255	Mar 2009-Feb 2010	Sarani et al. (2014)
29.5	24.2	39.2	7.1	Iran (Golestan)	Local	1059	2010–2011	Sofizadeh et al. (2014)
13.4	69.7	13.5	3.4	Iran	Across	1122	Apr 2012-Mar 2013	Moshaverinia and Moghaddas (2015)
53.8	39.5	6.8	–	Egypt (Matrouh Governorate)	Local	740	May 2011-Apr 2013	Barghash et al. (2016)
25.9	24.1	27.1	22.9	Egypt	Across	5223	Jun 2014-Jul 2016	Yassin et al. (2016)
36.0	84.0	15.3	4.7	Pakistan (Balochistan)	Local	200	–	Kakar et al. (2017)
43.4	31.5	12.4	12.6	Iran (Golestan)	Local	1798	2014–2015	Sedaghat et al. (2017)
–	29.7	40.2	30.1	Sudan	Across	9245	Nov 2014-Oct 2015	Bala et al. (2018)
Cattle								
25.9	24.7	36.2	13.2	Iraq (Basra)	Local	505	Jan-Dec 2004	Awad and Abudl-Hussein (2005)
42.7	14.7	36.2	7.8	Italy	Local	6208	2002–2003	Torina et al. (2006)
–	43.3	53.0	7.2	India (Uttarkhand)	Local	–	Jan 2004-Dec 2004	Vatsya et al. (2008)
38.6	28.0	–	33.3	Bangladesh (Gazipur)	Local	–	Nov 2008-Oct 2009	Rony et al. (2010a)
34.6	36.5	16.1	12.7	Iran (Yazd)	Local	583	2008–2009	Salim Abadi et al. (2010)
–	41.7	–	31.5	Bangladesh (Chittagong)	Local	280	Nov 2008-May 2009	Kabir et al. (2011)
29.5	25.0	25.3	26.2	Iran	Across	5706	Mar 2007-Feb 2008	Yakhchali et al. (2011)
99.2	93.5	72.7	60.3	Ethiopia (Amhara)	Local	2950	Nov 2009-Jun 2010	Kebede and Fetene (2012)
–	36.7	41.2	22.1	India (Punjab)	Local	–	Feb 2010-Aug 2011	Singh and Rath (2013)
35.7	45.9	13.3	5.1	Iran (Golestan)	Local	255	Mar 2009-Feb 2010	Sarani et al. (2014)
29.5	24.2	39.2	7.1	Iran (Golestan)	Local	1059	2010–2011	Sofizadeh et al. (2014)
18.3	37.5	17.9	26.3	Pakistan (Lahore)	Local	682	Jan 2012-Dec 2012	Ali et al. (2016)
19.1	34.3	36.2	10.5	Egypt	Across	5223	Jun 2014-Jul 2016	Yassin et al. (2016)
47.3	22.6	15.0	15.2	Iran (Lorestan)	Local	459	Apr-Mar 2014	Davari et al. (2017)
10.1	4.4	3.9	86.5	Iran (Hamadan)	Local	259	2015–2016	Fayazkhoo et al. (2017)
25.7	60.0	11.0	3.3	Pakistan (Balochistan)	Local	200	–	Kakar et al. (2017)
43.4	31.5	12.4	12.6	Iran (Golestan)	Local	1798	2014–2015	Sedaghat et al. (2017)
–	55.4	59.3	27.1	India (Bengal)	Local	–	Jul 2015-Jun 2016	Debbarma et al. (2018)
59.2	77.9	–	43.2	India (Mizoram)	Local	632	Apr 2017-Mar 2018	Ghosh et al. (2019)
Goats								
26.2	35.7	31.0	7.1	Iraq (Basra)	Local	505	Jan-Dec 2004	Awad and Abudl-Hussein (2005)
42.1	28.1	–	29.8	Bangladesh (Gazipur)	Local	–	Nov 2008-Oct 2009	Rony et al. (2010b)
34.6	36.5	16.1	12.7	Iran (Yazd)	Local	583	2008–2009	Salim Abadi et al. (2010)
20.0	20.0	15.5	25.0	Iran	Across	5706	Mar 2007-Feb 2008	Yakhchali et al. (2011)

Table 6 continued

STI (%)				Country (province or state)	Sampling			References
Spring	Summer	Autumn	Winter		Location	n	Date	
35.7	45.9	13.3	5.1	Iran (Golestan)	Local	255	Mar 2009-Feb 2010	Sarani et al. (2014)
29.5	24.2	39.2	7.1	Iran (Golestan)	Local	1059	2010–2011	Sofizadeh et al. (2014)
47.3	22.6	15.0	15.2	Iran (Lorestan)	Local	459	Apr-Mar 2014	Davari et al. (2017)
10.1	4.4	3.9	86.5	Iran (Hamadan)	Local	259	2015–2016	Fayazkhoo et al. (2017)
43.4	31.5	12.4	12.6	Iran (Golestan)	Local	1798	2014–2015	Sedaghat et al. (2017)
Sheep								
31.4	22.5	35.1	11.1	Iraq (Basra)	Local	505	Jan-Dec 2004	Awad and Abudl-Hussein (2005)
34.6	36.5	16.1	12.7	Iran (Yazd)	Local	583	2008–2009	Salim Abadi et al. (2010)
19.7	17.3	17.1	17.1	Iran	Across	5706	Mar 2007-Feb 2008	Yakhchali et al. (2011)
30.6	47.2	16.7	5.6	Iran (Qom)	Local	744	2010–2011	Farzinnia et al. (2012)
35.7	45.9	13.3	5.1	Iran (Golestan)	Local	255	Mar 2009-Feb 2010	Sarani et al. (2014)
29.5	24.2	39.2	7.1	Iran (Golestan)	Local	1059	2010–2011	Sofizadeh et al. (2014)
26.9	23.3	38.1	11.7	Egypt	Across	5223	Jun 2014-Jul 2016	Yassin et al. (2016)
47.3	22.6	15.0	15.2	Iran (Lorestan)	Local	459	Apr-Mar 2014	Davari et al. (2017)
10.1	4.4	3.9	86.5	Iran (Hamadan)	Local	259	2015–2016	Fayazkhoo et al. (2017)
36.0	84.0	15.3	4.7	Pakistan (Balochistan)	Local	200	–	Kakar et al. (2017)
43.4	31.5	12.4	12.6	Iran (Golestan)	Local	1798	2014–2015	Sedaghat et al. (2017)
41.3	55.9	29.6	19.3	Pakistan (Punjab)	Across	21,738	2016–2017	Batool et al. (2019)

n, sample size; and STI, seasonal tick infestations

were approximately constant during the past decades. The global trend of tick infestations in goats (Fig. 5b, c, d, f) in the northern and southern hemispheres, tropical regions, and the global world were approximately constant during the past decades. One-way ANOVA did not reveal a significant difference between annually tick infestations in buffaloes, camels, cattle, goats, and sheep ($0.905 \leq$ F ≤ 1.297; $15 \leq$ df ≤ 22; $0.243 \leq P \leq 0.584$). One-way ANOVA revealed a significant difference between the global annually tick infestations in the domestic ruminants (F = 2.172; df = 21; P = 0.002). Post hoc tests (Tukey) did not reveal a significant difference between the global annually tick infestations in the domestic ruminants ($0.11 \leq$ Mean difference ≤ 46.3; $4.9 \leq$ SEM ≤ 20.5; $0.059 \leq P$ value ≤ 1.0) (Table 8).

Global tick infestations in age categories of domestic ruminants

Based on the literature search, the global tick infestations in age categories of domestic ruminants exhibited different values for buffaloes (Fig. 8a), camels (Fig. 8b), cattle (Fig. 8c), goats (Fig. 8d), sheep (Fig. 8e), and the global domestic ruminants (Fig. 8f). In other words, the levels of interest of ticks for blood feeding on domestic ruminant change with their age categories. One-way ANOVA did not reveal a significant difference between tick infestations in buffaloes, camels, cattle, goats, and the global domestic ruminants in relation to their age categories ($0.366 \leq$ F ≤ 2.228; $4 \leq$ df ≤ 5; $0.071 \leq P \leq 0.515$) (Table 8). One-way ANOVA revealed a significant difference between tick infestations in sheep in relation to their age categories (F = 6.377; df = 4; P = 0.002) (Table 8). There was a significant difference between tick infestations in sheep in relation to their age categories of 4–5 with > 5, 3–4, and < 1 years ($29.6 \leq$ Mean difference ≤ 39.7; $7.4 \leq$ SEM ≤ 9.3; $0.003 \leq P \leq 0.005$) by post hoc tests (Tukey) (Table 9).

One-way ANOVA also revealed a significant difference between tick infestations in relation to age categories of the global annually buffaloes (F = 4.114; df = 7; P = 0.005); the world hemispheres and tropical regions, and countries of cattle ($3.782 \leq$ F ≤ 9.928; $1 \leq$ df ≤ 7; P = 0.002); the world continents and countries of sheep ($3.31 \leq$ F ≤ 9.963; $1 \leq$ df ≤ 4; $0.004 \leq P \leq 0.03$); and the global annually, hemispheres and tropical regions, and countries of the global domestic ruminants ($2.327 \leq$ F ≤ 8.185; $1 \leq$ df ≤ 11; $0.0001 \leq P \leq 0.014$) (Table 8). There was a significant difference between tick infestations in relation to age categories of the global annually of domestic ruminants between 2015 and 2007 (Mean difference = 26.8; SEM = 7.5; P = 0.019), and buffaloes between 2010 with 2007, 2014 and 2019 ($42.6 \leq$ Mean difference ≤ 57.8; $12.1 \leq$ SEM ≤ 14.6; $0.012 \leq P$

Table 7 Monthly tick infestations of domestic ruminant groups including buffaloes, camels, cattle, goats and sheep based on literature search

MTI (%) Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Buffaloes											
–	—	–	–	–	–	–	28.6	21.4	14.3	7.7	7.1
–	11.8	–	–	–	55.6	67.7	56.4	57.1	39.3	13.2	0
1.1	0.7	1.9	3.0	7.8	11.2	32.7	23.0	7.1	5.6	3.3	2.6
Camels											
9.5	9.8	9.5	4.3	9.2	11.0	9.5	4.6	4.0	9.5	9.5	9.2
60.0	61.5	56.0	60.4	62.9	56.4	64.5	–	–	–	45.5	25.6
0.94	0.94	1.9	3.8	4.7	12.3	19.8	17.9	15.1	9.4	8.5	4.7
Cattle											
–	–	–	–	–	14.6	54.9	30.5	–	–	–	–
–	–	50.0	85.0	94.0	100	90.0	–	64.0	80.0	84.0	100
2.1	0	0	20.2	21.0	17.0	7.1	2.1	14.4	7.2	3.1	5.9
1.3	2.0	5.6	17.2	17.8	12.2	16.1	4.0	6.4	11.2	4.9	1.2
8.6	10.8	–	–	–	–	–	35.1	32.4	27.8	18.9	8.3
3.4	3.6	5.6	11.2	12.9	11.8	17.5	15.1	8.9	4.8	2.4	2.5
0	0	0	1.5	18.4	10.4	28.0	19.4	15.4	6.9	0	0
–	–	–	–	–	9.2	36.7	45.9	8.3	–	–	–
0.7	0.5	2.9	17.5	22.1	20.7	16.5	4.6	5.4	4.1	2.9	1.9
7.7	0.29	0	0	8.3	18.5	17.4	0	7.7	20.8	0	19.4
0.32	0.32	5.4	3.5	3.8	10.9	29.5	26.6	7.4	5.8	5.4	1.0
Goats											
–	–	25.0	64.0	77.0	100	97.0	–	39.0	65.0	98.0	100
0	0	0	18.9	26.4	22.2	12.8	3.7	15.9	0	0	0
6.5	6.6	–	–	–	–	–	21.5	19.7	12.7	11.5	6.3
–	12.1	29.3	26.7	65.3	82.4	89.3	–	–	6.7	10.7	
–	–	–	–	–	100	23.6	30.0	–	–	–	–
9.1	11.6	7.4	1.7	0.8	5.0	3.3	9.9	13.2	3.3	19.0	15.7
0.7	0.5	2.9	17.5	22.1	20.7	16.5	4.6	5.4	4.1	2.9	1.9
1.1	1.1	3.3	4.4	6.7	8.9	21.1	16.7	13.3	12.2	6.7	4.4
Sheep											
–	–	25.0	64.0	77.0	100	97.0		39.0	65.0	98.0	100
1.5	1.8	1.5	31.0	23.9	20.4	7.4	1.1	3.3	5.0	0	3.0
20.7	10.1	10.0	1.2	0	0.23	0.29	0.15	8.9	16.4	24.1	8.1
3.1	4.5	3.4	10.8	18.5	9.7	2.6	5.7	6.0	12.2	15.1	8.4

Table 7 continued

MTI (%) Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5.1	7.9	–	–	–	–	–	25.0	20.5	17.9	7.7	5.1
2.2	0.89	1.8	7.2	5.8	14.1	16.1	17.4	22.1	5.8	3.8	2.7
7.5	–	–	–	–	39.0	60.9	–	–	–	20.0	–
3.4	3.6	5.6	11.2	12.9	11.8	17.5	15.1	8.9	4.8	2.4	2.5
11.8	12.9	19.4	21.2	22.9	–	–	–	–	–	–	11.8
0	0	0	1.5	18.4	10.4	28.0	19.4	15.4	6.9	0	0
–	–	–	–	–	1.6	0.3	0.5	–	–	–	–
2.6	27.2	24.2	13.2	17.0	9.1	4.1	1.7	0.77	0.09	0	0
–	0	0	2.8	14.6	10.8	4.1	11.8	33.1	22.8	0	0
13.1	11.8	11.1	4.4	3.4	2.4	7.4	10.4	8.4	4.0	11.4	12.1
0.7	0.5	2.9	17.5	22.1	20.7	16.5	4.6	5.4	4.1	2.9	1.9
0	0	0	1.5	1.7	2.8	2.6	3.7	2.6	1.3	0	0
0.74	0.74	2.2	3.7	6.6	10.3	28.7	21.3	8.8	7.4	5.9	3.7

MTI (%)	Country (province or state)	Sampling			References
Jan		Location	n	Date	
Buffaloes					
–	Pakistan (Peshawar)	Local	–	Aug 2003-Feb 2004	Manan et al. (2007)
–	Iraq	Across	749	Jun 2017-Feb 2018	Abed and Hasso (2019)
1.1	Pakistan (Balochistan)	Local	913	Dec 2018-Dec 2019	Bibi et al. (2020)
Camels					
9.5	Sudan	Across	51,253	2000–2001	Elghali and Hassan (2009)
60.0	Pakistan	Across	7720	Nov 2010-Jul 2011	Qamar et al. (2019)
0.94	Pakistan (Balochistan)	Local	913	Dec 2018-Dec 2019	Bibi et al. (2020)
Cattle					
–	Tunisia	Across	5097	Jun 1991-Jun 1992	Bouattour et al. (1996)
–	Greece (Macedonia)	Across	11,620	1983–1986	Papadopoulos et al. (1996)
2.1	Turkey (Burdur)	Local	3280	Sep 1999-Aug 2000	Yukari and Umur (2002)
1.3	Kenya (Nairobi)	Local	7642	1994–1995	Wesonga et al. (2006)
8.6	Pakistan (Peshawar)	Local	–	Aug 2003-Feb 2004	Manan et al. (2007)
3.4	Pakistan (Lahore)	Local	1214	1996–2000	Ahmed et al. (2012)
0	Iraq (Baghdad)	Local	521	Jan-Dec 2010	Hasson (2012)
–	Iran (Razavi Khorasan)	Local	612	Apr-Sep 2012	Riabi and Atarodi (2014)

Table 7 continued

MTI (%)	Country (province or state)	Sampling			References
Jan		Location	n	Date	
0.7	Iran (Lorestan)	Local	459	Apr-Mar 2014	Davari et al. (2017)
7.7	Argentina (Yungas)	Local	972	Jan 2012- Jun 2017	Saracho-Bottero et al. (2018)
0.32	Pakistan (Balochistan)	Local	913	Dec 2018-Dec 2019	Bibi et al. (2020)
Goats					
–	Greece (Macedonia)	Across	11,620	1983–1986	Papadopoulos et al. (1996)
0	Turkey (Burdur)	Local	3280	Sep 1999-Aug 2000	Yukari and Umur (2002)
6.5	Pakistan (Peshawar)	Local	–	Aug 2003-Feb 2004	Manan et al. (2007)
–	Pakistan (Islamabad)	Local	–	Feb-Nov 2009	Irshad et al. (2010)
–	Hungary	Across	320	Jun-Aug 2011	Hornok et al. (2012)
9.1	Sudan (South Darfur)	Local	1530	Mar 2006-Feb 2007	Yagoub et al. (2015)
0.7	Iran (Lorestan)	Local	459	Apr-Mar 2014	Davari et al. (2017)
1.1	Pakistan (Balochistan)	Local	913	Dec 2018-Dec 2019	Bibi et al. (2020)
Sheep					
–	Greece (Macedonia)	Across	11,620	1983–1986	Papadopoulos et al. (1996)
1.5	Turkey (Burdur)	Local	3280	Sep 1999-Aug 2000	Yukari and Umur (2002)
20.7	Sudan	Local	2229	–	Ahmed et al. (2005)
3.1	Kenya (Nairobi)	Local	2443	1994–1995	Wesonga et al. (2006)
5.1	Pakistan (Peshawar)	Local	–	Aug 2003-Feb 2004	Manan et al. (2007)
2.2	Iraq	Local	–	Jan 2002-Dec 2004	Tuama et al. (2007)
7.5	Pakistan (Islamabad)	Local	–	Feb-Nov 2009	Irshad et al. (2010)
3.4	Pakistan (Lahore)	Local	1214	1996–2000	Ahmed et al. (2012)
11.8	Yemen (Thamar governorate)	Local	875	Dec 2010-May 2011	Al-Shaibani (2012)
0	Iraq (Baghdad)	Local	521	Jan-Dec 2010	Hasson (2012)
–	Hungary	Across	320	Jun-Aug 2011	Hornok et al. (2012)
2.6	Iraq (Sulaymaniyah)	Local	1171	Mar 2009-Feb 2010	Kadir et al. (2012)
–	Iran (Semnan)	Local	1505	May 2010-May 2011	Changizi (2015)
13.1	Sudan (South Darfur)	Local	1530	Mar 2006-Feb 2007	Yagoub et al. (2015)
0.7	Iran (Lorestan)	Local	459	Apr-Mar 2014	Davari et al. (2017)
0	Tunisia (Gafsa)	Local	560	Oct 2013-Sep 2014	Elati et al. (2018b)
0.74	Pakistan (Balochistan)	Local	913	Dec 2018-Dec 2019	Bibi et al. (2020)

