Parasite Epidemiology and Control 25 (2024) e00356

Contents lists available at ScienceDirect

Parasite Epidemiology and Control

journal homepage: www.elsevier.com/locate/parepi

Prevalence, trend comparisons, and identification of ixodid ticks (Acari: Ixodoidea) among cattle in Ethiopia: A systematic review and meta-analysis

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ARTICLE INFO

Keywords:
Cattle
Ethiopia
Ixodid tick
Prevalence
Tick infestation

ABSTRACT

Ticks and tick-borne pathogens are the main challenge to livestock production and productivity in sub-Saharan Africa, particularly in Ethiopia, where favorable conditions exist for the activity of various parasites due to its geographical location, climate, and biological and cultural characteristics. This study was to provide pooled estimates for individually available data on ixodid ticks, their trend comparisons, and ixodid tick grouping among cattle in Ethiopia. Cochrane's Q, I^2, sensitivity analysis, funnel plot, Begg, and Egger regression tests were used to check heterogeneity and publication bias. A random effect model was used to calculate the pooled magnitude of ixodid ticks among cattle. A total of 17,161 cattle from 41 studies were included. The pooled prevalence of ixodid ticks among cattle was 64.42% (95% CI = 57.13–71.71). A total of 82,804 adult ticks belonging to three different genera of ixodid ticks, namely *Rhipicephalus* (*Boophilus*) (47.53%), *Amblyomma* (46.10%), and *Hyalomma* (6.37%), were recorded from the included studies. The general trend for the prevalence of ixodid tick infestation among cattle has decreased, from 68.65% in 2010–2015 to 60.13% in 2021–2023. In the present scenario, ixodid tick infestation range from 59.21 to 89.58% and are higher in Gambella region.

1. Introduction

Ethiopia has the largest livestock population on the African continent and the tenth largest in the world, containing 66 million cattle, 38 million sheep, 46 million goats, 56.06 million chickens, 2.14 million horses, 10 million donkeys, 0.36 million mules, 7 million camels, and 6.52 million hives. Of the cattle in the country (66 million), 96.76% are local breeds. The remaining are hybrid and exotic breeds, which accounted for about 2.71% and 0.41%, respectively (CSA, 2021/22).

The livestock sector contributes a considerable portion to the Ethiopian economy. Currently, it accounts for about 30% of the country's agricultural gross domestic product (GDP), with a projected increase to 40% by 2030 (Shapiro et al., 2017). Cattle play an important role in the socio-economic aspects of the lives of the Ethiopian people. In addition to the products of meat and milk, cattle provide draught power for the cultivation of agricultural land. Livestock also plays an important role in foreign exports, as live animals, hides, and skins are exported to generate foreign currency (Asresie et al., 2015).

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https://doi.org/10.1016/j.parepi.2024.e00356
Received 3 February 2024; Received in revised form 2 April 2024; Accepted 29 April 2024
Available online 1 May 2024
2405-6731/

However, the current levels of cattle contributions in Ethiopia, either macro- or micro-level, are below the expected potential due to several constraints that hinder productivity. Among the various constraints encountered, ectoparasites contribute to a wide range of productivity problems (Nejash, 2016b). Ectoparasites are very common and widely distributed in all agro-ecological zones of the world. Approximately 1.49 billion of cattle worldwide are susceptible to infestation with diverse ecto-parasitic fauna (De León et al., 2020). Arthropods, mainly insects, mites, and ticks, represent the most economically important group of cattle ectoparasites because of the direct effect associated with heavy infestations and indirectly through transmission of infections. Skin diseases caused by this parasite are among the major causes of serious economic loss (Byford et al., 1992).

Ticks (Acari: Ixodidae) are obligate blood-feeding ectoparasites that transmit a broad range of pathogens to humans and animals and cause major public health problems and considerable socioeconomic losses to the livestock industry in tropical and subtropical countries through direct infestation and tick-borne pathogens causing trans-boundary cattle diseases (De León et al., 2020). Approximately 80% of the world population of cattle is infested with ticks and tick-borne pathogens, which is considered to be the most important health problem across the globe (Marufu, 2008). The annual global cost associated with tick and tick-borne diseases in cattle ranges between US$13.9 and US$18.7 billion (Mondal et al., 2013). In Ethiopia, among the main parasitic diseases, ticks and tick-borne diseases rank third after trypanosomiasis and endoparasitism in causing economic losses. An estimated total loss of US $500,000 was due to skin degradation and shedding as a result of ticks, and approximately 65.5% of the main defects in Ethiopian hides are caused by ticks (Bekele, 2002).

Ticks of veterinary relevance belong to the family Ixodidae, also known as hard ticks, and the family Argasidae, which are known as soft ticks. The ixodid tick affects the health and production of cattle around the world (Byford et al., 1992). Different ixodid tick genera are widely distributed in Ethiopia, and several researchers have reported the distribution and abundance of ticks in different parts of the country. *Rhipicephalus* (*Boophilus*), *Amblyomma*, and *Hyalomma* are among the most commonly reported tick genera in Ethiopia (Nejash, 2016a), causing significant economic losses for Ethiopian farmers and international markets via direct infestation (Nejash, 2016b).