MTI, monthly tick infestations; and n, sample size

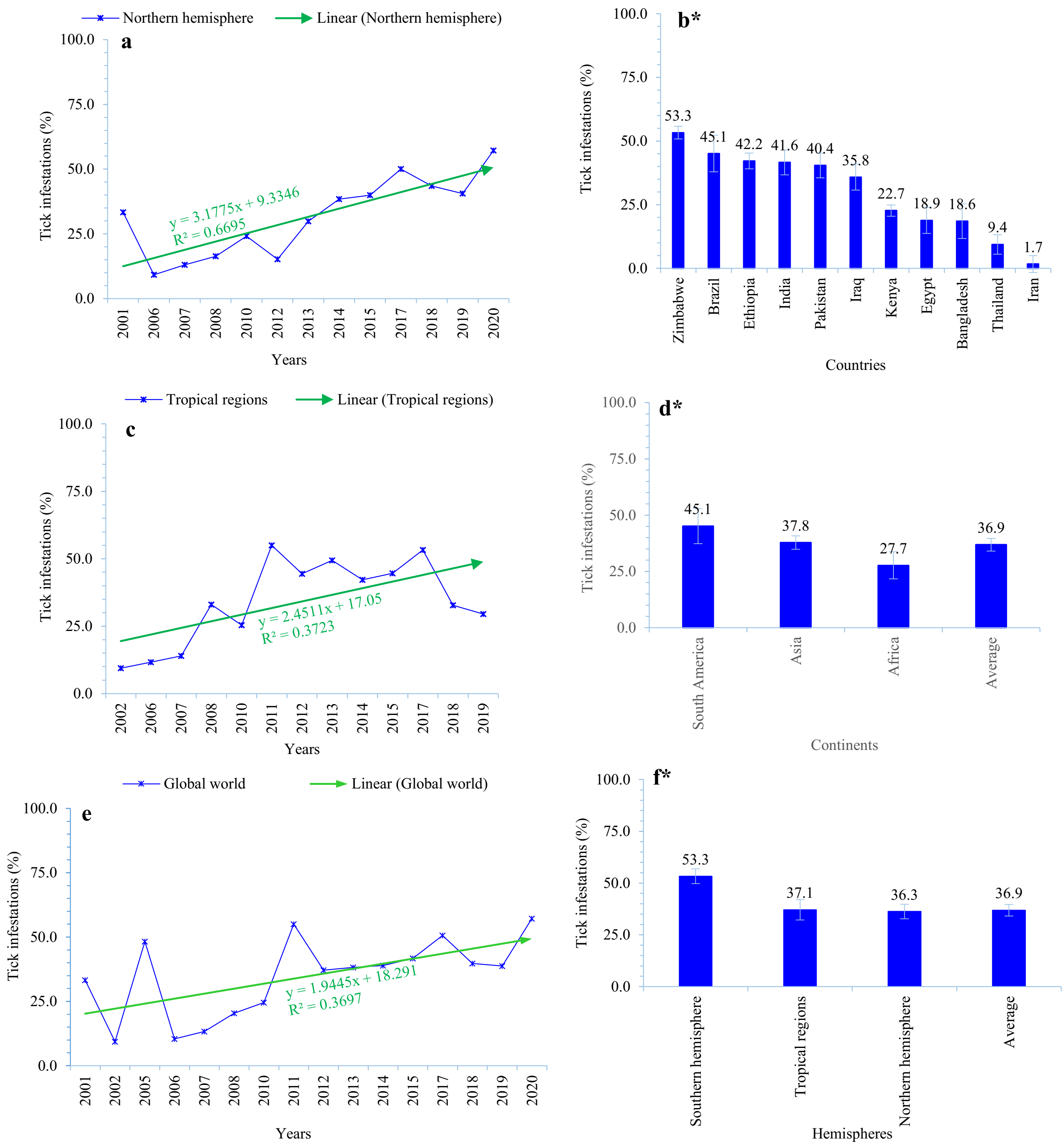

Fig. 2 Global mean and annually trend of buffalo tick infestations in the world countries, continents, hemispheres and tropical regions based on the literature search. **a** Trend of global buffalo tick infestations in northern hemisphere over time, **b** Global mean of buffalo tick infestations among countries, **c** Trend of global buffalo tick infestations in tropical regions over time, **d** Global mean of buffalo tick infestations among continents, **e** Trend of global buffalo tick infestations in the world over time, and **f** Global mean of buffalo tick infestations among the world hemispheres. *Sorted by their descending values

$\leq$ 0.033) by post hoc tests (Tukey). There was also a significant difference between tick infestations in relation to age categories of the global world countries of domestic ruminants between India and Iran (Mean difference = 21.9; SEM = 5.3; P = 0.003); cattle between India with Cameroon, Iran, Pakistan, and Ethiopia (21.6 $\leq$ Mean difference $\leq$ 46.4; 6.0 $\leq$ SEM $\leq$ 13.0; 0.004 $\leq$ P $\leq$ 0.047); and sheep between Ethiopia and Iran (Mean

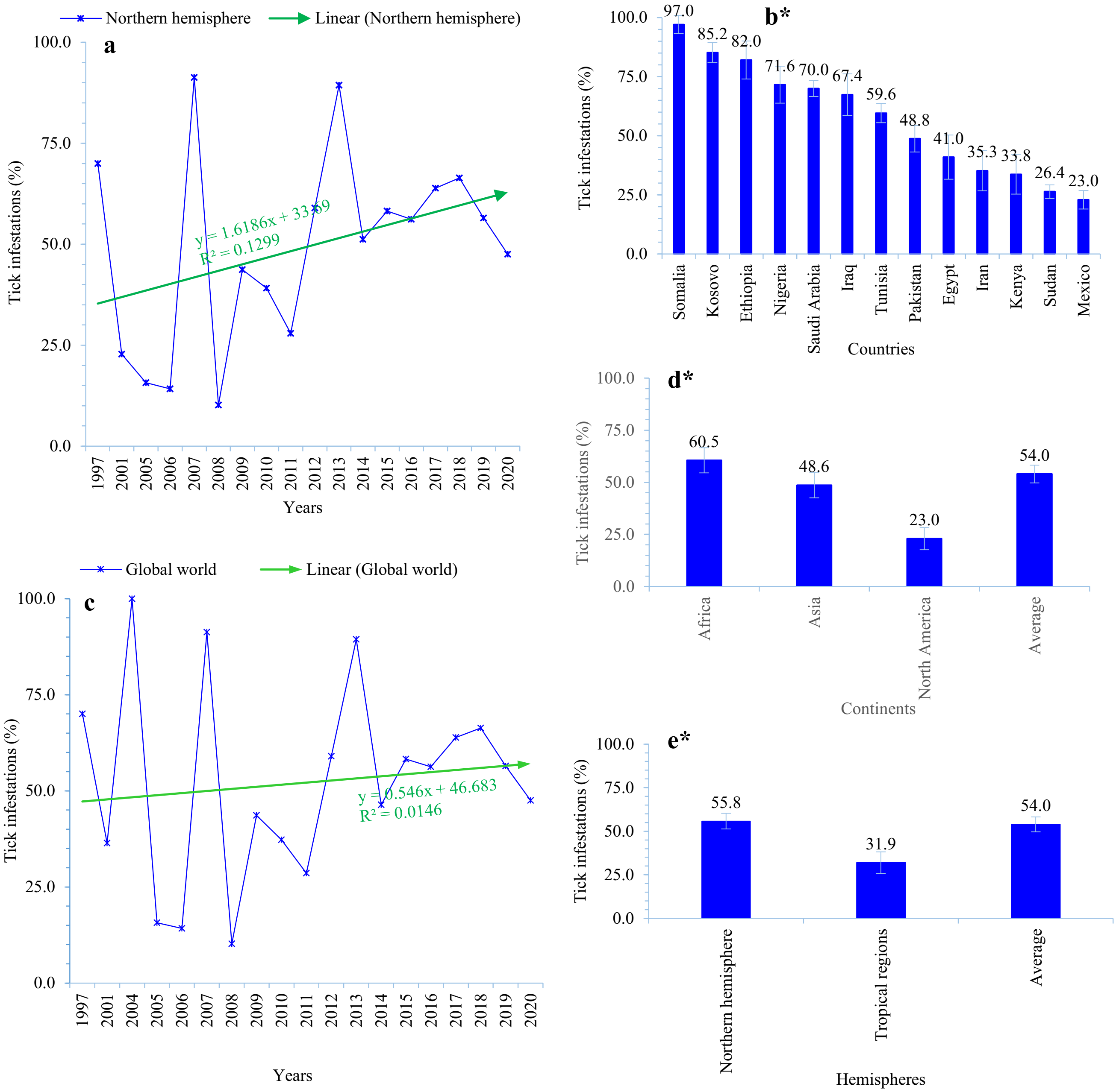

Fig. 3 Global mean and annually trend of camel tick infestations in the world countries, continents, northern hemisphere and tropical regions based on the literature search. **a** Trend of global camel tick infestations in northern hemisphere over time, **b** Global mean of camel tick infestations among countries, **c** Trend of global camel tick infestations in the world over time, **d** Global mean of camel tick infestations among continents, and **e** Global mean of camel tick infestations among the world hemispheres. *Sorted by their descending values

difference = 22.7; SEM = 7.2; $P = 0.034$) by post hoc tests (Tukey) (Table 9).

Global tick infestations in attachment sites of domestic ruminant group body parts

Based on the literature search, the global tick infestations in attachment sites of domestic ruminant body parts exhibited different values for buffaloes (Fig. 9a), camels (Fig. 9b), cattle (Fig. 9c), goats (Fig. 9d), sheep (Fig. 9e), and the global domestic ruminants (Fig. 9f). In other words, the levels of interest of ticks for blood feeding on domestic ruminants change with tick attachment sites of domestic ruminant body parts. One-way ANOVA did not reveal a significant difference between tick infestations in attachment sites of buffalo and camel body parts

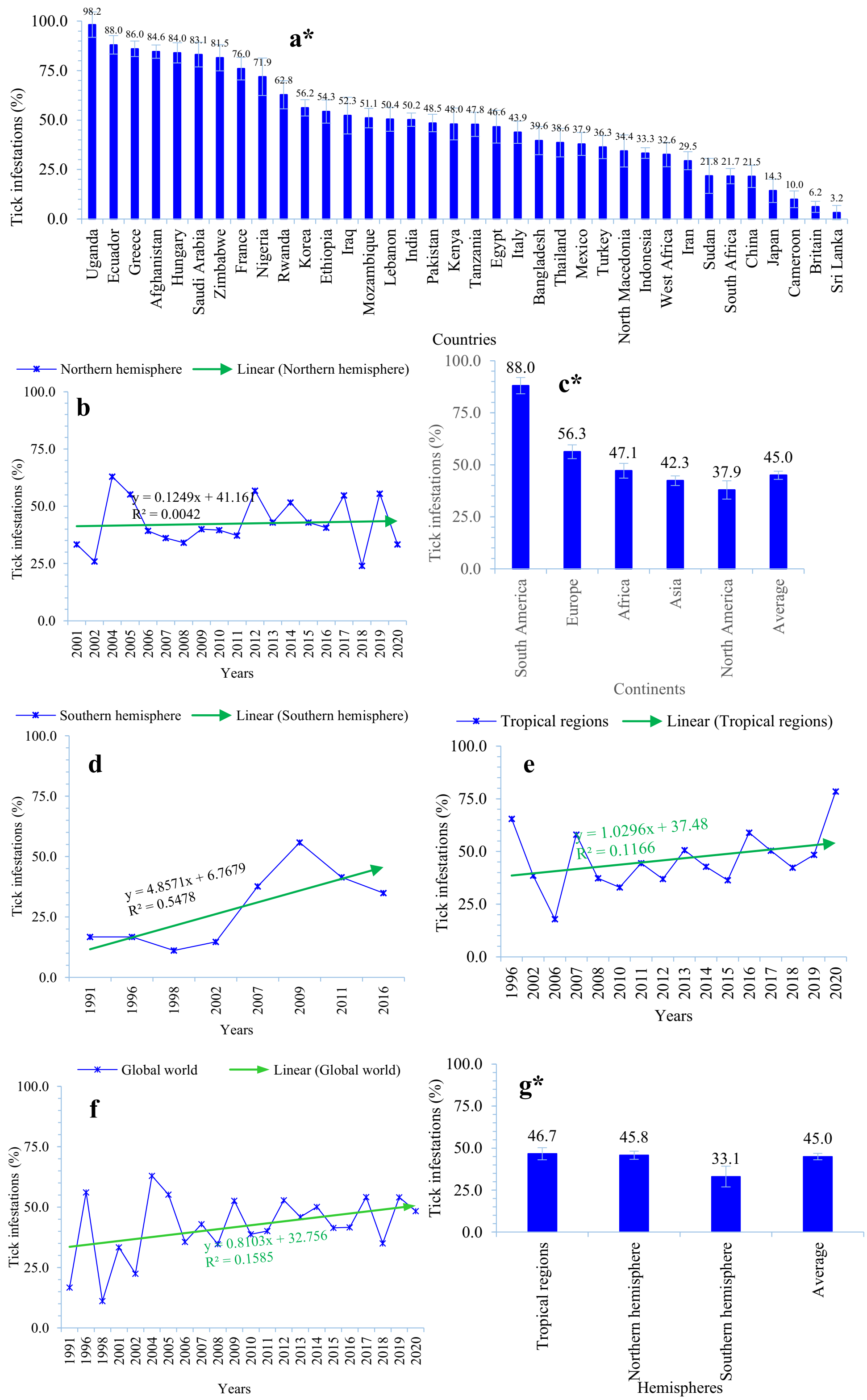

Fig. 4 Global mean and annually trend of cattle tick infestations in the world countries, continents, hemispheres and tropical regions based on the literature search. **a** Global mean of cattle tick infestations among countries, **b** Trend of global cattle tick infestations in northern hemisphere over time, **c** Global mean of cattle tick infestations among continents, **d** Trend of global cattle tick infestations in southern hemisphere over time, **e** Trend of global cattle tick infestations in tropical regions over time, **f** Trend of global cattle tick infestations in the world over time, and **g** Global mean of cattle tick infestations among the world hemispheres. *Sorted by their descending values

($1.498 \leq F \leq 1.799$; df = 5; $0.143 \leq P \leq 0.223$). One-way ANOVA revealed a significant difference between tick infestations in attachment sites of cattle, goat, sheep, and the global domestic ruminant body parts ($4.921 \leq F \leq 11.368$; df = 5; $0.0001 \leq P \leq 0.001$) (Table 8). There was a significant difference between tick infestations in relation to attachment sites of the global domestic ruminant body parts between tail and anal region, ear region and

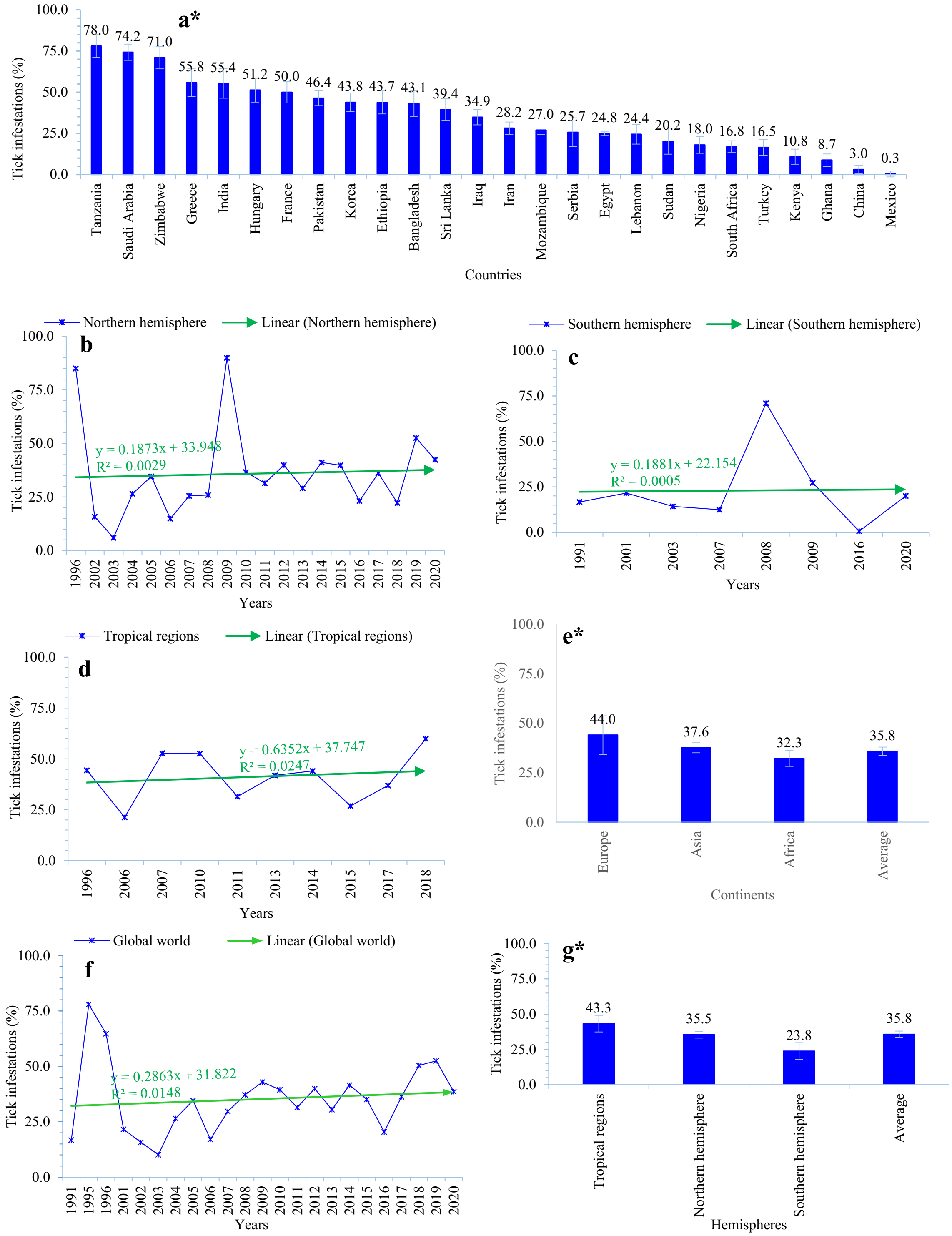

Fig. 5 Global mean and annually trend of goat tick infestations in the world countries, continents, hemispheres and tropical regions based on the literature search. **a** Global mean of goat tick infestations among countries, **b** Trend of global goat tick infestations in northern hemisphere over time, **c** Trend of global goat tick infestations in southern hemisphere over time, **d** Trend of global goat tick infestations in tropical regions over time, **e** Global mean of goat tick infestations among continents, **f** Trend of global goat tick infestations in the world over time, and **g** Global mean of goat tick infestations among the world hemispheres. *Sorted by their descending values