Ethiopia has favorable conditions for the activity of various ecto- and endoparasites due to its geographical location, climate, and biological and cultural characteristics. Various studies have been conducted on the prevalence of ixodid ticks among cattle in various parts of Ethiopia, but there have been no studies that have collected and analyzed this information systematically. The aim of this study was to provide summary estimates of available data on ixodid tick prevalence among cattle in Ethiopia.

2. Materials and methods

2.1. Search strategy

A systematic search of research articles was carried out in databases and registers (PubMed/Medline, Web of Science, ScienceDirect, Cochrane Library, EMBASE, Google Scholar, and ResearchGate), as well as other sources (websites, organizations, and citation searches). The following key terms and phrases were used in combination or separately with Boolean operators ("OR" or "AND") to search for research articles: "prevalence," "epidemiology," "tick burden," "cattle," "bovine," "tick," "ixodid tick," "tick genera," "ixodid tick infestation," "*Rhipicephalus* (*Boophilus*)," "*Amblyomma*," "*Hyalomma*," and "Ethiopia." The search strategy was carried out from September to November 2023.

2.2. Inclusion and exclusion criteria

The inclusion criteria were as follows: (a) original articles with observational designs; (b) studies conducted in cattle; (c) studies conducted in Ethiopia; (d) studies reported sample size, cases, or prevalence; (e) studies evaluating ixodid ticks; and (f) studies published with full texts available for searches; (g) studies identified and grouped ixodid ticks at the genera or species level.

The exclusion criteria for studies were as follows: (i) reported the knowledge, attitudes, and practices of veterinarians or cattle husbands about the ixodid tick; (ii) studies conducted outside Ethiopia; and (iii) had published other tick families.

2.3. Data extraction

The data abstraction process was carried out following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA-2020) guidelines as recommended by (Page et al., 2021). The collected articles were evaluated by four independent authors (IA, KT, AmG, and DT) following the inclusion and exclusion criteria. These researchers extracted the necessary data using a standardized data extraction format in a Microsoft Excel 2021. The following information was extracted from the studies: first author, publication year, study region, study design, sampling method, total number of cattle examined (sample size), number of cattle infected (cases), prevalence, and total number of adult ticks collected. When the four authors disagreed, a fifth author (AbG) was consulted, and disagreements were resolved through consensus and discussion.

2.4. Quality assessment tool

The overall quality of the evidence was evaluated using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) tool (Atkins et al., 2004). The tool contains three main evaluation instruments: methodological quality, comparability, and research results and statistical analysis, to determine the quality of each study. Each criterion received two points. Publications

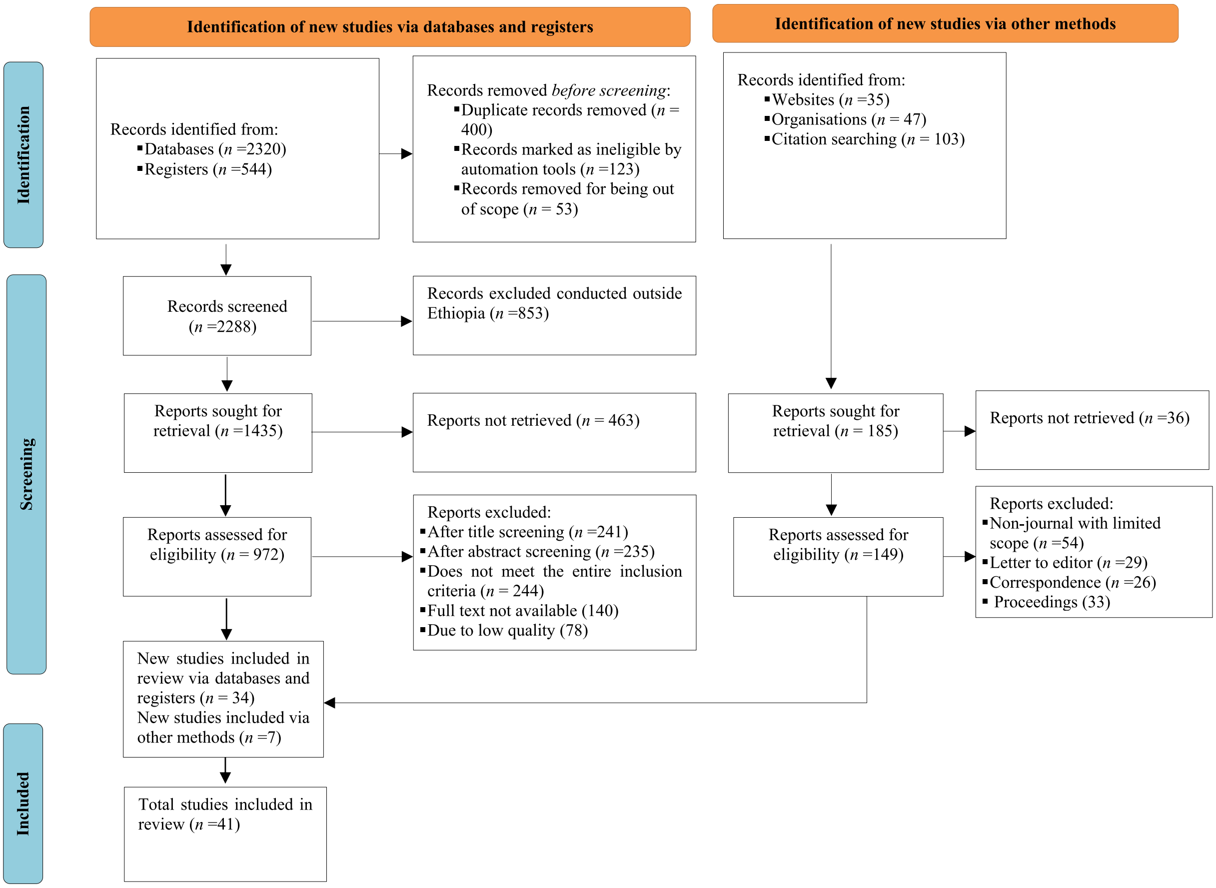

Fig. 1. PRISMA-2020 flow diagram of eligible studies.

that received a total score of 0 to 3 points were considered low-quality publications, 4 points were medium-quality publications, and 5 to 6 points were high-quality publications. Two reviewers (AbG and DT), independently selected the articles and evaluated their quality. Once a consensus was reached, articles were added, and differences between reviewers were settled through discussion.

2.5. Data analysis

The data were exported to STATA software version 14 for analysis after all pertinent findings had been extracted and placed in Microsoft Excel 2021. A 95% confidence interval was used to calculate the pooled prevalence of the ixodid tick. The funnel plot and Begg and Egger regression tests were used to detect publication bias, with a p-value of <0.05 indicating statistical significance (Begg and Mazumdar, 1994; Egger et al., 1997; Sterne and Egger, 2001). The Cochrane Q statistic was used to determine whether there was heterogeneity between the studies. I^2 was used to quantify the degree of heterogeneity between studies; values of 25, 50, and 75% indicated moderate, medium, and high heterogeneity, respectively (Higgins and Thompson, 2002; Rücker et al., 2008). A random-effects model was used to estimate the pooled prevalence of ixodid ticks, and a forest plot was generated to visually assess the presence of heterogeneity (Borenstein et al., 2010). Subgroup analysis was conducted based on region, publication year, sampling method, and sample size to identify potential sources of heterogeneity. Sensitivity analysis (using Duval and Tweedie's Trim and Fill analysis in the random effect model) (Duval and Tweedie, 2000) was used to investigate how one study affected the overall prevalence of the ixodid tick in the meta-analysis.

3. Results

3.1. Studies included

In total, 3049 articles on the prevalence of ixodid ticks were recovered. A total of 576 records were removed as duplicate records ($n = 400$), records marked as ineligible by automation tools ($n = 123$), and records removed because they were outside the scope ($n = 53$). Of the remaining 1620 articles, 853 studies were conducted outside Ethiopia and were also excluded. The remaining 499 articles were not found in registers, databases, or other methods. Of the 1121 articles, 1080 were further excluded after assessment and review

Table 1
Prevalence of major ixodid tick genera grouped from eligible studies.