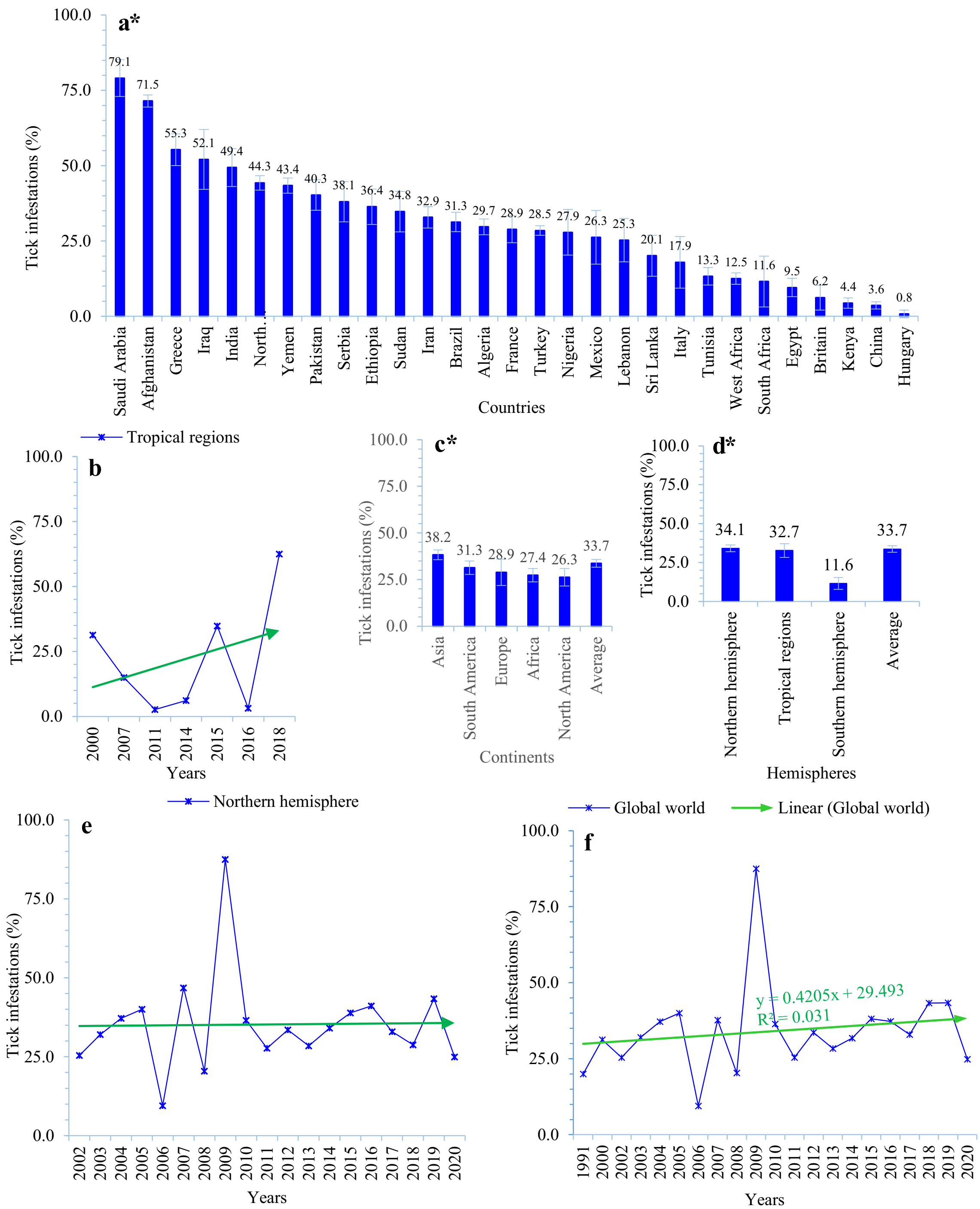

Fig. 6 Global mean and annually trend of sheep tick infestations in the world countries, continents, hemispheres and tropical regions based on the literature search. **a** Global mean of sheep tick infestations among countries, **b** Trend of global sheep tick infestations in tropical regions over time, **c** Global mean of sheep tick infestations among continents, **d** Global mean of sheep tick infestations among the world hemispheres, **e** Trend of global sheep tick infestations in northern hemisphere over time, and **f** Trend of global sheep tick infestations in the world over time. *Sorted by their descending values

scrotum or udder with dorsal surface; tail and anal region with neck and dewlap, and thigh and abdomen; ear region with neck and dewlap, and thigh and abdomen; and scrotum or udder with neck and dewlap ($9.7 \leq$ Mean difference ≤ 24.1; $3.2 \leq$ SEM ≤ 4.0; $0.0001 \leq P \leq 0.047$) by post hoc tests (Tukey) (Table 9).

There was also a significant difference between tick infestations in relation to attachment sites of body parts of

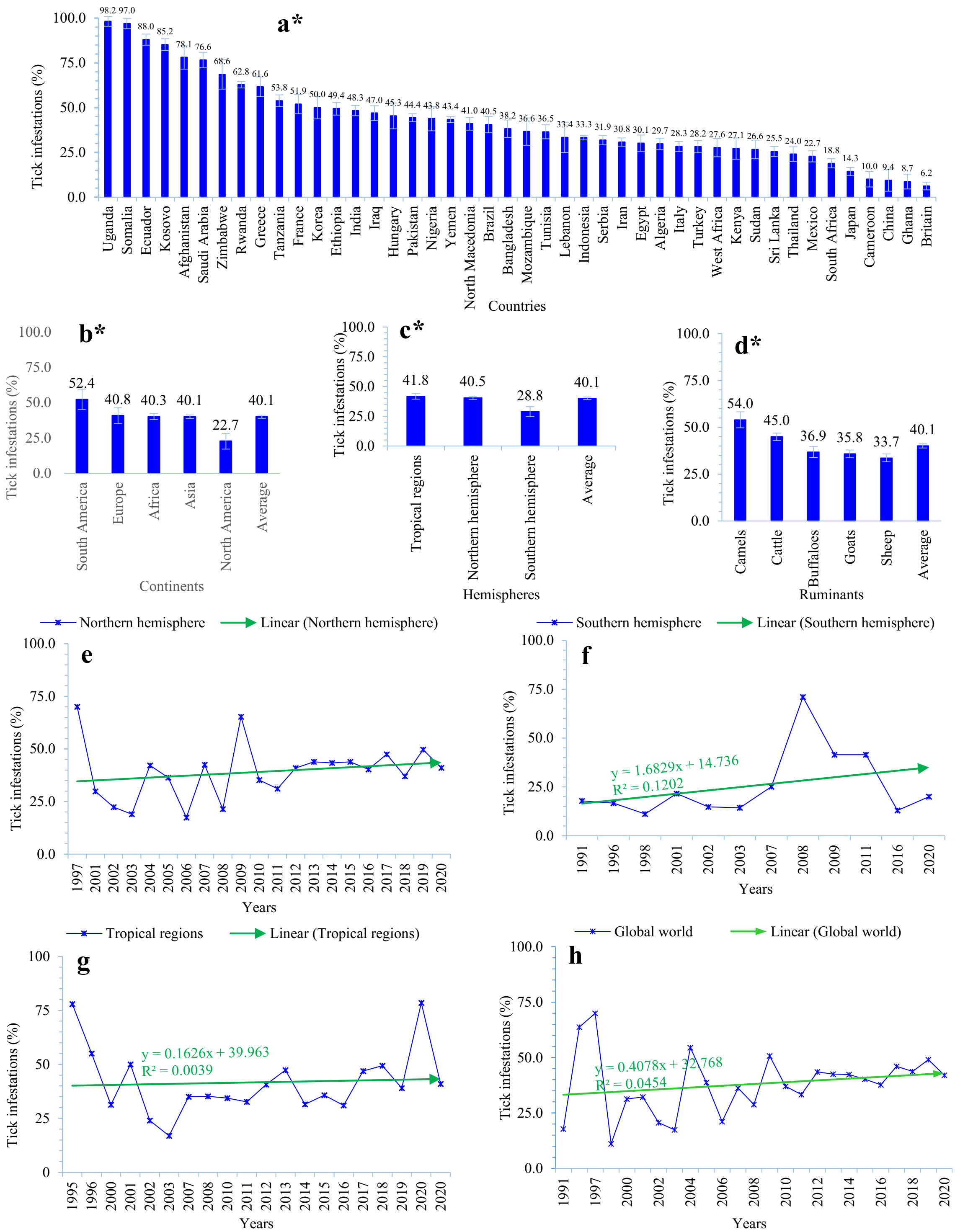

Fig. 7 Global mean and annually trend of global domestic ruminant tick infestations in the world countries, continents, hemispheres and tropical regions based on the literature search. **a** Global mean of global domestic ruminant tick infestations among countries, **b** Global mean of global domestic ruminant tick infestations among continents, **c** Global mean of global domestic ruminant tick infestations among the world hemispheres, **d** Global mean of tick infestations among global domestic ruminants in the world, **e** Trend of global domestic ruminant tick infestations in northern hemisphere over time, **f** Trend of global domestic ruminant tick infestations in southern hemisphere over time, **g** Trend of global domestic ruminant tick infestations in tropical regions over time, and **h** Trend of global domestic ruminant tick infestations in the world over time. *Sorted by their descending values

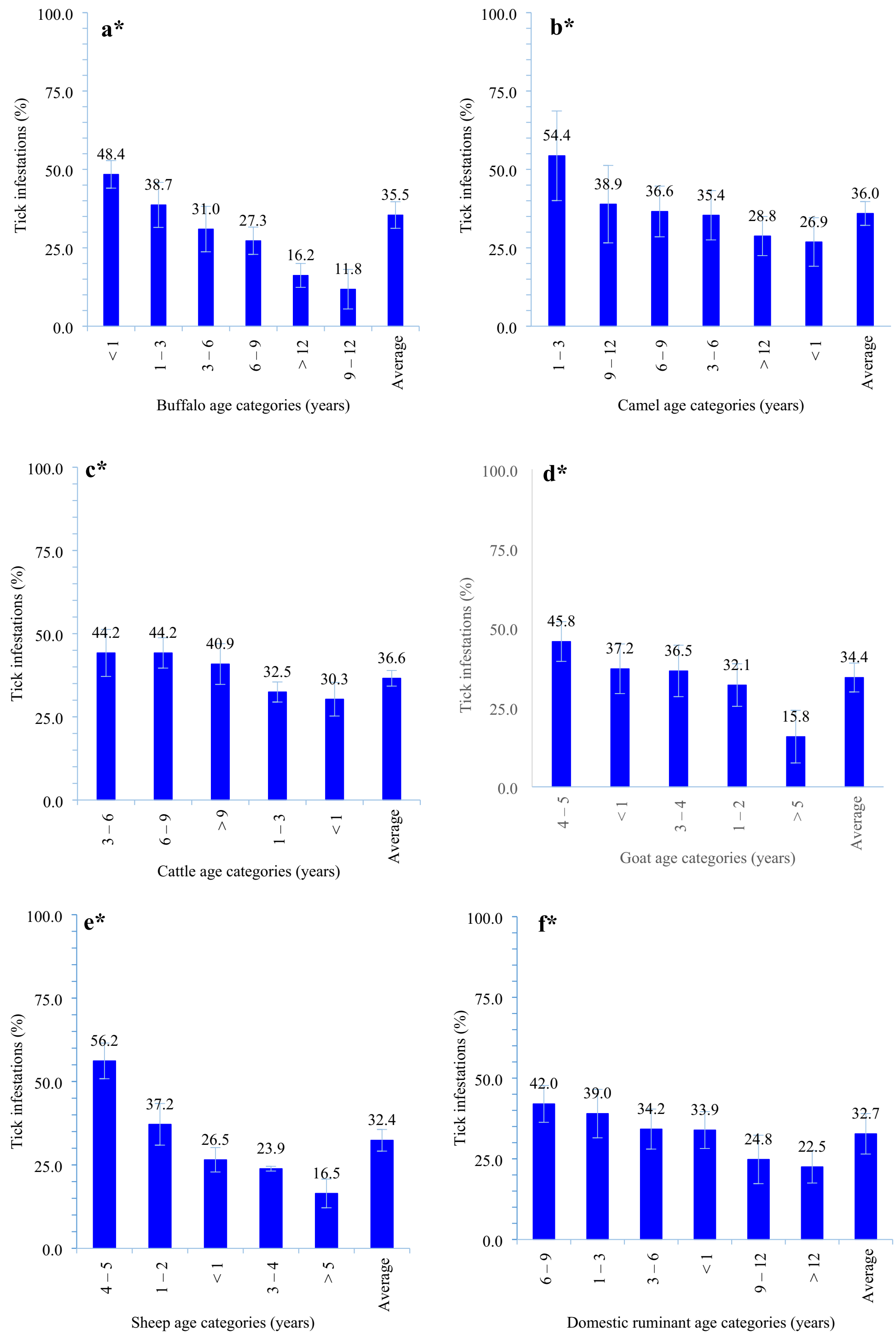

Fig. 8 Global mean tick infestations in age categories of domestic ruminant groups based on literature search. **a** Global mean tick infestations in age categories of buffaloes, **b** Global mean tick infestations in age categories of camels, **c** Global mean tick infestations in age categories of cattle, **d** Global mean tick infestations in age categories of goats, **e** Global mean tick infestations in age categories of sheep, and **f** Global mean tick infestations in age categories of global domestic ruminant. *Sorted by their descending values

cattle between tail and anal region, and scrotum or udder with dorsal surface; and tail and anal region, and scrotum or udder with ear region; goats between ear region with dorsal surface, thigh and abdomen, and scrotum or udder; and sheep between ear region with dorsal surface, neck and dewlap, and thigh and abdomen; and tail and anal region with neck and dewlap, and thigh and abdomen ($13.3 \leq$ Mean difference ≤ 36.0; $4.5 \leq$ SEM ≤ 10.2; $0.001 \leq P$

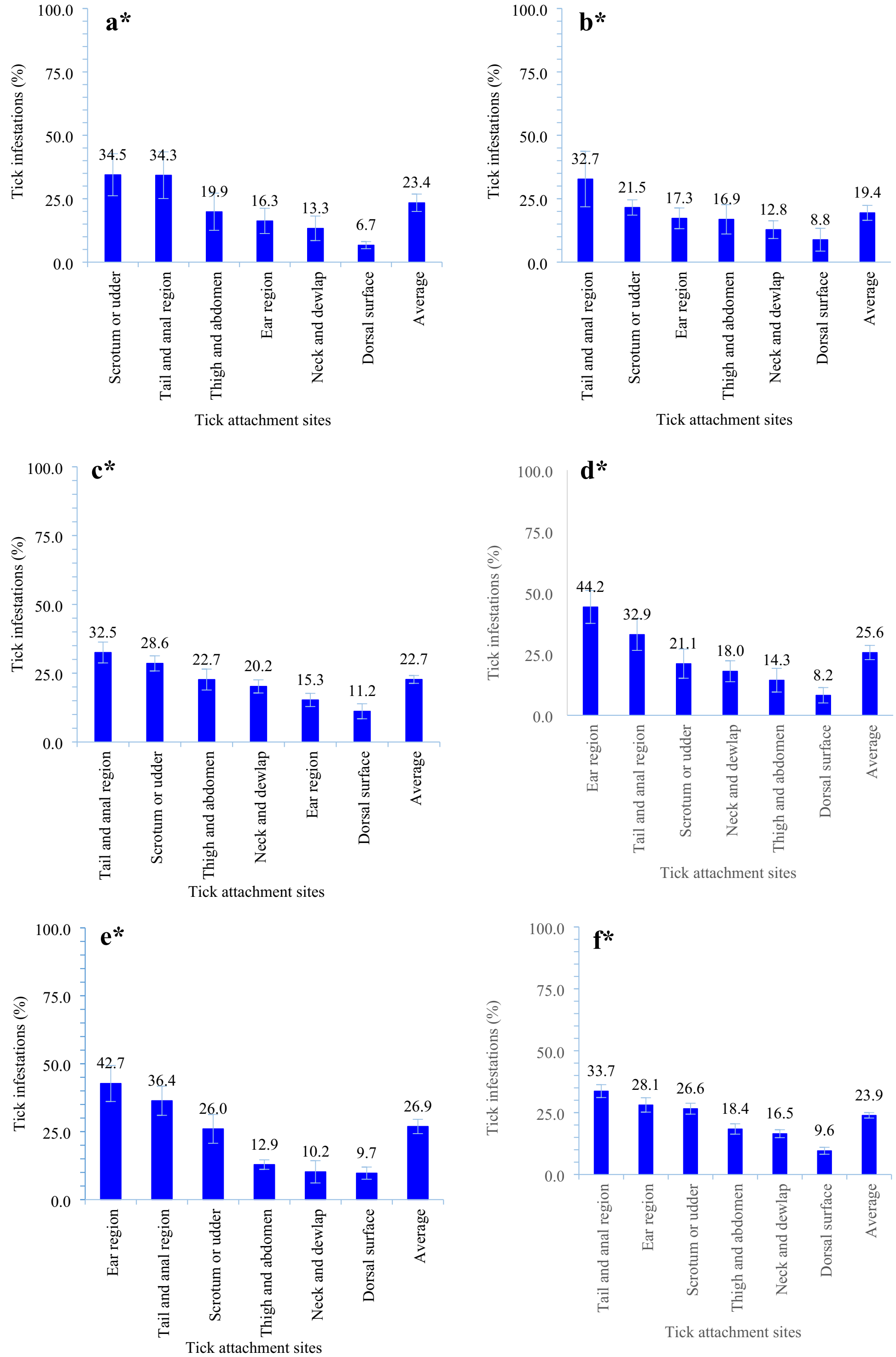

Fig. 9 Global mean tick infestations in attachment sites of domestic ruminant group body parts based on literature search. **a** Global mean tick infestations in attachment sites of buffalo body parts, **b** Global mean tick infestations in attachment sites of camel body parts, **c** Global mean tick infestations in attachment sites of cattle body parts, **d** Global mean tick infestations in attachment sites of goat body parts, **e** Global mean tick infestations in attachment sites of sheep body parts, and **f** Global mean tick infestations in attachment sites of global domestic ruminant body parts. *Sorted by their descending values

≤ 0.041) by post hoc tests (Tukey). There was a significant difference between tick infestations in relation to attachment sites of the global annually domestic ruminant body parts between 2020 with 2017 and 2013 ($18.8 \leq$ Mean difference ≤ 19.7; $5.3 \leq$ SEM ≤ 5.4; $0.027 \leq P \leq 0.035$) (Table 9) after significant difference of one-way ANOVA (F = 2.152; df = 15; $P = 0.008$) (Table 8).

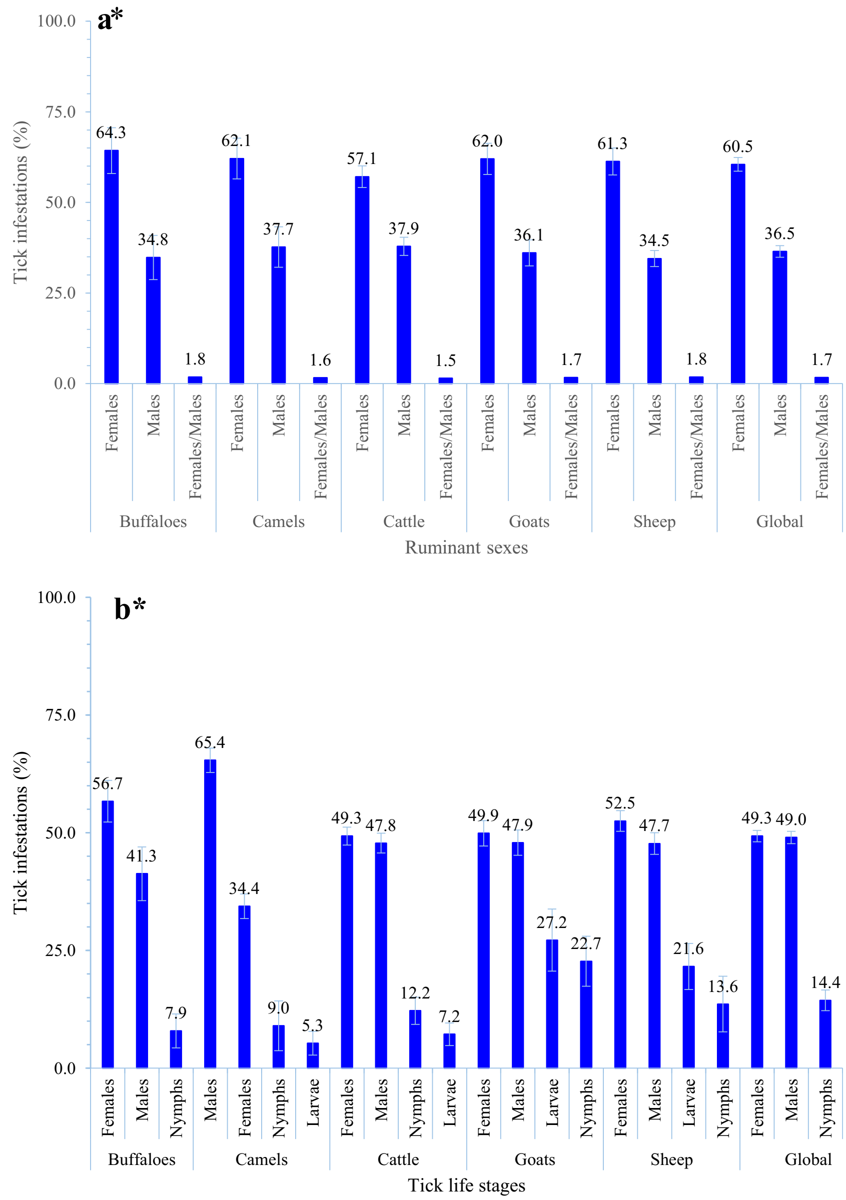

Fig. 10 Global mean tick infestations of domestic ruminant groups in relation to animal sexes and tick life stages based on literature search. **a** Global mean tick infestations of domestic ruminant groups in relation to animal sexes, and **b** Global mean tick life stage infestations of domestic ruminant groups. *Sorted by their descending values

Global tick infestations in relation to domestic ruminant group sexes and tick life stages

Based on the literature search, the global tick infestations in relation to ruminant females, males and females/males exhibited, respectively, 64.3, 62.1, 57.1, 62.0, 61.3, 60.5%; 34.8, 37.7, 37.9, 36.1, 34.5, 36.5%; and 1.8, 1.6, 1.5, 1.7, 1.8, 1.7 fold for buffaloes, camels, cattle, goats, sheep, and the global domestic ruminants (Fig. 10a). One-way ANOVA revealed a significant difference between tick infestations in relation to females and males of buffaloes, camels, cattle, goats, sheep, and the global domestic ruminants ($11.3 \leq F \leq 93.6$; $0.0001 \leq P \leq 0.004$) (Table 8). There was a significant difference between tick infestations in relation to countries of cattle between India, Ethiopia, Iran, and Pakistan with Iraq; India and Ethiopia with Cameroon ($44.3 \leq$ Mean difference ≤ 47.0; $12.5 \leq$ SEM ≤ 13.5; $0.016 \leq P \leq 0.041$) (Table 9) by post hoc tests (Tukey) after significant difference of one-way ANOVA (F = 2.93; df = 9; $P = 0.006$) (Table 8).

The females and males of tick life stages attack more buffaloes, camels, cattle, goats, sheep, and the global domestic ruminants than nymphalid and larval tick life stages (Fig. 10b). One-way ANOVA revealed a significant difference between tick life stage infestation in buffaloes, camels, cattle, goats, sheep, and the global domestic ruminants ($11.2 \leq F \leq 91.9$; $2 \leq df \leq 3$; $P = 0.0001$) (Table 8). There was a significant difference between tick

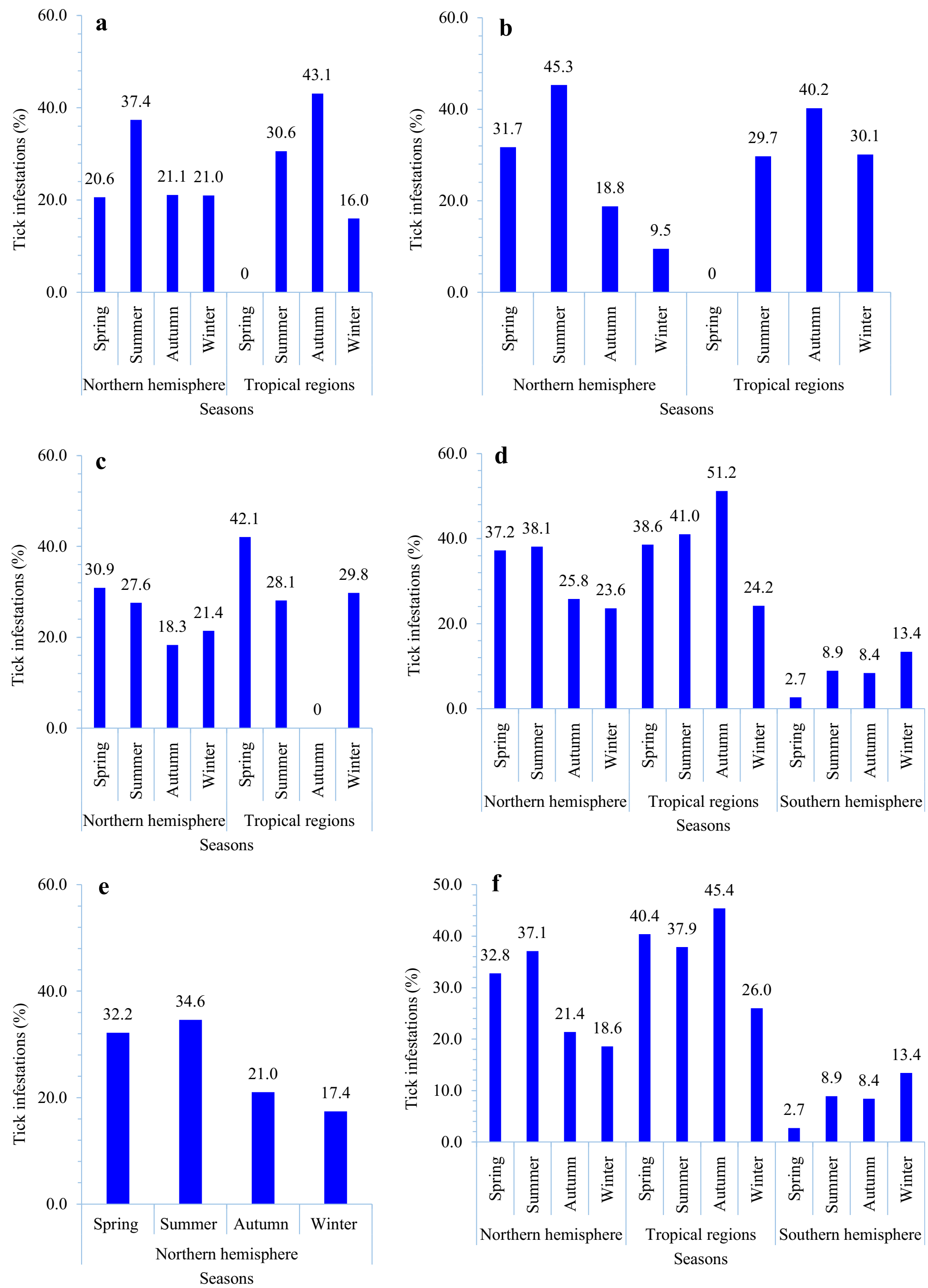

Fig. 11 Global seasonal tick infestations of domestic ruminant groups in the world hemispheres and tropical regions based on literature search. **a** Global seasonal tick infestations in buffaloes in the world northern hemisphere and tropical regions, **b** Global seasonal tick infestations in camels in the world northern hemisphere and tropical regions, **c** Global seasonal tick infestations in goats in the world northern hemisphere and tropical regions, **d** Global seasonal tick infestations in cattle in the world hemispheres and tropical regions, **e** Global seasonal tick infestations in sheep in the world northern hemisphere, and (f) Global seasonal tick infestations in global domestic ruminants in the world hemispheres and tropical regions

life stage infestation between females and males with nymphalid and or larval stages in buffaloes, camels, cattle, goats, sheep, and the global domestic ruminants ($20.6 \le$ Mean difference ≤ 56.4; $2.6 \le$ SEM ≤ 8.2; $0.0001 \le P \le 0.008$) by post hoc tests (Tukey) (Table 9).

There was a significant difference between tick life stage infestation in relation to continents in cattle between Africa and South America (Mean difference = 22.9; SEM = 7.5; $P = 0.015$), and the global domestic ruminants between Africa with South America, Europe, and Asia ($7.8 \le$ Mean difference ≤ 22.4; $2.4 \le$ SEM ≤ 7.5; $0.002 \le P \le 0.015$) by post hoc tests (Tukey) (Table 9) after significant difference of one-way ANOVA ($4.692 \le F \le 7.254$; df = 3; $0.0001 \le P \le 0.004$) (Table 8).

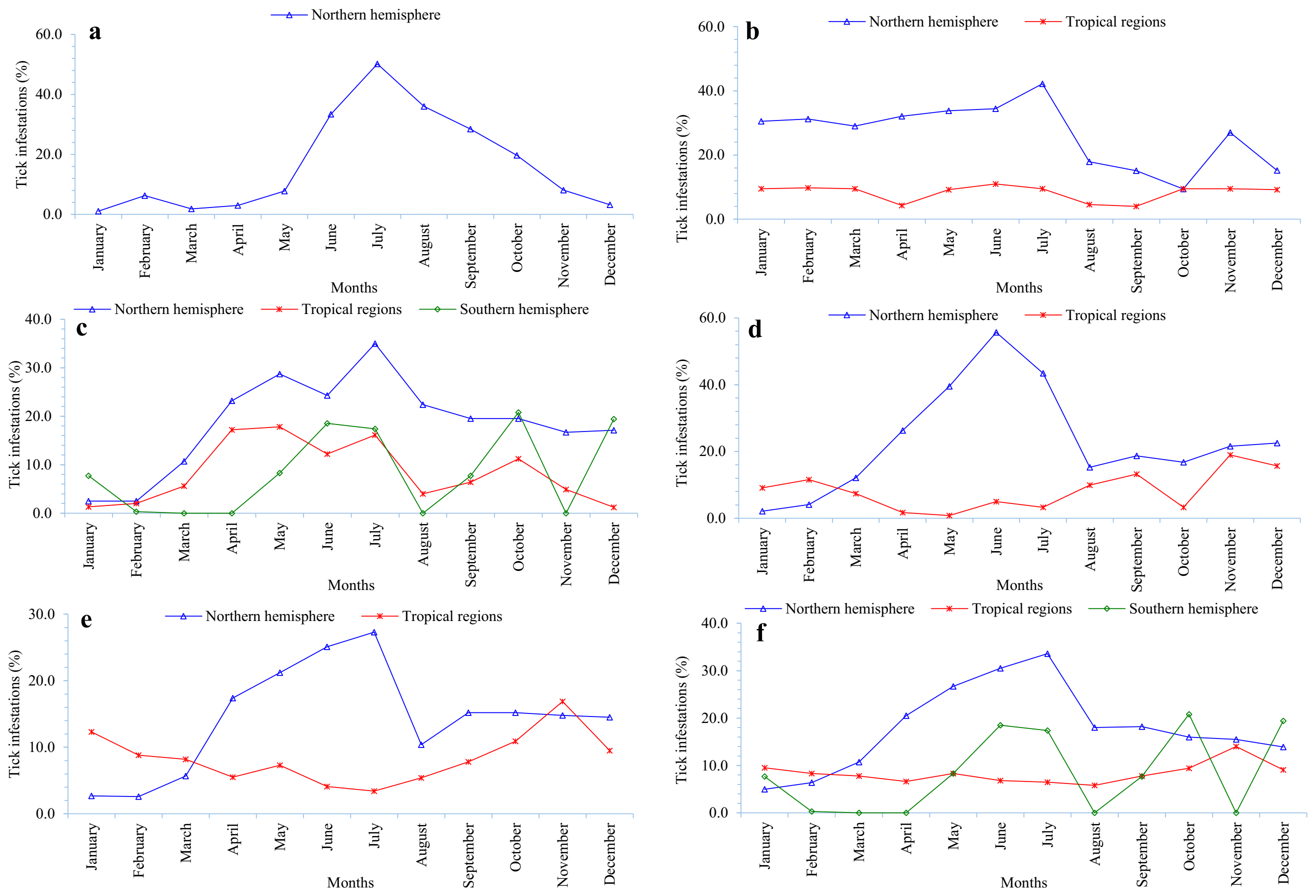

Fig. 12 Global monthly tick infestations of domestic ruminant groups in the world hemispheres and tropical regions based on literature search. **a** Global monthly tick infestations in buffaloes in the world northern hemisphere, **b** Global monthly tick infestations in camels in the world northern hemisphere and tropical regions, **c** Global monthly tick infestations in cattle in the world hemispheres and tropical regions, **d** Global monthly tick infestations in goats in the world northern hemisphere and tropical regions, **e** Global monthly tick infestations in sheep in the world northern hemisphere and tropical regions, and **f** Global monthly tick infestations in global domestic ruminants in the world hemispheres and tropical regions

Global seasonal and monthly tick infestations of domestic ruminant groups in relation to the world hemispheres and tropical regions

Based on the literature search, the global tick infestations in buffaloes, camels, cattle, sheep, and the global domestic ruminants is usually higher in summer than other seasons in the world northern hemisphere (Fig. 11a, b, d, e, f). The global tick infestations in buffaloes, camels, cattle, and the global domestic ruminants is usually higher in autumn than in other seasons in the world tropical regions (Fig. 11a, b, d, f). The global tick infestations in cattle and the global domestic ruminants is usually higher in winter than in other seasons in the world southern hemisphere (Fig. 11d, f). One-way ANOVA revealed a significant difference between global seasonal tick infestations in domestic ruminants (F = 3.79; df = 4; $P = 0.005$) (Table 8). There was a significant difference between camels and cattle with sheep tick infestations ($7.3 \leq$ Mean difference ≤ 8.1; $2.2 \leq$ SEM ≤ 2.8; $0.007 \leq P \leq 0.027$) by post hoc tests (Tukey) (Table 9). One-way ANOVA revealed a significant difference between seasonal tick infestations in buffaloes, camels, cattle, goats, and the global domestic ruminants ($3.701 \leq F \leq 13.407$; df = 3; $0.0001 \leq P \leq 0.014$) (Table 8). There was a significant difference between seasonal tick infestations in relation to the global domestic ruminants between summer and spring with winter and autumn ($7.2 \leq$ Mean difference ≤ 13.0; $2.3 \leq$ SEM ≤ 2.4; $0.0001 \leq P \leq 0.014$); buffaloes between summer and winter (Mean difference = 23.7; SEM = 7.1; $P = 0.01$); camels between summer with winter and autumn ($16.4 \leq$ Mean difference ≤ 17.8; $6.0 \leq$ SEM ≤ 6.1; $0.023 \leq P \leq 0.038$); cattle between summer and spring with winter ($13.7 \leq$ Mean difference ≤ 14.5; $5.1 \leq$ SEM ≤ 4.9; $0.018 \leq P \leq 0.39$); and goats between spring and winter (Mean difference = 15.4; SEM = 5.7; $P = 0.04$) by post hoc tests (Tukey) (Table 9). One-way ANOVA did not reveal a significant difference

Table 8 Tick and tick life stage infestation analysis of domestic ruminant groups by One-way ANOVA among domestic ruminant groups, age categories, attachment sites, and seasonal and monthly tick infestations in relation to the world hemispheres and tropical regions, continents, countries, and years

ANOVA analysis	SS	df	MS	F	*P* value	SS	df	MS	F	*P* value	SS	df	MS	F	*P* value
Between ruminants															
Ruminants	Buffaloes					Camels					Cattle				
Hemispheres	282.5	2	141.2	0.289	0.75	2104.0	1	2104.0	2.235	0.141	2170.2	2	1085.1	1.628	0.199
Continents	773.4	2	386.7	0.805	0.452	2816.6	2	1408.3	1.489	0.235	3922.6	4	980.7	1.477	0.211
Countries	5236.4	10	523.6	1.119	0.368	16,091.9	8	2011.5	2.731	**0.017**	28,586.9	18	1588.2	3.069	**0.0001**
Years	8651.9	15	576.8	1.301	0.243	20,402.4	18	1133.5	1.297	0.25	12,909.4	21	614.7	0.905	0.584
Ruminants	Goats					Sheep					Global				
Ruminants	–	–	–	–	–	–	–	–	–	–	22,762.6	4	5690.7	9.105	**0.0001**
Hemispheres	2608.8	2	1304.4	2.35	0.1	1014.2	2	507.1	0.918	0.402	3754.1	2	1877.1	2.855	0.058
Continents	2467.7	3	822.6	1.467	0.227	3625.1	4	906.3	1.677	0.159	2126.8	4	531.7	0.802	0.524
Countries	17,367.4	14	1240.5	2.740	**0.002**	20,891.0	28	746.1	1.496	0.075	67,189.9	33	2036.1	3.643	**0.0001**
Years	12,866.8	22	584.9	1.038	0.426	11,777.5	21	560.8	1.011	0.457	28,880.3	21	1375.3	2.172	**0.002***
Between age categories															
Ruminants	Buffaloes					Camels					Cattle				
Age categories	3087.8	5	617.6	1.138	0.366	5201.7	5	743.1	2.228	0.071	2661.6	4	665.4	1.84	0.132
Hemispheres	1206.0	1	1206.0	2.264	0.143	497.5	1	497.5	1.157	0.291	3330.2	1	3330.2	9.928	**0.002**
Continents	14.9	1	14.9	0.026	0.873	1.1	1	1.1	0.002	0.961	893.1	1	893.1	2.402	0.126
Countries	3708.6	3	1236.2	2.579	0.074	3482.5	4	870.6	2.403	0.077	7809.4	7	1115.6	3.782	**0.002**
Years	9257.7	7	1322.5	4.114	**0.005**	5201.7	7	743.1	2.228	0.071	3162.4	10	316.2	0.81	0.62
Ruminants	Goats					Sheep					Global				
Age categories	1649.9	4	412.5	0.845	0.515	3747.6	4	936.9	6.377	**0.002**	6405.4	5	640.5	1.625	0.103
Hemispheres	531.6	1	531.6	1.127	0.301	–	–	–	–	–	3210.1	1	3210.1	8.185	**0.005**
Continents	173.3	1	173.3	0.354	0.558	2004.3	1	2004.3	9.963	**0.004**	37.7	2	18.9	0.046	0.955
Countries	2305.5	4	576.4	1.276	0.316	2642.2	4	660.5	3.31	**0.03**	12,854.0	11	1168.5	3.265	**0.0001**
Years	3258.1	7	465.4	0.972	0.485	1845.3	6	307.6	1.172	0.362	8835.4	10	883.5	2.327	**0.014**
Between attachment sites															
Ruminants	Buffaloes					Camels					Cattle				
Attachment sites	3411.8	5	682.4	1.799	0.143	2000.0	5	400.0	1.498	0.223	6687.3	5	1337.5	5.559	**0.0001**
Hemispheres	16.7	1	16.7	0.038	0.846	747.7	1	747.7	2.739	0.108	231.8	2	115.9	0.41	0.665
Continents	0.463	1	0.463	0.001	0.974	586.3	1	586.3	2.108	0.157	386.8	1	386.8	1.384	0.242
Countries	476.2	5	95.2	0.2	0.96	1271.6	5	254.3	0.865	0.517	2150.9	9	239.0	0.844	0.577
Years	3168.1	7	452.6	1.09	0.396	1390.7	6	231.8	0.771	0.6	3732.8	13	287.1	1.027	0.43
Ruminants	Goats					Sheep					Global				
Attachment sites	8883.9	5	1776.8	4.921	**0.001**	12,777.6	5	2555.5	6.329	**0.0001**	19,280.8	5	3856.2	11.368	**0.0001**
Hemispheres	783.9	1	783.9	1.634	0.206	886.1	1	886.1	1.644	0.204	877.7	2	438.9	1.125	0.326