No.	Ixodid tick genera	Total number of tick collected	Prevalence	Reference
1.	*Rhipicephalus* (*Boophilus*)	39,357	47.53%	(Bahiru et al., 2018; Detamo and Handalo, 2020; Abera et al., 2010; Tiki and Addis, 2011; Alemu and Chanie, 2012; Asrate and Yalew, 2012; Amante et al., 2014; Kumsa et al., 2014; Meaza et al., 2014; Wolde and Mohamed, 2014; Admassu et al., 2015; Nateneal et al., 2015; Ayana et al., 2016; Gudina et al., 2016; Kemal et al., 2016a; b; Wogayehu et al., 2016; Mohammed et al., 2017; Seid, 2017; Tesgera et al., 2017; Yalew et al., 2017; Hussein et al., 2018; Leyikun et al., 2018; Mohammed and SAMARA, 2018; Nuna and Guder, 2018; Abiso et al., 2019; Gelelcha et al., 2019; Getiso and Geinoro, 2019; Tafesse and Amante, 2019; Amante, 2020; Ayana et al., 2021; Blate, 2021; Chumburo and Bayou, 2021; Wondimu and Bayu, 2021; Abdurehman et al., 2022; Adugna and Tamrat, 2022; Belete and Mekuria, 2023; Fanda, 2023; Fentahun et al., 2023; Lemu et al., 2023; Tadesse and Bulbula, 2023)
2.	*Amblyomma*	38,175	46.10%	(Bahiru et al., 2018; Detamo and Handalo, 2020; Abera et al., 2010; Tiki and Addis, 2011; Alemu and Chanie, 2012; Asrate and Yalew, 2012; Amante et al., 2014; Kumsa et al., 2014; Meaza et al., 2014; Wolde and Mohamed, 2014; Admassu et al., 2015; Nateneal et al., 2015; Ayana et al., 2016; Gudina et al., 2016; Kemal et al., 2016a; b; Wogayehu et al., 2016; Mohammed et al., 2017; Seid, 2017; Tesgera et al., 2017; Yalew et al., 2017; Hussein et al., 2018; Leyikun et al., 2018; Mohammed and SAMARA, 2018; Nuna and Guder, 2018; Abiso et al., 2019; Gelelcha et al., 2019; Getiso and Geinoro, 2019; Tafesse and Amante, 2019; Amante, 2020; Ayana et al., 2021; Blate, 2021; Chumburo and Bayou, 2021; Wondimu and Bayu, 2021; Abdurehman et al., 2022; Adugna and Tamrat, 2022; Belete and Mekuria, 2023; Fanda, 2023; Fentahun et al., 2023; Lemu et al., 2023; Tadesse and Bulbula, 2023)
3.	*Hyalomma*	5272	6.37%	(Bahiru et al., 2018; Tiki and Addis, 2011; Alemu and Chanie, 2012; Kumsa et al., 2014; Meaza et al., 2014; Admassu et al., 2015; Ayana et al., 2016; Gudina et al., 2016; Kemal et al., 2016b; Mohammed et al., 2017; Tesgera et al., 2017; Hussein et al., 2018; Leyikun et al., 2018; Nuna and Guder, 2018; Tafesse and Amante, 2019; Amante, 2020; Ayana et al., 2021; Blate, 2021; Abdurehman et al., 2022; Adugna and Tamrat, 2022; Belete and Mekuria, 2023; Fentahun et al., 2023; Tadesse and Bulbula, 2023)
Total		**82,804**	**100%**	

according to the inclusion and exclusion criteria used. Finally, 41 articles were eligible for the current systematic review and meta-analysis (Fig. 1).

3.2. Grouping of ixodid tick genera

In the review, out of a total of 17,161 cattle examined, 82,804 ticks were collected, identified, and grouped into three tick genera. *Rhipicephalus* (*Boophilus*) and *Hyalomma* were the predominant and lowest tick genera, with a pooled prevalence of 47.53% and 6.37%, respectively (Table 1).

3.3. Characteristics of the included studies

All studies included in the current review employed a cross-sectional study design. Twenty studies were carried out in the Oromia region, thirteen in the Southern Nations Nationalists and Peoples Region (SNNPR), six in the Amhara region, and one each in the Gambella and Benishangul-Gumuz regions. The sample sizes of the studies ranged from 179 to 1209, and the prevalence rates of ixodid ticks within the studies ranged from 5.99 to 97.80%. All studies were evaluated using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) tool and showed low risk scores (Table 2).

3.4. Meta-analysis

The pooled prevalence of ixodid tick infestation among cattle in Ethiopia is presented in the forest plots in Fig. 2. A random effects model showed that the pooled prevalence of ixodid ticks among cattle was 64.42% (95% CI = 57.13–71.71; I^2 = 98.6%).

3.5. Subgroup analysis

A sample size of <384 with a pooled prevalence of 72.54% (95% CI: 35.54, 109.55) was comparatively greater than that of its counterparts (a sample size greater than or equal to 384), with a pooled prevalence of 63.76% (95% CI: 56.46, 71.07) (Fig. 3 and Table 3). With respect to region, 89.58% (95% CI: 83.93, 95.23), 77.60% (95% CI: 49.50, 105.70), 70.05% (95% CI: 56.86, 83.24), 63.75% (95% CI: 51.91, 75.59), and 59.21% (95% CI: 48.27, 70.15) were the pooled prevalence of ixodid tick in Gambella, Benishangul-Gumuz Region (BGR), Southern Nations, Nationalities, and People's Region (SNNPR), Amhara, and Oromia, respectively (Fig. 4 and Table 3). Regarding the sampling technique, the pooled prevalence of ixodid tick was higher in the systematic random sampling method (72.35%; 95% CI: 58.94, 85.75) than in the simple random sampling method (61.09%; 95% CI: 52.98, 69.20) (Fig. 5

Table 2
General characteristics of the studies included in the systematic review and meta-analysis.

Year	Region	Study design	Sampling method	Total number of cattle examined	Number of cattle infected	Prevalence (95% CI)	Total Number of collected adult tick	Quality
(Abera et al., 2010)	SNNPR	CS	Systematic random	179	175	97.8 (92.8–100)	4772	5
(Tiki and Addis, 2011)	Oromia	CS	Systematic random	1209	310	25.64 (20.6–31.8)	1831	6
(Asrate and Yalew, 2012)	Oromia	CS	Simple random	560	186	33.21 (28.2–39.4)	1446	6
(Kumsa et al., 2014)	Oromia	CS	Simple random	267	228	85.4 (80.4–91.5)	1006	5
(Alemu and Chanie, 2012)	Amhara	CS	Simple random	384	312	81.25 (76.3–87.5)	1451	6
(Amante et al., 2014)	Oromia	CS	Systematic random	394	336	85.3 (78.3–89.6)	1444	6
(Wolde and Mohamed, 2014)	SNNPR	CS	Simple random	638	418	65.5 (60.5–71.6)	3261	6
(Meaza et al., 2014)	Amhara	CS	Simple random	404	299	74 (69.1–80.4)	1500	6
(Admassu et al., 2015)	Amhara	CS	Simple random	384	216	56.2 (51.2–62.5)	864	6
(Nateneal et al., 2015)	Oromia	CS	Simple random	384	315	82 (77.1–88.5)	1984	6
(Tesgera et al., 2017)	Oromia	CS	Systematic random	384	232	60.4 (55.5–66.8)	1447	6
(Gudina et al., 2016)	Gambella	CS	Simple random	384	344	89.58 (84.6–95.9)	2005	6
(Kemal et al., 2016b)	SNNPR	CS	Systematic random	384	291	75.7 (70.5–81.8)	2024	6
(Ayana et al., 2016)	Amhara	CS	Simple random	384	287	74.7 (69.5–80.8)	919	6
(Kemal et al., 2016a)	Oromia	CS	Simple random	384	360	93.8 (88.4–99.8)	1984	6
(Wogayehu et al., 2016)	SNNPR	CS	Simple random	480	417	86.87 (81.8–92.9)	4337	6
(Seid, 2017)	Oromia	CS	Systematic random	384	370	96.4 (91.4–100)	3908	6
(Yalew et al., 2017)	Oromo	CS	Simple random	462	186	40.26 (35.3–46.6)	1446	6
(Mohammed et al., 2017)	Oromia	CS	Simple random	384	229	59.6 (54.6–65.8)	1201	6
(Bahiru et al., 2018)	Oromia	CS	Simple random	384	113	29.43 (24.4–35.8)	966	6
(Leyikun et al., 2018)	Amhara	CS	Systematic random	384	197	51.3 (46.3–57.8)	799	6
(Hussein et al., 2018)	Oromia	CS	Simple random	384	236	61.5 (56.5–67.7)	279	6
(Nuna and Guder, 2018)	Oromia	CS	Random sampling	400	215	53.8 (48.5–59.9)	645	6
(Mohammed and SAMARA, 2018)	Oromia	CS	Systematic random	384	159	41.4 (36.4–47.8)	657	6
(Tafesse and Amante, 2019)	Oromia	CS	Simple random	384	274	71 (66.2–77.8)	2255	6
(Getiso and Geinoro, 2019)	SNNPR	CS	Simple random	501	327	65.26 (60.2–71.6)	3290	6
(Gelelcha et al., 2019)	SNNPR	CS	Systematic random	384	370	96.4 (91.4–100)	3908	6
(Abiso et al., 2019)	SNNPR	CS	Simple random	501	327	65.27 (60.3–71.5)	3290	6
(Detamo and Handalo, 2020)	SNNPR	CS	Simple random	384	23	5.99 (1.2–11.9)	264	6
(Amante, 2020)	BGR	CS	Simple random	384	298	77.6 (72.6–83.8)	2686	6
(Blate, 2021)	SNNPR	CS	Systematic random	384	304	79.2 (74.2–85.8)	4112	6
(Wondimu and Bayu, 2021)	Oromia	CS	Simple random	353	121	34.3 (29.3–40.7)	447	6

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Table 2 (*continued*)

Year	Region	Study design	Sampling method	Total number of cattle examined	Number of cattle infected	Prevalence (95% CI)	Total Number of collected adult tick	Quality
(Ayana et al., 2021)	Oromia	CS	Systematic random	445	400	89.89 (84.8–96.1)	7778	6
(Chumburo and Bayou, 2021)	SNNPR	CS	Random	384	296	77.1 (72.1–83.5)	780	6
(Adugna and Tamrat, 2022)	Amhara	CS	Simple random	384	173	45 (40.1–51.5)	2047	6
(Abdurehman et al., 2022)	Oromia	CS	Simple random	384	177	46.1 (41.1–52.6)	680	6
(Belete and Mekuria, 2023)	SNNPR	CS	Systematic random	384	262	68.2 (63.2–74.5)	579	6
(Fentahun et al., 2023)	SNNPR	CS	Random	384	275	71.6 (66.6–77.8)	683	6
(Lemu et al., 2023)	Oromia	CS	Random	384	276	71.9 (66.9–78.1)	3192	6
(Tadesse and Bulbula, 2023)	Oromia	CS	Simple random	384	87	22.66 () 17.7–28.9	514	6
(Fanda, 2023)	SNNPR	CS	Simple random	384	213	55.5 (50.5–61.8)	1019	6

SNNPR, Southern Nations, Nationalities and People's Region; *BGR*, Benishangul-Gumuz Region; *CS*, Cross-sectional.

and Table 3). The estimate of ixodid tick prevalence was higher between 2010 and 2015, with a pooled prevalence estimate of 68.65% (95% CI: 53.40, 83.91) than in the study period 2016 to 2020, at 64.67% (95% CI: 53.62, 75.72), and 2021 to 2023, at 60.13% (95% CI: 47.72, 72.54) (Fig. 6 and Table 3).