Table 8 continued

ANOVA analysis	SS	df	MS	F	*P* value	SS	df	MS	F	*P* value	SS	df	MS	F	*P* value
Continents	18.2	1	18.2	0.037	0.848	1304.7	2	652.3	1.207	0.305	1277.1	2	638.6	1.641	0.195
Countries	899.2	4	224.8	0.445	0.775	3334.9	6	555.8	1.025	0.417	5647.7	13	434.4	1.118	0.343
Years	2709.4	9	301.0	0.579	0.807	3691.9	10	369.2	0.648	0.767	12,001.9	15	800.1	2.152	**0.008**
Between ruminant sexes															
Ruminants	Buffaloes					Camels					Cattle				
Ruminant sexes	5242.2	1	5242.17	11.3	**0.003**	5041.1	1	5041.1	9.504	**0.004**	6689.4	1	6689.4	24.4	**0.0001**
Hemispheres	0.42	1	0.42	0.001	0.981	0.06	1	0.06	0.0001	0.992	168.9	1	168.9	0.46	0.5
Continents	–	–	–	–	–	0.37	1	0.37	0.001	0.982	16.0	1	16.0	0.043	0.836
Countries	1.8	2	0.91	0.001	0.999	3.6	7	0.51	0.001	1.0	7713.3	9	857.0	2.93	**0.006**
Years	32.0	7	4.6	0.005	1.0	2.2	11	0.20	0.0001	1.0	1993.7	12	166.1	0.411	0.954
Ruminants	Goats					Sheep					Global				
Ruminants	–	–	–	–	–	–	–	–	–	–	188.8	4	47.2	0.1	0.982
Ruminant sexes	7030.6	1	7030.6	20.887	**0.0001**	6793.8	1	6793.8	39.314	**0.0001**	30,101.0	1	30,101.0	93.6	**0.0001**
Hemispheres	6.6	1	6.6	0.013	0.91	9.4	1	9.4	0.026	0.873	109.8	1	109.8	0.236	0.628
Continents	378.7	1	378.7	0.753	0.391	233.3	1	233.3	0.657	0.423	1.8	1	1.8	0.004	0.951
Countries	1709.2	6	284.9	0.531	0.781	3054.4	6	509.1	1.584	0.185	7056.7	11	641.5	1.412	0.17
Years	3916.8	11	356.1	0.644	0.777	475.1	10	47.5	0.102	1.0	3198.4	15	213.2	0.441	0.965
Between tick life stages															
Ruminants	Buffaloes					Camels					Cattle				
Tick life stages	13,772.6	3	4590.9	23.6	**0.0001**	12,574.5	2	6287.3	66.2	**0.0001**	28,796.2	3	9598.7	44.6	**0.0001**
Hemispheres	543.1	2	271.5	0.411	0.667	85.6	1	85.6	0.163	0.689	637.9	2	319.0	0.755	0.472
Continents	1374.7	2	687.4	1.091	0.35	0.12	1	0.12	0.0001	0.988	5481.0	3	1827.0	4.692	**0.004**
Countries	1507.0	4	376.7	0.559	0.694	1490.1	9	165.6	0.256	0.98	9299.0	22	422.7	1.005	0.464
Years	833.3	6	138.9	0.183	0.979	1966.3	10	196.6	0.301	0.973	7717.8	16	482.4	1.169	0.303
Ruminants	Goats					Sheep					Global				
Ruminants	–	–	–	–	–	–	–	–	–	–	2569.7	4	642.4	1.444	0.219
Tick life stages	9827.9	3	3276.0	11.2	**0.0001**	14,940.0	3	4980.0	18.5	**0.0001**	71,051.2	3	23,683.7	91.9	**0.0001**
Hemispheres	826.4	2	413.2	1.018	0.366	243.6	2	121.8	0.279	0.757	570.4	2	285.2	0.637	0.53
Continents	1608.5	2	804.2	2.032	0.138	1028.8	2	514.4	1.204	0.305	9259.5	3	3086.5	7.254	**0.0001**
Countries	2302.4	9	255.8	0.602	0.791	3104.8	12	258.7	0.567	0.862	18,000.1	30	600.0	1.384	0.091
Years	3115.9	15	207.7	0.46	0.952	4048.6	17	238.2	0.501	0.944	13,286.1	21	632.7	1.451	0.092

Table 8 continued

ANOVA analysis	SS	df	MS	F	*P* value	SS	df	MS	F	*P* value	SS	df	MS	F	*P* value
Between seasonal infestation															
Ruminants	Buffaloes					Camels					Cattle				
Seasonal	3455.4	3	1151.8	4.307	**0.011**	4162.6	3	1387.5	3.95	**0.011**	5578.9	3	1859.6	3.701	**0.013**
Hemispheres	313.3	1	313.3	0.932	0.34	2441.1	1	2441.1	6.694	**0.012**	1422.1	2	711.0	1.354	0.261
Continents	–	–	–	–	–	1336.2	1	1336.2	3.524	0.064	20,658.4	3	6886.1	16.9	**0.0001**
Countries	4957.4	3	1652.5	7.321	**0.001**	2809.9	4	702.5	1.875	0.124	55,538.8	12	4628.2	23.0	**0.0001**
Years	6663.1	7	951.9	4.745	**0.001**	15,350.8	10	1535.1	6.947	**0.0001**	34,261.6	15	2284.1	6.536	**0.0001**
Ruminants	Goats					Sheep					Global				
Ruminants	–	–	–	–	–	–	–	–	–	–	6459.9	4	1615.0	3.79	**0.005**
Seasonal	4449.3	3	1483.1	3.7	**0.014**	2830.8	3	943.6	2.6	0.053	16,399.5	3	5466.5	13.4	**0.0001**
Hemispheres	1072.2	1	1072.2	2.5	0.115	2794.3	1	2794.3	7.8	**0.006**	2730.2	2	1365.1	3.17	**0.043**
Continents	9995.9	2	4998.0	14.9	**0.0001**	20,957.3	2	10,478.6	38.9	**0.0001**	47,264.2	3	15,754.7	44.4	**0.0001**
Countries	12,512.8	7	1787.5	5.5	**0.0001**	35,230.1	10	3523.0	17.1	**0.0001**	101,458.9	15	6763.9	25.4	**0.0001**
Years	17,738.8	10	1773.9	6.4	**0.0001**	39,429.4	14	2816.4	15.0	**0.0001**	106,007.7	17	6235.7	24.0	**0.0001**
Between monthly infestation															
Ruminants	Buffaloes					Camels					Cattle				
Monthly	5556.9	11	505.2	1.41	0.281	1439.4	11	130.9	0.19	0.997	6245.5	11	567.8	1.19	0.305
Hemispheres	–	–	–	–	–	3032.5	1	3032.5	7.3	**0.011**	1679.5	2	839.8	1.75	0.179
Continents	–	–	–	–	–	3032.5	1	3032.5	7.3	**0.011**	31,931.9	3	10,644.0	66.8	**0.0001**
Countries	–	–	–	–	–	–	–	–	–	–	33,564.5	7	4794.9	32.4	**0.0001**
Years	5428.3	2	2714.1	12.9	**0.0001**	14,116.2	2	7058.1	120.6	**0.0001**	31,311.0	8	3913.9	22.3	**0.0001**
Ruminants	Goats					Sheep					Global				
Ruminants	–	–	–	–	–	–	–	–	–	–	2732.9	4	683.2	1.58	0.178
Monthly	6986.6	11	635.1	1.33	0.234	2994.5	11	272.2	0.772	0.667	14,142.6	11	1285.7	3.15	**0.0001**
Hemispheres	1638.4	1	1638.4	3.37	0.071	1127.3	1	1127.3	3.3	0.071	6258.0	2	3129.0	7.46	**0.001**
Continents	10,870.1	2	5435.1	15.7	**0.0001**	23,372.6	2	11,686.3	59.2	**0.0001**	63,959.7	3	21,319.9	81.0	**0.0001**
Countries	13,558.3	5	2711.7	8.5	**0.0001**	35,886.9	9	3987.4	33.0	**0.0001**	81,690.8	10	8169.1	37.3	**0.0001**
Years	18,890.2	7	2698.6	11.5	**0.0001**	37,245.0	10	3724.5	33.2	**0.0001**	108,157.0	13	8319.8	56.6	**0.0001**

*Tukey was not significant between the global annually world domestic ruminant tick infestation ($0.11 \leq$ Mean difference ≤ 46.3; $4.9 \leq$ Std. error ≤ 20.5; $0.059 \leq P$ value ≤ 1.0). The *P* value of significant ($P < 0.05$) are shown in bold font style. MS, Mean square; and SS, Sum of squares

Table 9 Post hoc tests (Tukey) tick and tick life stage infestation analysis in domestic ruminant groups after One-way ANOVA significant among domestic ruminant groups, age categories, attachment sites, and seasonal and monthly tick infestation in relation to the world hemispheres and tropical regions, continents, countries, and years

Global: ruminants		MD[a]	SE	*P* value	Global: countries		MD[a]	SE	*P* value
Tukey analysis									
Between global ruminants									
Camels	Sheep	20.3*	4.1	**0.0001**	Iraq	South Africa	28.1*	6.7	**0.013**
	Goats	18.1*	4.1	**0.0001**	Pakistan	South Africa	25.5*	6.0	**0.009**
	Buffaloes	17.1*	4.7	**0.003**	Ethiopia	Iran	18.6*	3.6	**0.0001**
Cattle	Sheep	11.3*	2.9	**0.001**	India	Iran	17.6*	4.3	**0.02**
	Goats	9.1*	2.9	**0.015**	Pakistan	Iran	13.6*	3.4	**0.031**
Global: countries					Camels: countries				
Saudi Arabia	China	67.2*	16.7	**0.026**	Ethiopia	Iran	46.8	12.2	**0.012**
	South Africa	57.7*	11.1	**0.0001**	Cattle: countries				
	Kenya	49.5*	12.0	**0.018**	Nigeria	South Africa	50.2*	12.5	**0.012**
	Turkey	48.4*	11.2	**0.008**		Iran	42.4*	11.1	**0.023**
	Egypt	46.5*	10.8	**0.009**	Ethiopia	South Africa	32.6*	8.5	**0.021**
	Iran	45.8*	9.9	**0.002**		Iran	24.9*	6.3	**0.014**
Ethiopia	South Africa	30.6*	6.1	**0.0001**	Goats: countries				
India	South Africa	29.5*	6.5	**0.003**	India	South Africa	38.5	11.0	**0.047**
Between age categories									
Global: countries					Cattle: countries				
India	Iran	21.9	5.3	**0.003**	India	Cameroon	46.4*	13.0	**0.016**
Global: years						Iran	31.0*	7.7	**0.004**
2015	2007	26.8	7.5	**0.019**		Pakistan	23.5*	7.4	**0.047**
Buffaloes: years						Ethiopia	21.6*	6.0	**0.013**
2010	2019	57.8*	14.6	**0.012**	Sheep: age categories				
	2007	51.9*	14.6	**0.031**	4–5 years	> 5 years	39.7*	9.3	**0.003**
	2014	42.6*	12.1	**0.033**		3–4 years	32.3*	8.6	**0.009**
Sheep: countries						< 1 year	29.6*	7.4	**0.005**
Ethiopia	Iran	22.7	7.2	**0.034**					
Between attachment sites									
Global: attachment sites					Goats: attachment sites				
Tail and anal region	Dorsal surface	24.1*	4.0	**0.0001**	Ear region	Dorsal surface	36.0*	8.9	**0.002**
Ear region	Dorsal surface	18.5*	4.0	**0.0001**		Thigh and abdomen	29.9*	8.5	**0.012**
Tail and anal region	Neck and dewlap	17.2*	3.4	**0.0001**		Scrotum or udder	23.1*	7.6	**0.041**
Scrotum or udder	Dorsal surface	16.9*	4.1	**0.001**	Sheep: attachment sites				
Tail and anal region	Thigh and abdomen	15.3*	3.2	**0.0001**	Ear region	Dorsal surface	33.0*	10.2	**0.021**
Ear region	Neck and dewlap	11.6*	3.4	**0.009**		Neck and dewlap	32.5*	8.2	**0.002**
Scrotum or udder	Neck and dewlap	10.0*	3.5	**0.047**		Thigh and abdomen	29.8*	7.2	**0.001**
Ear region	Thigh and abdomen	9.7*	3.2	**0.035**	Tail and anal region	Neck and dewlap	26.2*	8.3	**0.027**
Cattle: attachment sites						Thigh and abdomen	23.5*	7.3	**0.021**
Tail and anal region	Dorsal surface	21.3*	5.4	**0.001**	Global: years				
Scrotum or udder	Dorsal surface	17.4*	5.6	**0.026**	2020	2017	19.7*	5.4	**0.027**
Tail and anal region	Ear region	17.2*	4.2	**0.001**		2013	18.8*	5.3	**0.035**
Scrotum or udder	Ear region	13.3*	4.5	**0.039**					
Between ruminant sexes									
Cattle: countries					Cattle: countries				
India	Iraq	47.0*	13.5	**0.029**	India	Cameroon	45.4*	13.5	**0.041**
Ethiopia	Iraq	46.0*	12.5	**0.016**	Pakistan	Iraq	45.1*	13.2	**0.036**
Iran	Iraq	46.0*	13.5	**0.037**	Ethiopia	Cameroon	44.3*	12.5	**0.024**

Table 9 continued

Global: ruminants		MD[a]	SE	*P* value	Global: countries		MD[a]	SE	*P* value
Between tick life stages									
Global: tick life stages					Cattle: tick life stages				
Females	Nymphs	34.9*	2.6	**0.0001**	Males	Nymphs	35.6*	4.2	**0.0001**
Males	Nymphs	34.7*	2.6	**0.0001**	Goats: tick life stages				
Females	Larvae	32.5*	3.3	**0.0001**	Females	Nymphs	27.2*	5.7	**0.0001**
Males	Larvae	32.2*	3.3	**0.0001**	Males	Nymphs	25.2*	5.7	**0.0001**
Buffaloes: tick life stages					Females	Larvae	22.7*	6.3	**0.003**
Females	Nymphs	48.9*	6.9	**0.0001**	Males	Larvae	20.6*	6.3	**0.008**
Females	Larvae	51.4*	8.2	**0.0001**	Sheep: tick life stages				
Males	Nymphs	33.4*	6.9	**0.0001**	Females	Nymphs	38.9*	5.8	**0.0001**
Males	Larvae	35.9*	8.2	**0.001**	Males	Nymphs	34.1*	5.8	**0.0001**
Camels: tick life stages					Females	Larvae	31.0*	7.8	**0.001**
Males	Nymphs	56.4*	5.5	**0.0001**	Males	Larvae	26.1*	7.8	**0.007**
Males	Females	31.0*	3.7	**0.0001**	Global: continents				
Females	Nymphs	25.5*	5.5	**0.0001**	Africa	South America	22.4*	6.3	**0.002**
Cattle: tick life stages					Africa	Europe	12.2*	4.1	**0.015**
Females	Larvae	42.1*	5.5	**0.0001**	Africa	Asia	7.8*	2.4	**0.007**
Males	Larvae	40.6*	5.5	**0.0001**	Cattle: continents				
Females	Nymphs	37.0*	4.2	**0.0001**	Africa	South America	22.9*	7.5	**0.015**
Between seasonal infestation									
Global: ruminants					Buffaloes: years				
Camels	Sheep	8.1*	2.8	**0.027**	2019	2007	27.2*	8.3	**0.046**
Cattle	Sheep	7.3*	2.2	**0.007**	Camels: years				
Global: seasonal					2019	2009	46.5*	6.6	**0.0001**
Summer	Winter	13.0*	2.3	**0.0001**	2019	2020	46.4*	6.6	**0.0001**
Spring	Winter	12.0*	2.4	**0.0001**	2019	2010	29.8*	8.9	**0.05**
Summer	Autumn	8.2*	2.3	**0.003**	2019	2012	29.8*	7.2	**0.005**
Spring	Autumn	7.2*	2.4	**0.014**	2019	2014	29.8*	7.2	**0.005**
Buffaloes: seasonal					2019	2015	29.8*	8.9	**0.05**
Summer	Winter	23.7	7.1	**0.01**	2019	2016	26.2*	7.5	**0.032**
Camels: seasonal					2019	2017	24.8*	7.2	**0.038**
Summer	Winter	17.8*	6.1	**0.023**	Cattle: continents				
Summer	Autumn	16.4*	6.0	**0.038**	Europe	South America	49.9*	9.2	**0.0001**
Goats: seasonal					Europe	Asia	42.1*	6.1	**0.0001**
Spring	Winter	15.4*	5.7	**0.04**	Europe	Africa	35.2*	7.2	**0.0001**
Cattle: seasonal					Cattle: countries				
Summer	Winter	14.5*	4.9	**0.018**	Ethiopia	Kenya	73.1*	8.2	**0.0001**
Spring	Winter	13.7*	5.1	**0.039**	Greece	Kenya	72.6*	6.5	**0.0001**
Global: hemispheres					Ethiopia	Turkey	72.3*	8.3	**0.0001**
Northern hemisphere	Southern hemisphere	9.5*	7.4	**0.408**	Greece	Turkey	71.8*	6.6	**0.0001**
Northern hemisphere	Tropical regions	5.1*	2.3	**0.066**	Ethiopia	Argentina	68.9*	8.7	**0.0001**
Tropical regions	Southern hemisphere	4.4*	7.6	**0.833**	Greece	Argentina	68.4*	7.1	**0.0001**
Global: continents					Ethiopia	Pakistan	67.2*	7.5	**0.0001**
Europe	South America	44.9*	7.4	**0.0001**	Greece	Pakistan	66.7*	5.5	**0.0001**
Europe	Africa	42.4*	3.8	**0.0001**	Ethiopia	Iraq	63.2*	8.3	**0.0001**
Europe	Asia	37.5*	3.4	**0.0001**	Greece	Iraq	62.7*	6.6	**0.0001**
Global: countries					Ethiopia	Iran	60.7*	7.4	**0.0001**

Table 9 continued

Global: ruminants		MD[a]	SE	*P* value	Global: countries		MD[a]	SE	*P* value
Ethiopia	Kenya	73.1*	8.8	**0.0001**	Greece	Iran	60.2*	5.5	**0.0001**
Ethiopia	Sudan	71.4*	8.5	**0.0001**	Ethiopia	Egypt	56.4*	10.0	**0.0001**
Ethiopia	Turkey	70.7*	8.7	**0.0001**	Ethiopia	Italy	56.1*	10.0	**0.0001**
Ethiopia	Hungary	70.2*	11.0	**0.0001**	Greece	Egypt	55.9*	8.7	**0.0001**
Ethiopia	Tunisia	69.8*	9.7	**0.0001**	Greece	Italy	55.5*	8.7	**0.0001**
Ethiopia	Argentina	68.9*	10.0	**0.0001**	Ethiopia	Tunisia	48.1*	10.8	**0.001**
Ethiopia	Yemen	64.8*	10.5	**0.0001**	Greece	Tunisia	47.5*	9.6	**0.0001**
Greece	Kenya	64.7*	4.8	**0.0001**	Ethiopia	Bangladesh	46.8*	9.5	**0.0001**
Ethiopia	Pakistan	63.5*	8.3	**0.0001**	Greece	Bangladesh	46.3*	8.1	**0.0001**
Greece	Sudan	63.0*	4.1	**0.0001**	Ethiopia	India	37.6*	8.2	**0.001**
Greece	Turkey	62.3*	4.6	**0.0001**	Greece	India	37.1*	6.5	**0.0001**
Greece	Hungary	61.8*	8.1	**0.0001**	India	Kenya	35.5*	5.8	**0.0001**
Greece	Tunisia	61.4*	6.2	**0.0001**	India	Turkey	34.7*	5.9	**0.0001**
Ethiopia	Iran	61.4*	8.3	**0.0001**	India	Argentina	31.3*	6.5	**0.0001**
Greece	Argentina	60.5*	6.7	**0.0001**	India	Pakistan	29.6*	4.7	**0.0001**
Ethiopia	Iraq	60.3*	8.5	**0.0001**	Bangladesh	Kenya	26.3*	7.6	**0.036**
Greece	Yemen	56.3*	7.5	**0.0001**	India	Iraq	25.6*	5.9	**0.002**
Ethiopia	Italy	56.1*	11.5	**0.0001**	India	Iran	23.1*	4.6	**0.0001**
Greece	Pakistan	55.1*	3.6	**0.0001**	Cattle: years				
Ethiopia	Egypt	54.7*	9.2	**0.0001**	1996	2020	58.9*	8.0	**0.0001**
Greece	Iran	52.9*	3.6	**0.0001**	1996	2002	58.8*	8.0	**0.0001**
Ethiopia	Bangladesh	51.9*	9.7	**0.0001**	1996	2006	55.3*	7.3	**0.0001**
Greece	Iraq	51.8*	4.1	**0.0001**	2019	2020	51.1*	12.2	**0.005**
Greece	Italy	47.7*	8.8	**0.0001**	2019	2002	51.0*	12.2	**0.005**
Greece	Egypt	46.3*	5.4	**0.0001**	1996	2017	49.9*	6.7	**0.0001**
Greece	Bangladesh	43.4*	6.2	**0.0001**	1996	2007	47.6*	9.0	**0.0001**
Ethiopia	India	40.9*	9.0	**0.001**	2019	2006	47.5*	11.8	**0.008**
Greece	India	32.5*	5.1	**0.0001**	1996	2018	45.9*	8.0	**0.0001**
India	Kenya	32.2*	5.1	**0.0001**	1996	2012	45.1*	6.9	**0.0001**
India	Sudan	30.5*	4.5	**0.0001**	1996	2005	42.9*	10.9	**0.012**
India	Turkey	29.8*	4.9	**0.0001**	1996	2014	42.9*	7.8	**0.0001**
India	Hungary	29.3*	8.3	**0.035**	1996	2016	42.9*	8.7	**0.0001**
India	Tunisia	28.9*	6.4	**0.001**	2019	2017	42.1*	11.4	**0.025**
India	Argentina	28.0*	6.9	**0.006**	1996	2010	39.4*	9.0	**0.003**
India	Pakistan	22.6*	4.1	**0.0001**	1996	2011	38.0*	9.5	**0.009**
Bangladesh	Kenya	21.2*	6.1	**0.048**	Goats: continents				
India	Iran	20.4*	4.0	**0.0001**	Europe	Africa	44.2*	8.4	**0.0001**
Bangladesh	Sudan	19.6*	5.7	**0.047**	Europe	Asia	32.7*	6.8	**0.0001**
India	Iraq	19.3*	4.5	**0.002**	Goats: countries				
Egypt	Sudan	16.7*	4.8	**0.045**	Greece	Sudan	52.8*	9.0	**0.0001**
Iraq	Sudan	11.2*	3.2	**0.048**	Greece	Turkey	44.5*	10.4	**0.001**
Iran	Sudan	10.1*	2.6	**0.013**	Greece	Pakistan	42.4*	8.1	**0.0001**
Global: years					Greece	Iran	41.5*	7.9	**0.0001**
1996	2009	60.1*	5.6	**0.0001**	Greece	Iraq	36.2*	11.7	**0.05**
1996	2020	60.0*	3.8	**0.0001**	Goats: years				
1996	2002	57.7*	4.4	**0.0001**	1996	2020	52.8*	8.3	**0.0001**
1996	2006	57.7*	4.4	**0.0001**	1996	2015	52.8*	8.3	**0.0001**

Table 9 continued

Global: ruminants		MD[a]	SE	*P* value	Global: countries		MD[a]	SE	*P* value
1996	2015	57.0*	4.2	**0.0001**	1996	2007	49.1*	9.3	**0.0001**
1996	2007	55.4*	4.1	**0.0001**	1996	2002	44.5*	9.6	**0.001**
1996	2012	51.3*	3.7	**0.0001**	1996	2017	44.3*	7.6	**0.0001**
1996	2018	49.3*	4.6	**0.0001**	1996	2011	41.0*	10.8	**0.011**
1996	2017	49.2*	3.6	**0.0001**	1996	2005	36.2*	10.8	**0.043**
1996	2005	48.4*	4.3	**0.0001**	1996	2014	36.2*	9.0	**0.006**
1996	2011	44.8*	5.3	**0.0001**	1996	2012	34.4*	13.6	**0.306**
1996	2014	43.4*	4.1	**0.0001**	2010	2020	26.5*	6.5	**0.004**
1996	2016	42.3*	4.6	**0.0001**	2010	2015	26.5*	6.5	**0.004**
2019	2009	40.4*	5.7	**0.0001**	Sheep: continents				
2019	2020	40.3*	4.0	**0.0001**	Europe	Africa	46.6*	5.3	**0.0001**
1996	2010	38.6*	4.1	**0.0001**	Europe	Asia	39.7*	4.9	**0.0001**
2019	2002	38.0*	4.5	**0.0001**	Asia	Africa	6.9*	2.8	**0.038**
2019	2006	37.9*	4.5	**0.0001**	Sheep: countries				
2019	2015	37.3*	4.3	**0.0001**	Greece	Hungary	73.1*	9.6	**0.0001**
2019	2007	35.7*	4.3	**0.0001**	Greece	Tunisia	71.6*	7.2	**0.0001**
1996	2013	35.1*	9.8	**0.04**	Greece	Kenya	65.6*	6.3	**0.0001**
1996	2008	33.9*	7.3	**0.001**	Greece	Sudan	65.2*	5.6	**0.0001**
2019	2012	31.6*	3.8	**0.0001**	Greece	Turkey	64.8*	6.5	**0.0001**
2019	2018	29.6*	4.7	**0.0001**	Greece	Iraq	60.8*	5.6	**0.0001**
2019	2017	29.5*	3.8	**0.0001**	Greece	Pakistan	57.3*	5.3	**0.0001**
2019	2005	28.7*	4.5	**0.0001**	Greece	Yemen	57.2*	7.6	**0.0001**
2008	2020	26.0*	6.9	**0.02**	Greece	Iran	56.3*	5.1	**0.0001**
2019	2011	25.1*	5.5	**0.001**	Greece	Egypt	48.9*	8.6	**0.0001**
2019	2014	23.7*	4.3	**0.0001**	Sheep: years				
2019	2016	22.6*	4.8	**0.0001**	1996	2018	71.6*	6.9	**0.0001**
2010	2009	21.5*	5.4	**0.009**	1996	2006	65.6*	6.1	**0.0001**
2010	2020	21.3*	3.4	**0.0001**	1996	2020	65.5*	6.1	**0.0001**
1996	2019	19.7*	4.6	**0.003**	1996	2002	64.8*	6.2	**0.0001**
2010	2002	19.1*	4.1	**0.0001**	1996	2015	63.4*	5.6	**0.0001**
2010	2006	19.0*	4.1	**0.0001**	1996	2007	63.0*	5.5	**0.0001**
2019	2010	18.9*	4.3	**0.002**	1996	2012	61.9*	5.0	**0.0001**
2010	2015	18.3*	3.8	**0.0001**	1996	2005	60.5*	5.8	**0.0001**
2016	2020	17.6*	4.0	**0.001**	1996	2011	56.1*	8.2	**0.0001**
2010	2007	16.8*	3.7	**0.001**	1996	2017	54.4*	5.3	**0.0001**
2014	2020	16.5*	3.4	**0.0001**	1996	2014	48.9*	6.7	**0.0001**
2014	2002	14.3*	4.1	**0.048**	1996	2016	48.9*	8.2	**0.0001**
2014	2006	14.2*	4.1	**0.049**	1996	2010	45.5*	6.7	**0.0001**
2014	2015	13.6*	3.8	**0.043**	1996	2019	37.4*	8.2	**0.001**
2010	2012	12.7*	3.3	**0.014**	2019	2018	34.2*	8.6	**0.008**
Buffaloes: countries					2019	2006	28.2*	7.9	**0.034**
Iraq	Pakistan	23.2*	5.6	**0.001**	2019	2020	28.2*	7.9	**0.035**
India	Pakistan	20.6*	7.0	**0.026**	2010	2018	26.1*	7.1	**0.024**
Buffaloes: years					2019	2015	26.0*	7.5	**0.049**
2019	2020	34.7*	6.7	**0.0001**	2019	2007	27.2*	8.3	**0.046**

Table 9 continued

Global: ruminants		MD[a]	SE	*P* value	Global: countries		MD[a]	SE	*P* value
Between monthly infestation									
Global: monthly					Cattle: countries				
July	January	21.9*	5.1	**0.001**	Greece	Tunisia	41.3*	8.1	**0.0001**
July	February	20.8*	5.1	**0.003**	Tunisia	Kenya	25.0*	7.9	**0.04**
July	December	18.2*	5.2	**0.025**	Cattle: years				
Global: hemispheres					1996	2017	56.0	5.4	**0.0001**
Northern hemisphere	Tropical regions	10.4	2.7	**0.0001**	1996	2006	56.0	5.4	**0.0001**
Global: continents					1996	2020	55.3	5.5	**0.0001**
Europe	Africa	53.1*	3.6	**0.0001**	1996	2002	55.2	5.5	**0.0001**
Europe	South America	49.5*	6.5	**0.0001**	1996	2012	53.8	4.9	**0.0001**
Europe	Asia	47.6*	3.2	**0.0001**	1996	2018	51.8	6.1	**0.0001**
Asia	Africa	5.5*	2.1	**0.042**	1996	2007	44.1	6.3	**0.0001**
Global: countries					1996	2014	39.3	7.7	**0.0001**
Greece	Kenya	64.7*	4.3	**0.0001**	Goats: continents				
Greece	Sudan	64.5*	3.8	**0.0001**	Europe	Africa	44.2*	8.5	**0.0001**
Greece	Iran	62.5*	3.7	**0.0001**	Europe	Asia	36.7*	7.1	**0.0001**
Greece	Turkey	62.3*	4.2	**0.0001**	Goats: countries				
Greece	Hungary	61.8*	7.3	**0.0001**	Greece	Iran	52.9*	8.9	**0.0001**
Greece	Tunisia	61.4*	5.6	**0.0001**	Greece	Sudan	52.8*	8.9	**0.0001**
Greece	Argentina	60.5*	6.1	**0.0001**	Greece	Turkey	44.5*	10.3	**0.001**
Greece	Pakistan	57.3*	3.3	**0.0001**	Greece	Pakistan	42.4*	8.0	**0.0001**
Greece	Yemen	56.3*	6.8	**0.0001**	Goats: years				
Greece	Iraq	54.8*	4.0	**0.0001**	1996	2017	52.9*	7.7	**0.0001**
Global: years					1996	2020	52.8*	7.7	**0.0001**
1996	2018	60.7	3.9	**0.0001**	1996	2015	52.8*	7.7	**0.0001**
1996	2009	60.1	4.2	**0.0001**	1996	2007	49.1*	8.5	**0.0001**
1996	2017	60.1	3.1	**0.0001**	1996	2002	44.5*	8.9	**0.0001**
1996	2006	60.1	3.4	**0.0001**	2010	2017	32.0*	7.0	**0.001**
1996	2020	60.0	2.9	**0.0001**	2010	2020	32.0*	7.0	**0.001**
1996	2005	59.3	4.4	**0.0001**	2010	2015	32.0*	7.0	**0.001**
1996	2015	58.7	3.2	**0.0001**	2010	2007	28.2*	7.9	**0.016**
1996	2002	57.7	3.3	**0.0001**	Sheep: continents				
1996	2012	57.3	2.9	**0.0001**	Europe	Africa	48.1*	4.6	**0.0001**
1996	2007	55.4	3.1	**0.0001**	Europe	Asia	44.5*	4.3	**0.0001**
1996	2014	43.4	6.5	**0.0001**	Sheep: countries				
2019	2018	41.9	4.4	**0.0001**	Greece	Hungary	73.1*	7.3	**0.0001**
2019	2009	41.3	4.6	**0.0001**	Greece	Tunisia	71.6*	5.5	**0.0001**
2019	2017	41.3	3.6	**0.0001**	Greece	Kenya	65.6*	4.8	**0.0001**
2019	2006	41.3	3.9	**0.0001**	Greece	Sudan	65.2*	4.3	**0.0001**
2019	2020	41.2	3.4	**0.0001**	Greece	Turkey	64.8*	4.9	**0.0001**
2019	2005	40.5	4.7	**0.0001**	Greece	Iran	63.6*	4.2	**0.0001**
2019	2015	39.9	3.7	**0.0001**	Greece	Iraq	63.4*	4.4	**0.0001**
2019	2002	38.9	3.8	**0.0001**	Greece	Pakistan	62.2*	4.1	**0.0001**
2019	2012	38.5	3.4	**0.0001**	Greece	Yemen	57.2*	5.8	**0.0001**
2019	2007	36.6	3.6	**0.0001**	Sheep: years				
1996	2010	30.9	4.2	**0.0001**	1996	2018	71.6*	5.3	**0.0001**
2019	2014	24.6	6.8	**0.022**	1996	2020	65.9*	4.6	**0.0001**

Table 9 continued

Global: ruminants		MD[a]	SE	*P* value	Global: countries		MD[a]	SE	*P* value
1996	2019	18.8	3.9	**0.0001**	1996	2017	65.6*	4.7	**0.0001**
Buffaloes: years					1996	2006	65.6*	4.7	**0.0001**
2019	2020	34.7*	6.9	**0.0001**	1996	2002	64.8*	4.8	**0.0001**
2019	2007	27.2*	8.5	**0.012**	1996	2005	64.8*	4.8	**0.0001**
Camels: years					1996	2007	63.9*	4.3	**0.0001**
2019	2009	46.5*	3.4	**0.0001**	1996	2015	63.4*	4.3	**0.0001**
2019	2020	46.4*	3.4	**0.0001**	1996	2012	63.3*	3.9	**0.0001**
Cattle: continents					1996	2010	42.0*	6.4	**0.0001**
Europe	Asia	62.8*	4.5	**0.0001**	2010	2018	29.5*	6.6	**0.001**
Europe	South America	62.2*	6.1	**0.0001**	2010	2020	23.9*	6.1	**0.006**
Europe	Africa	61.3*	5.3	**0.0001**	2010	2017	23.5*	6.1	**0.008**
Cattle: countries					2010	2006	23.5*	6.1	**0.008**
Greece	Kenya	66.3*	5.4	**0.0001**	2010	2002	22.8*	6.2	**0.014**
Greece	Turkey	65.6*	5.5	**0.0001**	2010	2005	22.7*	6.2	**0.014**
Greece	Pakistan	62.7*	4.6	**0.0001**	2010	2007	21.9*	5.8	**0.011**
Greece	Iran	62.2*	5.1	**0.0001**	2010	2015	21.3*	5.8	**0.015**
Greece	Argentina	62.2*	5.9	**0.0001**	2010	2012	21.3*	5.6	**0.009**
Greece	Iraq	60.4*	6.1	**0.0001**					

*The mean difference is significant at the 0.05 level. The *P* value of significant ($P < 0.05$) are shown in bold font style. Tukey analyses which are not significant are not shown ($P > 0.05$)

[a]Sorted by their descending values. MD, Mean difference; and SE, Std. error

between seasonal tick infestations in sheep (F = 2.608; df = 3; *P* = 0.053) (Table 8).

One-way ANOVA also revealed a significant difference between seasonal tick infestations in relation to the global annually and countries of buffaloes ($4.745 \leq F \leq 7.321$; $3 \leq df \leq 7$; $P = 0.001$); global annually and hemispheres of camels ($6.694 \leq F \leq 6.947$; $1 \leq df \leq 10$; $0.0001 \leq P \leq 0.012$); global annually, continents and countries of cattle and goats ($5.483 \leq F \leq 23.0$; $2 \leq df \leq 15$; $P = 0.0001$); global annually, hemispheres, continents and countries of sheep and the global domestic ruminants ($3.171 \leq F \leq 44.4$; $1 \leq df \leq 17$; $0.043 \leq P \leq 0.006$) (Table 8).

There was a significant difference between seasonal tick infestations in relation to the global annually and countries of buffaloes between 2019 with 2020 and 2007, and Iraq and India with Pakistan ($20.6 \leq$ Mean difference ≤ 34.7; $5.6 \leq SEM \leq 8.3$; $0.0001 \leq P \leq 0.046$); global annually of camels between 2019 with 2009, 2010, 2012, 2014, 2015, 2016, 2017, and 2020 ($24.8 \leq$ Mean difference ≤ 46.5; $6.6 \leq SEM \leq 8.9$; $0.0001 \leq P \leq 0.038$); global annually, continents and countries of cattle and goats between 1996 with 2002, 2005, 2007, 2011, 2012, 2014, 2015, 2017, and 2018; 2010 with 2015 and 2020; 2019 with 2002, 2006, 2017, and 2020; Europe with South America, Asia, and Africa; Bangladesh with Kenya; Ethiopia, Greece and India with Argentina, Bangladesh, Egypt, India, Iran, Iraq, Italy, Kenya, Pakistan, Tunisia and Turkey; Greece with Sudan, Turkey, Pakistan, Iran and Iraq ($73.1 \leq$ Mean difference ≤ 23.1; $4.7 \leq SEM \leq 12.2$; $0.0001 \leq P \leq 0.043$); global annually, hemispheres, continents and countries of sheep and the global domestic ruminants between some years and countries; northern hemisphere with southern hemisphere and tropical regions, tropical regions with southern hemisphere; Europe with South America, Africa and Asia; and Asia with Africa ($6.9 \leq$ Mean difference ≤ 73.1; $2.6 \leq SEM \leq 11.5$; $0.0001 \leq P \leq 0.049$) by post hoc tests (Tukey) (Table 9).