3.6. Heterogeneity, publication bias, and sensitivity analysis

All heterogeneity and publication bias of included studies were evaluated, and high levels of heterogeneity were present (I^2 = 98.6%, $p < 0.001$). The funnel plot revealed an asymmetrical distribution (Fig. 7). The Egger and Begg tests revealed that there was no substantial publication bias (Figs. 8 and 9). To clarify the impact of each study on the size of the pooled effect, a sensitivity analysis was performed by removing each study one at a time. According to the sensitivity analysis, the studies not included in Fig. 10 had determinant effects on the overall magnitude of the ixodid tick among cattle in Ethiopia.

4. Discussion

The current systematic review and meta-analysis revealed that ixodid ticks are important external parasites and highly distributed in Ethiopia. In the present study, a total of 82,804 adult ticks were collected from 17,161 cattle, with a prevalence of 64.42% of tick infestation. This finding is comparable to the previous report of 61.98% in Humbo (Wasihun and Doda, 2013) and 65.50% in Sodo Zuriya (Wolde and Mohamed, 2014) districts. However, the current finding disagrees with (Misgana, 2017), who reported an overall prevalence of 91.5% in the Oromia regional state of Adaa and Boset districts. On the other hand, our study is higher than the findings reported, with an overall prevalence of 25.6% in Holetta (Tiki and Addis, 2011) and 27.3% in Bench Maji Zone (Onu and Shiferaw, 2013). The variation of these findings may be due to different management systems, seasonal variation, agroecology, animal health practice, study design, and different target animals, which may not be conducive to their reproduction and survival (Adugna and Tamrat, 2022).

In the present study, *Rhipicephalus* (*Boophilus*), *Amblyomma*, and *Hyalomma* were the three genera of ixodid ticks grouped in abundance. *Rhipicephalus* (*Boophilus*) (47.53%) was the most abundant tick genus in Ethiopia. This finding is in agreement with the report of the study done by (Peter et al., 2021) in Kenya, where *Rhipicephalus* was the most abundant genera with a prevalence of 67.0%. *Hyalomma* was the least abundant tick species in Ethiopia, with a prevalence of 6.37%. This report coincides with the previous studies with a prevalence of 4.7% and 13.8% by (Teshome et al., 2016) and (Peter et al., 2021) in Oromia, Ethiopia, and Nairobi, Kenya, respectively. However, the current study disagrees with the study reported by (Fesseha and Mathewos, 2020) in Hossana district, Hadiya zone, Ethiopia, which stated that *Hyalomma* was the most abundant tick genus with a prevalence of 11.9%. This variation could be due to the difference in the season of tick collection and agroecological systems in the study areas.

The economic losses due to tick-borne diseases such as babesiosis, anaplasmosis, and teileriosis have been divided into direct and indirect. The direct production losses are those that are directly attributable to the presence of disease in the animal population through morbidity and mortality (Yusuf, 2017). Other losses are related to the animals that recovered that may suffer from weight loss, lesions such as soft and pulpy spleen, damage and irritation to hide, swollen liver, dark-colored kidneys, anemia and jaundice, low milk