Based on the literature search, the global monthly domestic ruminant group tick infestations usually starts from January, gradually increases from March to July, and then gradually decreases from July to December during the year in the world northern hemisphere. The global monthly domestic ruminant group tick infestations usually starts from January, and approximately continues with degrees of ups and downs fluctuation from January to December during the year in the world tropical regions (Fig. 12). The global monthly domestic ruminant group tick infestations usually starts from January, suddenly decreases from February to April, and then approximately increases from

Table 10 Descriptive tick and tick life stage infestation analysis in domestic ruminant groups after One-way ANOVA significant among domestic ruminant groups, age categories, attachment sites, and seasonal and monthly tick infestation in relation to the world hemispheres and tropical regions, continents, countries, and years

Global: ruminants	Mean[a]	SD	SE
Descriptives			
Ruminants			
Camels	54.0	31.0	4.3
Cattle	45.0	25.9	2.0
Buffaloes	36.9	21.8	2.8
Goats	35.8	23.8	2.1
Sheep	33.7	23.5	2.0
Global: countries			
Afghanistan	78.1	9.3	6.6
Saudi Arabia	76.6	10.7	4.4
Zimbabwe	68.6	14.3	8.2
Greece	61.6	32.5	14.5
Tanzania	53.8	36.3	16.2
France	51.9	25.5	11.4
Korea	50.0	8.8	6.2
Ethiopia	49.4	30.7	3.5
India	48.3	19.2	2.9
Iraq	47.0	24.7	4.1
Hungary	45.3	41.9	24.2
Pakistan	44.4	22.1	2.3
Nigeria	43.8	31.2	6.8
North Macedonia	41.0	6.2	3.6
Brazil	40.5	38.0	22.0
Bangladesh	38.2	18.9	4.9
Mozambique	36.6	17.0	7.6
Tunisia	36.5	36.9	18.4
Lebanon	33.4	14.8	8.5
Serbia	31.9	20.7	10.3
Iran	30.8	22.3	2.2
Egypt	30.1	21.8	4.5
Italy	28.3	24.1	10.8
Turkey	28.2	13.9	3.4
West Africa	27.6	26.3	13.2
Kenya	27.1	19.7	5.9
Sudan	26.6	12.8	5.2
Sri Lanka	25.5	31.0	15.5
Thailand	24.0	20.6	14.6
Mexico	22.7	22.8	10.2
South Africa	18.8	11.1	2.6
Cameroon	10.0	6.0	4.3
China	9.4	10.5	6.1
Britain	6.2	0.0001	0.0001
Camels: countries			
Ethiopia	82.0	22.7	8.0
Nigeria	71.6	29.6	14.8

Camels: countries	Mean[a]	SD	SE
Saudi Arabia	70.0	19.7	13.9
Iraq	67.4	31.0	13.8
Tunisia	59.6	43.8	31.0
Pakistan	48.8	22.4	10.0
Egypt	41.0	24.8	9.4
Iran	35.3	30.7	8.5
Kenya	33.8	14.5	8.4
Cattle: countries			
Saudi Arabia	83.1	19.7	13.9
France	76.0	18.1	12.8
Nigeria	71.9	21.2	9.5
Ethiopia	54.3	29.6	5.8
Iraq	52.3	24.6	9.3
Mozambique	51.1	20.4	14.5
India	50.2	14.3	3.4
Pakistan	48.5	22.2	4.4
Kenya	48.0	13.9	8.0
Tanzania	47.8	38.9	19.5
Egypt	46.6	18.6	8.3
Italy	43.9	32.8	23.2
Bangladesh	39.6	18.9	7.1
Turkey	36.3	15.4	5.8
West Africa	32.6	29.8	17.2
Iran	29.5	23.6	4.5
Sudan	21.8	12.6	8.9
South Africa	21.7	12.1	3.8
Cameroon	10.0	6.0	4.3
Goats: countries			
Greece	55.8	41.4	29.3
India	55.4	25.6	9.1
Pakistan	46.4	21.0	4.6
Ethiopia	43.7	30.3	7.0
Bangladesh	43.1	19.0	7.8
Sri Lanka	39.4	44.5	31.5
Iraq	34.9	13.3	4.7
Iran	28.2	18.1	3.7
Mozambique	27.0	4.4	2.5
Serbia	25.7	12.4	8.8
Egypt	24.8	1.6	1.2
Nigeria	18.0	12.4	5.1
South Africa	16.8	9.6	3.6
Turkey	16.5	10.8	4.8
Kenya	10.8	6.5	4.6

Table 10 continued

Global: ruminants	Mean[a]	SD	SE	Camels: countries	Mean[a]	SD	SE
Age categories							
Global: hemispheres				Buffaloes: years			
Tropical regions	42.4	23.7	3.4	2017	34.7	15.6	11.0
Northern hemisphere	32.8	18.2	1.6	2014	25.0	17.3	6.1
Global: countries				2007	15.7	8.2	4.7
Somalia	69.0	17.3	12.2	2019	9.8	7.3	4.2
India	48.1	26.3	5.6	Cattle: hemispheres			
Bangladesh	47.7	20.5	6.5	Tropical regions	46.1	20.9	4.3
Ethiopia	38.2	18.2	2.7	Northern hemisphere	31.5	16.8	2.5
Brazil	33.3	22.4	12.9	Cattle: countries			
Egypt	33.3	14.3	8.2	India	56.3	20.2	5.6
Pakistan	32.4	19.5	3.2	Bangladesh	34.8	14.7	6.6
Sudan	30.8	18.2	5.0	Ethiopia	34.8	17.9	3.7
Nigeria	28.4	12.5	5.1	Egypt	33.3	14.3	8.2
Iran	26.2	13.4	2.4	Sudan	33.3	16.5	6.7
Yemen	25.0	15.0	7.5	Pakistan	32.8	17.5	5.8
Cameroon	10.0	8.3	5.9	Iran	25.4	11.4	4.0
Global: years				Cameroon	10.0	8.3	5.9
2015	45.9	24.2	5.3	Sheep: age categories			
2010	43.0	18.0	3.9	4–5 years	56.2	10.7	5.3
2017	39.7	21.5	6.8	1–2 years	37.2	16.5	6.2
2019	37.9	23.5	6.5	< 1 year	26.5	10.3	3.7
2018	37.1	22.0	5.9	3–4 years	23.9	1.4	0.71
2020	36.9	13.1	3.4	> 5 years	16.5	13.4	7.7
2012	36.4	20.9	4.9	Sheep: continents			
2013	30.7	22.2	5.1	Africa	44.5	15.7	5.2
2014	28.6	20.4	4.5	Asia	26.0	13.3	3.2
2011	28.1	7.8	1.9	Sheep: countries			
2007	19.1	8.1	2.6	Ethiopia	50.0	13.3	5.4
Buffaloes: years				Nigeria	33.4	16.5	9.5
2010	67.6	8.1	4.6	Iran	27.4	13.6	4.1
2015	63.3	39.2	27.7	Yemen	25.0	15.0	7.5
2020	47.3	8.0	4.6	Pakistan	20.5	15.1	10.7
2018	40.2	22.5	8.5				
Attachment sites							
Global: attachment sites				Sheep: attachment sites			
Tail and anal region	33.7	21.8	2.6	Tail and anal region	36.4	22.2	5.4
Ear region	28.1	23.8	2.9	Scrotum or udder	26.0	20.5	5.3
Scrotum or udder	26.6	17.4	2.2	Thigh and abdomen	12.9	6.5	1.7
Thigh and abdomen	18.4	16.1	2.1	Neck and dewlap	10.2	12.3	4.1
Neck and dewlap	16.5	11.9	1.6	Dorsal surface	9.7	5.0	2.2
Dorsal surface	9.6	7.9	1.4	Global: years			
Cattle: attachment sites				2020	36.0	17.8	3.6
Tail and anal region	32.5	20.1	3.8	2007	33.3	37.2	12.4
Scrotum or udder	28.6	12.9	2.7	2008	33.2	20.6	8.4
Thigh and abdomen	22.7	19.4	3.8	2014	29.2	22.7	3.3
Neck and dewlap	20.2	11.7	2.4	2011	28.2	18.3	3.3

Table 10 continued

Global: ruminants	Mean[a]	SD	SE	Camels: countries	Mean[a]	SD	SE
Ear region	15.3	12.4	2.4	2018	25.1	22.8	4.4
Dorsal surface	11.2	9.4	2.7	2006	25.0	34.1	12.1
Goats: attachment sites				2010	25.0	29.4	10.4
Ear region	44.2	24.2	6.7	2016	21.4	14.3	3.4
Tail and anal region	32.9	21.4	6.5	2015	21.0	15.3	3.3
Scrotum or udder	21.1	20.6	5.9	2012	20.6	18.3	2.8
Neck and dewlap	18.0	11.3	4.3	2019	20.0	10.6	3.4
Thigh and abdomen	14.3	13.7	4.8	2005	20.0	14.1	2.8
Dorsal surface	8.2	8.3	3.1	2013	17.2	13.6	2.5
Sheep: attachment sites				2017	16.3	13.1	2.6
Ear region	42.7	28.1	6.6	2009	14.1	14.3	4.5
Ruminant sexes							
Cattle: countries				Cattle: countries			
India	51.1	26.9	9.5	Nigeria	50.0	15.0	10.6
Egypt	50.1	12.2	8.6	Sudan	50.0	33.9	16.9
Bangladesh	50.0	18.2	12.9	Pakistan	49.2	22.0	7.0
Ethiopia	50.0	10.5	1.9	Cameroon	5.7	0.4	0.3
Iran	50.0	12.8	4.5	Iraq	4.1	2.2	1.6
Tick life stages							
Global: tick life stages				Goats: tick life stages			
Females	49.3	14.6	1.2	Females	49.9	14.3	2.7
Males	49.0	15.7	1.3	Males	47.9	14.4	2.7
Nymphs	14.4	15.5	2.2	Larvae	27.2	27.3	8.6
Larvae	16.8	24.2	4.6	Nymphs	22.7	19.1	5.3
Buffaloes: tick life stages				Sheep: tick life stages			
Females	56.7	13.9	4.4	Females	52.5	13.5	2.2
Males	41.3	17.9	5.7	Males	47.7	13.9	2.3
Nymphs	7.9	9.5	3.6	Larvae	21.6	39.2	17.5
Camels				Nymphs	13.6	18.6	5.9
Males	65.4	9.6	2.6	Global: continents			
Females	34.4	9.7	2.6	Africa	48.3	17.3	1.6
Nymphs	9.0	10.6	5.3	Asia	40.5	21.4	1.5
Larvae	5.3	5.0	2.5	Europe	36.1	24.8	4.3
Cattle: tick life stages				South America	25.9	24.0	6.9
Females	49.3	14.6	1.9	Cattle: continents			
Males	47.8	16.2	2.1	Africa	49.2	14.8	2.2
Nymphs	12.2	11.4	2.9	Asia	40.3	21.8	2.6
Larvae	7.2	6.9	2.4	Europe	32.7	21.6	6.8
				South America	26.3	22.4	7.9
Seasonal infestation							
Global: seasonal				Global: countries			
Summer	26.2	21.8	1.7	Pakistan	17.9	19.3	1.6
Spring	25.2	22.0	1.8	Yemen	16.7	5.1	2.1
Autumn	18.0	19.2	1.6	Argentina	12.5	7.5	2.6
Winter	13.2	16.8	1.4	Tunisia	11.6	17.8	5.6
Global: ruminants				Hungary	11.2	14.4	6.5

Table 10 continued

Global: ruminants	Mean[a]	SD	SE	Camels: countries	Mean[a]	SD	SE
Camels	24.8	19.8	2.2	Turkey	10.7	9.3	1.8
Cattle	23.9	23.0	1.8	Sudan	10.0	8.0	1.1
Buffaloes	22.7	18.3	2.9	Kenya	8.3	5.6	1.1
Goats	21.1	20.7	2.1	Global: years			
Sheep	16.6	19.3	1.4	1996	68.4	26.7	5.2
Global: hemispheres				2019	48.7	18.0	3.7
Northern hemisphere	22.0	21.7	1.0	2008	34.5	21.6	8.8
Tropical regions	16.9	16.2	1.6	2013	33.3	10.0	5.8
Southern hemisphere	12.5	7.5	2.6	2010	29.8	19.7	3.3
Global: continents				2016	26.1	11.2	2.3
Europe	57.4	33.6	5.9	2014	25.0	14.7	2.5
Asia	19.9	17.7	0.8	2011	23.6	7.2	1.9
Africa	15.0	17.7	1.7	2005	20.0	13.1	2.4
South America	12.5	7.5	2.6	2017	19.3	21.2	2.3
Global: countries				2018	19.1	17.6	3.6
Ethiopia	81.4	18.1	9.1	2012	17.1	19.1	2.2
Greece	73.0	24.2	5.0	2007	13.0	9.0	1.5
India	40.5	18.2	4.3	2015	11.4	12.1	2.0
Bangladesh	29.6	11.1	3.5	2006	10.8	9.7	1.8
Egypt	26.7	12.4	3.2	2002	10.7	9.3	1.8
Italy	25.4	16.7	8.4	2020	8.5	8.1	1.0
Iraq	21.2	16.1	2.2	2009	8.3	2.5	0.7
Iran	20.1	16.6	1.3				
Buffaloes: seasonal				Cattle: years			
Summer	35.4	18.3	5.1	2017	18.0	20.1	3.8
Spring	19.8	18.9	7.7	2006	12.6	12.0	3.0
Autumn	18.4	16.3	4.7	2002	9.1	7.7	2.3
Winter	11.7	10.7	3.6	2020	9.0	9.9	3.0
Buffaloes: countries				Goats: seasonal			
Iraq	36.5	20.5	6.2	Spring	29.2	22.8	4.5
India	33.9	15.9	6.5	Summer	25.2	22.3	4.2
Pakistan	13.3	11.5	2.5	Autumn	14.3	14.2	3.0
Bangladesh	11.3	4.5	3.2	Winter	13.8	18.2	3.8
Buffaloes: years				Goats: continents			
2019	43.0	22.4	8.5	Europe	52.6	27.1	9.6
2008	34.5	24.1	13.9	Asia	19.9	18.5	2.1
2018	33.3	7.0	4.0	Africa	8.3	5.8	1.7
2005	25.0	11.1	5.5	Goats: countries			
2016	25.0	10.7	5.4	Greece	61.2	25.9	10.6
2007	15.8	9.2	4.1	Bangladesh	33.3	7.6	4.4
2010	11.3	4.5	3.2	Hungary	26.8	4.5	3.2
2020	8.3	9.8	2.8	Iraq	25.0	12.5	6.3
Camels: seasonal				Iran	19.6	17.1	2.7
Summer	34.9	22.2	5.1	Pakistan	18.8	23.1	4.5
Spring	28.7	19.3	4.3	Turkey	16.7	7.9	3.2
Autumn	18.5	12.3	2.7	Sudan	8.3	5.8	1.7

Table 10 continued

Global: ruminants	Mean[a]	SD	SE	Camels: countries	Mean[a]	SD	SE
Winter	17.1	20.0	4.6	Goats: years			
Camels: hemispheres				1996	61.2	25.9	10.6
Northern hemisphere	27.5	20.5	2.6	2010	34.8	25.5	6.6
Tropical regions	13.3	10.8	2.8	2012	26.8	4.5	3.2
Camels: years				2005	25.0	12.5	6.3
2019	54.8	12.3	4.1	2014	25.0	15.2	5.4
2005	33.3	16.7	9.6	2011	20.1	3.9	1.9
2018	33.3	6.0	3.4	2017	16.9	19.5	4.0
2017	30.0	25.6	9.1	2002	16.7	7.9	3.2
2016	28.6	14.7	5.5	2007	12.1	6.4	2.4
2014	25.0	15.2	5.4	2015	8.3	5.8	1.7
2015	25.0	30.2	15.1	2020	8.3	6.3	1.8
2012	25.0	15.7	5.5	Sheep: seasonal			
2010	25.0	12.3	6.2	Spring	20.1	19.6	2.7
2020	8.3	6.6	1.9	Summer	18.9	20.1	2.7
2009	8.3	2.5	0.7	Autumn	16.5	21.5	3.1
Cattle: seasonal				Winter	10.2	13.5	2.0
Summer	29.3	21.9	3.2	Sheep: hemispheres			
Spring	28.5	25.6	4.1	Northern hemisphere	18.4	20.6	1.6
Autumn	21.5	22.6	3.7	Tropical regions	8.6	5.9	1.0
Winter	14.8	18.9	3.1	Sheep: continents			
Cattle: continents				Europe	55.6	40.8	11.8
Europe	62.4	31.5	9.1	Asia	15.9	15.1	1.3
Africa	27.2	29.3	6.1	Africa	9.0	8.0	1.2
Asia	20.2	17.1	1.6	Sheep: countries			
South America	12.5	7.5	2.6	Greece	73.9	28.0	9.3
Cattle: countries				Egypt	25.0	10.9	5.4
Ethiopia	81.4	18.1	9.1	Iran	17.6	15.8	2.0
Greece	80.9	16.4	5.8	Yemen	16.7	5.1	2.1
India	43.8	19.1	5.5	Pakistan	16.6	17.6	2.7
Bangladesh	34.6	5.5	2.5	Iraq	13.0	10.1	2.1
Tunisia	33.3	20.3	11.7	Turkey	9.1	10.7	3.2
Italy	25.4	16.7	8.4	Sudan	8.7	6.3	1.3
Egypt	25.0	12.3	6.2	Kenya	8.3	5.1	1.5
Iran	20.7	17.2	2.6	Tunisia	2.3	0.86	0.32
Iraq	18.2	10.1	3.1	Hungary	0.8	0.7	0.40
Pakistan	14.2	12.9	2.1	Sheep: years			
Argentina	12.5	7.5	2.6	1996	73.9	28.0	9.3
Turkey	9.1	7.7	2.3	2019	36.5	15.7	7.9
Kenya	8.3	6.3	1.8	2010	28.4	17.6	6.2
Cattle: years				2014	25.0	15.2	5.4
1996	67.9	27.6	8.3	2016	25.0	10.9	5.4
2019	60.1	17.4	10.0	2017	19.5	22.4	4.2
2008	34.5	24.1	13.9	2011	17.8	1.3	0.6
2013	33.3	10.0	5.8	2005	13.4	11.3	2.9
2011	29.9	6.3	2.6	2012	12.0	10.1	1.6
2010	28.5	10.2	3.9	2007	10.9	8.5	1.9

Table 10 continued

Global: ruminants	Mean[a]	SD	SE	Camels: countries	Mean[a]	SD	SE
2016	25.0	10.1	3.6	2015	10.5	7.5	1.7
2014	25.0	15.8	4.5	2002	9.1	10.7	3.2
2005	25.0	9.4	4.7	2020	8.3	8.5	2.5
2012	22.8	29.0	6.1	2006	8.3	5.1	1.5
2018	22.0	19.1	5.8	2018	2.3	0.9	0.3
2007	20.3	11.5	4.4				
Monthly infestation							
Global: monthly				Cattle: countries			
July	28.8	28.6	4.7	Greece	74.7	24.1	8.0
May	23.4	24.6	4.4	Tunisia	33.3	20.3	11.7
June	22.1	25.7	4.3	Iraq	14.3	8.8	3.3
April	17.8	21.6	3.9	Argentina	12.5	7.5	2.6
September	16.1	14.9	2.5	Iran	12.5	13.4	3.4
November	16.1	23.1	4.4	Pakistan	11.9	10.2	1.8
August	15.8	13.5	2.3	Turkey	9.1	7.7	2.3
October	15.4	19.1	3.3	Kenya	8.3	6.3	1.8
March	12.1	14.8	2.9	Cattle: years			
December	10.6	19.2	3.8	1996	64.3	29.1	8.4
February	8.0	12.4	2.4	2014	25.0	19.2	9.6
January	6.9	11.7	2.2	2007	20.3	11.5	4.4
Global: hemispheres				2018	12.5	7.5	2.6
Northern hemisphere	18.8	22.8	1.3	2012	10.5	7.2	1.6
Southern hemisphere	12.5	7.5	2.6	2002	9.1	7.7	2.3
Tropical regions	8.4	5.4	0.64	2020	9.0	9.9	3.0
Global: continents				2006	8.3	6.3	1.8
Europe	62.0	33.0	6.2	2017	8.3	8.3	2.4
Asia	14.3	15.6	1.0	Goats: continents			
South America	12.5	7.5	2.6	Europe	52.6	27.1	9.6
Africa	8.8	7.9	0.88	Asia	15.7	19.0	2.8
Global: countries				Africa	8.3	5.8	1.7
Greece	73.0	24.2	5.0	Goats: countries			
Iraq	18.2	17.9	3.1	Greece	61.2	25.9	10.6
Yemen	16.7	5.1	2.1	Hungary	26.8	4.5	3.2
Pakistan	15.7	17.9	1.6	Pakistan	18.8	23.1	4.5
Argentina	12.5	7.5	2.6	Turkey	16.7	7.9	3.2
Tunisia	11.6	17.8	5.6	Sudan	8.3	5.8	1.7
Hungary	11.2	14.4	6.5	Iran	8.3	8.3	2.4
Turkey	10.7	9.3	1.8	Goats: years			
Iran	10.5	10.4	1.4	1996	61.2	25.9	10.6
Sudan	8.5	5.4	0.78	2010	40.3	33.6	11.9
Kenya	8.3	5.6	1.1	2012	26.8	4.5	3.2
Global: years				2002	16.7	7.9	3.2
1996	68.4	26.7	5.2	2007	12.1	6.4	2.4
2019	49.6	17.8	4.5	2015	8.3	5.8	1.7
2010	37.5	29.7	8.6	2020	8.3	6.3	1.8
2014	25.0	19.2	9.6	2017	8.3	8.3	2.4

Table 10 continued

Global: ruminants	Mean[a]	SD	SE	Camels: countries	Mean[a]	SD	SE
2007	13.0	9.0	1.5	Sheep: continents			
2012	11.1	8.2	1.1	Europe	55.6	40.8	11.8
2002	10.7	9.3	1.8	Asia	11.1	10.2	1.0
2015	9.7	6.8	1.2	Africa	7.5	5.8	0.9
2005	9.1	8.5	2.5	Sheep: countries			
2020	8.5	8.1	1.0	Greece	73.9	28.0	9.3
2006	8.3	5.6	1.1	Yemen	16.7	5.1	2.1
2017	8.3	8.0	1.3	Pakistan	11.7	12.1	2.0
2009	8.3	2.5	0.7	Iraq	10.5	8.1	1.9
2018	7.8	7.5	1.9	Iran	10.3	9.4	1.8
Buffaloes: years				Turkey	9.1	10.7	3.2
2019	43.0	22.4	8.5	Sudan	8.7	6.3	1.3
2007	15.8	9.2	4.1	Kenya	8.3	5.1	1.5
2020	8.3	9.8	2.8	Tunisia	2.3	0.86	0.32
Camels: hemispheres				Hungary	0.80	0.70	0.40
Northern hemisphere	28.2	25.3	5.5	Sheep: years			
Tropical regions	8.3	2.5	0.71	1996	73.9	28.0	9.3
Camels: continents				2010	31.9	23.3	11.6
Asia	28.2	25.3	5.5	2012	10.6	8.2	1.3
Africa	8.3	2.5	0.71	2015	10.5	7.5	1.7
Camels: years				2007	10.0	7.7	1.8
2019	54.8	12.3	4.1	2005	9.1	8.5	2.5
2009	8.3	2.5	0.71	2002	9.1	10.7	3.2
2020	8.3	6.6	1.9	2006	8.3	5.1	1.5
Cattle: continents				2017	8.3	8.3	2.4
Europe	74.7	24.1	8.0	2020	8.0	8.2	2.3
Africa	13.3	14.0	3.6	2018	2.3	0.86	0.32
South America	12.5	7.5	2.6				
Asia	11.8	10.5	1.3				

[a]Sorted by their descending values. SD, Std. deviation; and SE, Std. error

April and continues to December with degrees of ups and downs fluctuation during the year in the world southern hemisphere (Fig. 12c, f). One-way ANOVA did not reveal a significant difference between monthly tick infestations in buffaloes, camels, cattle, goats, and sheep ($0.19 \leq F \leq 1.192$; df = 11; $0.234 \leq P \leq 0.997$) (Table 8). One-way ANOVA revealed a significant difference between monthly tick infestations in the global domestic ruminants (F = 3.151; df = 11; $P = 0.0001$) (Table 8). There was a significant difference between monthly tick infestations between July with January, February, and December in the global domestic ruminants ($18.2 \leq$ Mean difference ≤ 21.9; $5.1 \leq$ SEM ≤ 5.2; $0.001 \leq P \leq 0.025$) (Table 9).

One-way ANOVA also revealed a significant difference between monthly tick infestations in relation to the annually of buffaloes; annually, hemispheres and continents of camels; annually, continents and countries of cattle, goats and sheep, and the global annually, hemispheres, continents and countries of domestic ruminants ($7.3 \leq F \leq 120.6$; $1 \leq df \leq 13$; $0.0001 \leq P \leq 0.011$) (Table 8). There was a significant difference between monthly tick infestations in relation to the annually of buffaloes between 2019 with 2007 and 2020; annually, hemispheres and continents of camels between 2019 with 2009 and 2020; annually, continents and countries of cattle, goats and sheep between some years and countries, Europe with Asia, South America and Africa; and the global annually, hemispheres, continents and countries of domestic ruminants between some years and countries, northern hemisphere and tropical regions, Europe with Africa, South America and Asia, and Asia with Africa by post hoc tests (Tukey) ($21.3 \leq$ Mean difference ≤ 73.1; $2.1 \leq$ SEM ≤ 10.3; $0.0001 \leq P \leq 0.042$) (Table 9).

Discussion

Based on the literature search, the results of this global meta-analysis review indicated that the global means and domain means of tick infestations in the world countries, continents, hemispheres and tropical regions exhibited different values and ranges for buffaloes, camels, cattle, goats, sheep, and the global domestic ruminants (Figs. 2, 3, 4, 5, 6, 7). Although a variety of methods with intensity and debility are used to prevent or control domestic ruminant tick infestations in all around the globe and a plenty of costs are spent in this way. However, the results of this global meta-analysis review indicate that the global tick infestations in the world countries, continents, hemispheres and tropical regions exhibited different values and ranges for buffaloes, camels, cattle, goats, sheep, and the global domestic ruminants (Figs. 2, 3, 4, 5, 6, 7). The global tick infestations were 36.9, 54.0, 45.0, 35.8, 33.7, and 40.1% in buffaloes, camels, cattle, goats, sheep, and the global domestic ruminants, respectively (Fig. 7d) that are globally considerable amount of tick infestations to cause significant economical and medical damages in domestic ruminant groups (Dehaghi et al. 2011; Dumitrache et al. 2012; Abbasi et al. 2017; Rehman et al. 2017; Sajid et al. 2018; Balinandi et al. 2020; Ghafar et al. 2020a).

Ticks are widely distributed obligate hematophagous ectoparasites of vertebrates. While feeding on the host, ticks can transmit various zoonotic pathogens and cause serious health problems for human and animals especially with economic losses in industries from domestic ruminants (Liu et al. 2020). Massive tick infestations of domestic ruminant groups not only cause declining their meat and milk yields and therefore huge financial losses, but also bear a health risk for domestic ruminant group holders due to possible infections with zoonotic pathogens like CCHFV or *Rickettsia* (Schulz et al. 2020). Domestic ruminant groups are infected through tick bites and are able to infect more ticks to perpetuate the CCHFV. The CCHF virus may be transmitted to humans by the bite of an infected tick or by contact with body fluids from an infected animal or person (Sang et al. 2011). The role of these vertebrates could be as either CCHFV reservoirs or non-reservoirs but they are significant contributors to the tick vector population density and/or epidemiologically important members of the biocenose (EFSA Panel on Animal Health Welfare 2010). As the antibody prevalence in domestic ruminant groups is a good indicator for the presence or absence of the CCHFV in a region, seroepidemiological studies can be used for the definition of risk areas for CCHFV. Sheep and goats can be used as more suitable indicator animals for the CCHFV circulation infections and CCHFV seroepidemiological monitoring studies to determine the CCHFV presence or absence in a given region and should therefore be tested preferentially, when risk areas are to be identified (Schuster et al. 2016).

Based on the literature search, the global resultant trend of tick infestations in buffaloes, camels, cattle, goats, sheep, and the global domestic ruminants exhibited predominantly an increasing or poorly an approximately constant trend in the world northern or southern hemispheres, tropical regions, and globally in the world during the past decades (Figs. 2, 3, 4, 5, 6, 7). These valuable results suggest that the preventive or control measures to prohibit tick infestations in domestic ruminant groups have not been successful, which increases the global trend of tick infestations in domestic ruminant groups over the past decades. Towards an effective, rational and sustainable for the tick control approaches, the preventive or control measures to prohibit tick infestations in domestic ruminant groups must be continued with more strength and intensity with special emphasis on progress in tick control researches (Ghosh and Nagar 2014; Estrada-Peña et al. 2020). Of course, with the mechanization of animal husbandry and agricultural methods and moving away from traditional animal husbandry and agricultural methods and avoiding domestic ruminant groups' contact with tick-infested areas, it would be predicted that tick infestation control measures to be successful.

Although based on the literature search, the global tick infestations in age categories of domestic ruminants exhibited different values for buffaloes, camels, cattle, goats, sheep, and the global domestic ruminants (Fig. 8). In other words, the levels of interest of ticks for blood feeding on domestic ruminant groups change with their age categories. Because one-way ANOVA did not reveal a significant difference between tick infestations in buffaloes, camels, cattle, goats, and the global domestic ruminants in relation to their age categories ($0.366 \leq F \leq 2.228$; $4 \leq df \leq 5$; $0.071 \leq P \leq 0.515$) (Table 8), except a significant difference between sheep age categories of 4–5 with > 5, 3–4, and < 1 years ($29.6 \leq$ Mean difference ≤ 39.7; $7.4 \leq$ SEM ≤ 9.3; $0.003 \leq P \leq 0.005$) by post hoc tests (Tukey) (Table 9) after one-way ANOVA of significant tick infestations ($F = 6.377$; $df = 4$; $P = 0.002$) (Table 8). These valuable results suggest that the all age categories of domestic ruminant groups including buffaloes, camels, cattle, goats, and sheep are threatened by ticks.

Tick attachment site specificity is one of the population limiting system that operate through the restriction of ticks to certain parts of their host body. They seek out places on the hosts where they are host's body (Abdela 2016). Based on the literature search, the global tick infestations in attachment sites of domestic ruminant group body parts exhibited different values for buffaloes, camels, cattle, goats, sheep, and the global domestic ruminants (Fig. 9). In other words, the levels of interest of ticks for blood feeding on domestic ruminant groups change with tick attachment sites of domestic ruminant group body parts. Although one-way ANOVA did not reveal a significant difference between tick infestations in attachment sites of buffalo and camel body parts ($1.498 \leq F \leq 1.799$; df = 5; $0.143 \leq P \leq 0.223$) and revealed a significant difference between tick infestations in attachment sites of cattle, goat, sheep, and the global domestic ruminant body parts ($4.921 \leq F \leq 11.368$; df = 5; $0.0001 \leq P \leq 0.001$) (Table 8). There is no doubt that ticks are tend to attach tail and anal region, ear region and scrotum or udder than other body parts of buffaloes, camels, cattle, goats, sheep, and the global domestic ruminants for their blood feeding which confirmed by a significant difference between tick infestations in relation to these attachment sites of cattle, goat, sheep, and the global domestic ruminant body parts with other attachment sites by post hoc tests (Tukey) (Table 9).

Based on the literature search, the global tick infestations in relation to ruminant females, males and females/males exhibited, respectively, 64.3, 62.1, 57.1, 62.0, 61.3, 60.5%; 34.8, 37.7, 37.9, 36.1, 34.5, 36.5%; and 1.8, 1.6, 1.5, 1.7, 1.8, 1.7 fold for buffaloes, camels, cattle, goats, sheep, and the global domestic ruminants. The global resultant tick infestations in relation to ruminant sexes exhibited that ticks are predominantly tend to attach the females of cattle, goat, sheep, and the global domestic ruminants as approximately twice than males (Fig. 10a). These valuable results confirmed by one-way ANOVA that revealed a significant difference between tick infestations in relation to females and males of buffaloes, camels, cattle, goats, sheep, and the global domestic ruminants ($11.3 \leq F \leq 93.6$; $0.0001 \leq P \leq 0.004$) (Table 8). Based on another part of the study results, the females and males of tick life stages attack more buffaloes, camels, cattle, goats, sheep, and the global domestic ruminants than nymphalid and larval tick life stages (Fig. 10b). One-way ANOVA revealed a significant difference between tick life stage infestation in buffaloes, camels, cattle, goats, sheep, and the global domestic ruminants ($11.2 \leq F \leq 91.9$; $2 \leq df \leq 3$; $P = 0.0001$) (Table 8). There was a significant difference between tick life stage infestation between females and males with nymphalid and or larval stages in buffaloes, camels, cattle, goats, sheep, and the global domestic ruminants ($20.6 \leq$ Mean difference ≤ 56.4; $2.6 \leq$ SEM ≤ 8.2; $0.0001 \leq P \leq 0.008$) by post hoc tests (Tukey) (Table 9).

The tick-borne diseases are strongly influenced by the seasonal dynamics and abundance of ticks under natural conditions. The knowledge of tick ecology is essential for developing an effective strategy for controlling ticks and their associated pathogens. The knowledge of distribution and seasonal abundance of ticks is helpful to the development of effective control measures for ticks and tick-borne diseases (Liu et al. 2020). It is very likely that seasonal domestic ruminant tick infestation patterns may be different in tropical regions and in the northern and southern hemispheres. Based on the literature search, the global tick infestations in buffaloes, camels, cattle, sheep, and the global domestic ruminants is usually higher in summer than other seasons in the world northern hemisphere (Fig. 11a, b, d, e, f). The global tick infestations in buffaloes, camels, cattle, and the global domestic ruminants is usually higher in autumn than in other seasons in the world tropical regions (Fig. 11a, b, d, f). The global tick infestations in cattle and the global domestic ruminants is usually higher in winter than in other seasons in the world southern hemisphere (Fig. 11d, f). The outcome of statistical analysis of current study on the relevant literature data showed that there is difference between seasonal domestic ruminant tick infestation patterns in tropical regions and in the northern and southern hemispheres.

One-way ANOVA revealed a significant difference between global seasonal tick infestations in domestic ruminants ($F = 3.79$; df = 4; $P = 0.005$) (Table 8). There was a significant difference between camels and cattle with sheep tick infestations ($7.3 \leq$ Mean difference ≤ 8.1; $2.2 \leq$ SEM ≤ 2.8; $0.007 \leq P \leq 0.027$) by post hoc tests (Tukey) (Table 9). One-way ANOVA revealed a significant difference between seasonal tick infestations in buffaloes, camels, cattle, goats, and the global domestic ruminants ($3.701 \leq F \leq 13.407$; df = 3; $0.0001 \leq P \leq 0.014$) (Table 8). There was a significant difference between seasonal tick infestations in relation to the global domestic ruminants between summer and spring with winter and autumn ($7.2 \leq$ Mean difference ≤ 13.0; $2.3 \leq$ SEM ≤ 2.4; $0.0001 \leq P \leq 0.014$); buffaloes between summer and winter (Mean difference = 23.7; SEM = 7.1; $P = 0.01$); camels between summer with winter and autumn ($16.4 \leq$ Mean difference ≤ 17.8; $6.0 \leq$ SEM ≤ 6.1; $0.023 \leq P \leq 0.038$); cattle between summer and spring with winter ($13.7 \leq$ Mean difference ≤ 14.5; $5.1 \leq$ SEM ≤ 4.9; $0.018 \leq P \leq 0.39$); and goats between spring and winter (Mean difference = 15.4; SEM = 5.7; $P = 0.04$) by post hoc tests (Tukey) (Table 9). One-way ANOVA did not reveal a significant difference between seasonal tick infestations in sheep ($F = 2.608$; df = 3; $P = 0.053$) (Table 8). Although ticks were present on the domestic ruminant populations throughout the year, their abundance seemed to increase particularly after the rains. Hence, rainfall was considered the most important climatic factor that influenced the seasonal variation in numbers (Latha et al. 2004). In general, the abundance of tick population gradually increases in association with increasing of the average daily temperature, the mean relative humidity and precipitation. Conversely, the abundance of tick population gradually decreases in association with decreasing the average daily temperature, the mean relative humidity and precipitation.

Based on the literature search, the global monthly domestic ruminant group tick infestations usually starts from January, gradually increases from March to July, and then gradually decreases from July to December during the year in the world northern hemisphere. The global monthly domestic ruminant group tick infestations usually starts from January, and approximately continues with degrees of ups and downs fluctuation from January to December during the year in the world tropical regions (Fig. 12). The global monthly domestic ruminant group tick infestations usually starts from January, suddenly decreases from February to April, and then approximately increases from April and continues to December with degrees of ups and downs fluctuation during the year in the world southern hemisphere (Fig. 12c, f). One-way ANOVA did not reveal a significant difference between monthly tick infestations in buffaloes, camels, cattle, goats, and sheep ($0.19 \leq F \leq 1.192$; df = 11; $0.234 \leq P \leq 0.997$) (Table 8). One-way ANOVA revealed a significant difference between monthly tick infestations in the global domestic ruminants ($F = 3.151$; df = 11; $P = 0.0001$) (Table 8). There was a significant difference between monthly tick infestations between July with January, February, and December in the global domestic ruminants ($18.2 \leq$ Mean difference ≤ 21.9; $5.1 \leq$ SEM ≤ 5.2; $0.001 \leq P \leq 0.025$) (Table 9).

Different significant degrees of tick infestations in domestic ruminant groups by one-way ANOVA analysis and as a results followed by post hoc tests (Tukey) between tick and tick life stage infestations in relation to domestic ruminant groups, domestic ruminant age categories, attachment sites of domestic ruminant group body parts, domestic ruminant group sexes, and seasonal and monthly tick infestations among years, countries, continents, hemispheres and tropical regions (Tables 8, 9, 10), show the temporal, spatial and epidemiological tick infestation values in different climatic, geographical and environmental conditions among countries, continents, hemispheres and tropical regions of the world. Cumulative tick infestations were found significantly higher in hilly (44.4%) and hot arid plane (34.8%) areas than plain (30.3%) and cold hilly (18.6%) areas (Kabir et al. 2011; Khan et al. 2013).

Conclusion

Based on the literature search, the results of this global meta-analysis review indicate that the global tick infestations in the world countries, continents, hemispheres and tropical regions exhibited different values and ranges for buffaloes, camels, cattle, goats, sheep, and the global domestic ruminants that are globally considerable amount of tick infestations to cause significant economical and medical damages in domestic ruminant groups. The global resultant trend of tick infestations in buffaloes, camels, cattle, goats, sheep, and the global domestic ruminants, exhibited predominantly an increasing or poorly an approximately constant trend in the world northern or southern hemispheres, tropical regions, and globally in the world during the past decades. These valuable results suggest that the preventive or control measures to prohibit tick infestations in domestic ruminant groups have not been successful, which increases the global trend of tick infestations in domestic ruminant groups over the past decades. Towards an effective, rational and sustainable for the tick control approaches, the preventive or control measures to prohibit tick infestations in domestic ruminant groups must be continued with more strength and intensity with special emphasis on progress in tick control researches.

The global tick infestations in age categories of domestic ruminants exhibited different values for buffaloes, camels, cattle, goats, sheep, and the global domestic ruminants. In other words, the levels of interest of ticks for blood feeding on domestic ruminant groups change with their age categories. These valuable results suggest that the all age categories of domestic ruminant groups including buffaloes, camels, cattle, goats, and sheep are threatened by ticks. The global tick infestations in attachment sites of domestic ruminant group body parts exhibited different values for buffaloes, camels, cattle, goats, sheep, and the global domestic ruminants. In other words, the levels of interest of ticks for blood feeding on domestic ruminant groups change with tick attachment sites of domestic ruminant group body parts. There is no doubt that ticks are tend to attach tail and anal region, ear region and scrotum or udder than other body parts of buffaloes, camels, cattle, goats, sheep, and the global domestic ruminants for their blood feeding which confirmed by a significant difference between tick infestations in relation to these attachment sites of cattle, goat, sheep, and the global domestic ruminant body parts with other attachment sites. The global resultant tick infestations in relation to ruminant sexes exhibited that ticks are predominantly tend to attach the females of cattle, goat, sheep, and the global domestic ruminants as approximately twice than males.

Based on another part of the study results, the females and males of tick life stages attack more buffaloes, camels, cattle, goats, sheep, and the global domestic ruminants than nymphalid and larval tick life stages. It is very likely that seasonal domestic ruminant tick infestation patterns may be different in tropical regions and in the northern and southern hemispheres. The outcome of statistical analysis of current study on the relevant literature data showed that there is difference between seasonal domestic ruminant tick infestation patterns in tropical regions and in the northern and southern hemispheres. Different significant degrees of tick infestations in domestic ruminant groups by analysis between tick and tick life stage infestations in relation to animal age categories, attachment sites of body parts, sexes, and seasonal and monthly tick infestations among years, countries, continents, hemispheres and tropical regions, show the temporal, spatial and epidemiological tick infestation values in different climatic, geographical and environmental conditions among countries, continents, hemispheres and tropical regions of the world.

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Declarations

Conflict of interest None.

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