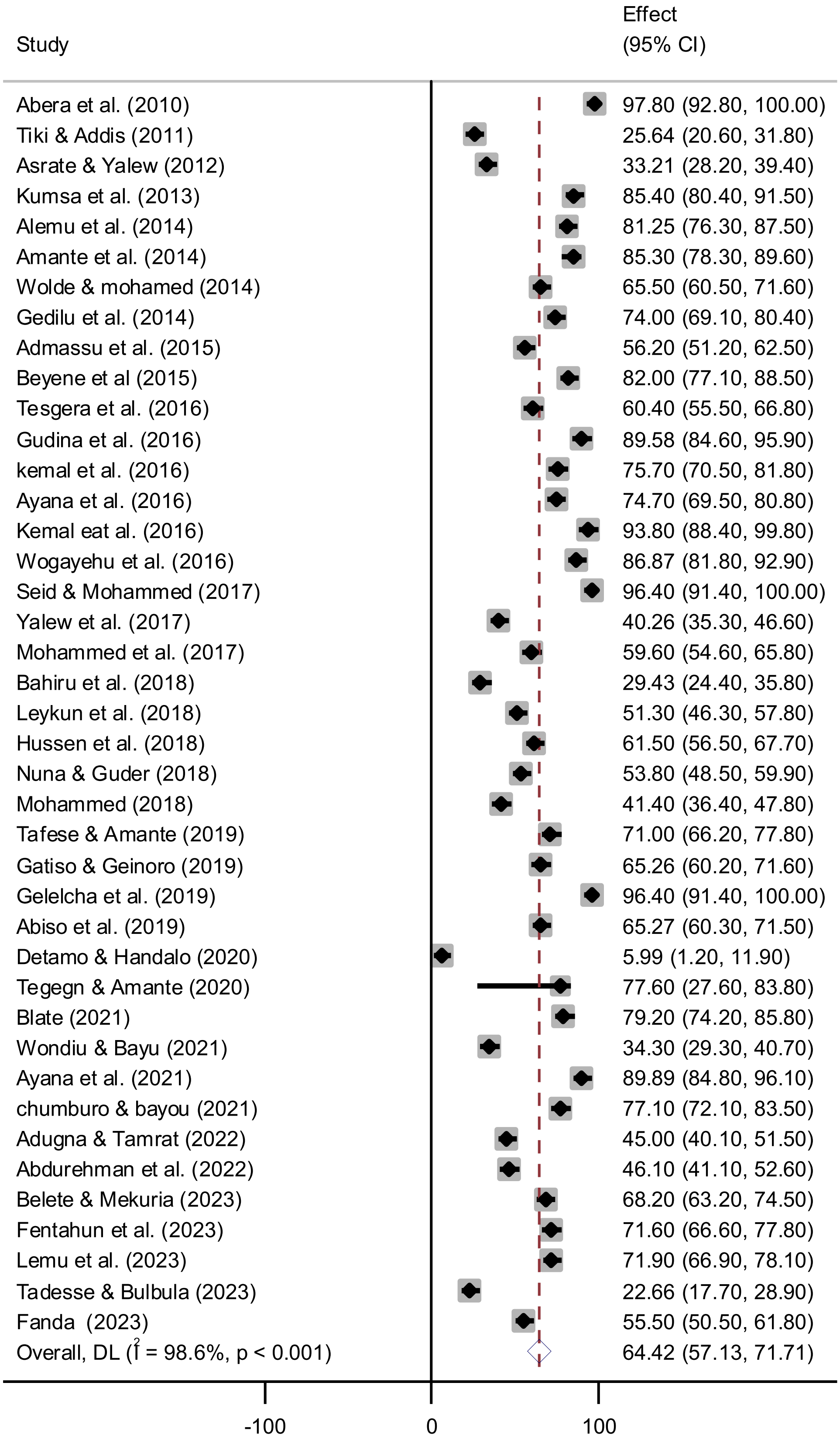

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Fig. 2. Forest plot of the prevalence of the ixodid tick among cattle in Ethiopia.

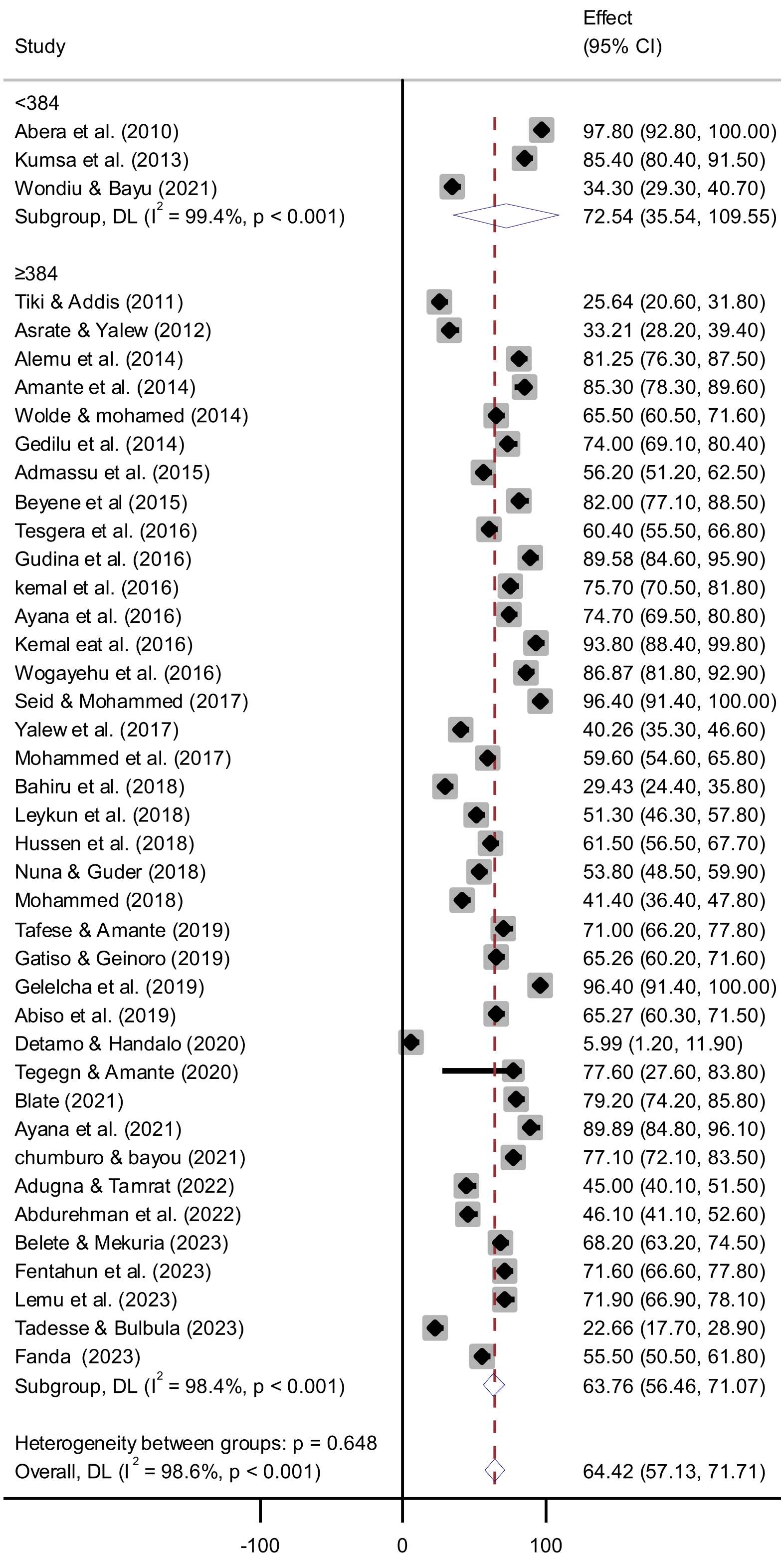

Fig. 3. Subgroup analysis by sample size on the pooled prevalence of ixodid tick among cattle in Ethiopia.

Table 3
Subgroup analysis of the magnitude of ixodid tick among cattle

Variables	Characteristics	Included studies	Sample size	Prevalence (95% CI)	I^2, *P*–value
Sample size	<384	3	799	72.54 (95% CI: 35.54, 109.55)	99.4, $P < 0.001$
	≥384	38	16,362	63.76 (95% CI: 56.46, 71.07)	98.4, $P < 0.001$
Region	SNNPR	13	5371	70.05 (95% CI: 56.86, 83.24)	98.8, $P < 0.001$
	Oromia	20	8698	59.21 (95% CI: 48.27, 70.15)	98.7, $P < 0.001$
	Amhara	6	2324	63.75 (95% CI: 51.91, 75.59)	96.2, $P < 0.001$
	Gambella	1	384	89.58 (95% CI: 83.93, 95.23)	–, –
	BGR	1	384	77.60 (95% CI: 49.50, 105.70)	–, –
Sampling method	Simple random	29	11,862	61.09 (95% CI: 52.98, 69.20)	98.3, $P < 0.001$
	Systematic random	12	5299	72.35 (95% CI: 58.94, 85.75)	98.8, $P < 0.001$
Publication Year	2010–2015	10	4803	68.65 (95% CI: 53.40, 83.91)	98.8, $P < 0.001$
	2016–2020	20	8104	64.67 (95% CI: 53.62, 75.72)	98.7, $P < 0.001$
	2021–2023	11	4254	60.13 (95% CI: 47.72, 72.54)	98.1, $P < 0.001$
	Overall	41	17,161	64.42 (95% CI: 57.13, 71.71)	98.6, $P < 0.001$

SNNPR, Southern Nations, Nationalities and People's Region; *BGR*, Benishangul-Gumuz Region.

yields, reduction in meat, provide less draught power, and suffer from reduced fertility and delays in reaching maturity (Manjunathachar et al., 2014; Yusuf, 2017; Kyari et al., 2022).

In the current study, the pooled prevalence and abundance of ixodid tick infestation in cattle were higher in lowland and midland than in highland. This is observed with respect to the prevalence of ixodid ticks between regions, and 89.58%, 77.60%, 70.05%, 63.75%, and 59.21% were the pooled prevalence of ixodid tick infestation in Gambella, Benishangul-Gumuz Region (BGR), Southern Nations, Nationalities, and People's Region (SNNPR), Amhara, and Oromia, respectively. This finding is in line with previous results in Ethiopia reported by (Sileshi et al., 2007) and (Adugna and Tamrat, 2022). It was due to the fact that lowland agroecological systems with high temperature and humidity are more suitable for tick multiplication and survival than in the highland area, as previously reported by (Kemal et al., 2020).

In the present systematic review and meta-analysis, the prevalence of ixodid tick infestation among cattle has decreased, from 68.65% in 2010–2015 to 64.67% in 2016–2020 and from 2021 to 2023 to 60.13%, respectively. This pooled prevalence tread difference might be due to breed differences; a good management system such as a small livestock population and herd size, good veterinary service, and great attention given to cattle management practices employed by the herders could also contribute to a decrease in the pooled prevalence trend in ixodid tick infestation among cattle in Ethiopia.

Several concepts, such as integrated tick control strategies (host resistance to ticks and diseases they transmit), the use of biological control measures, cross-breeding, and the development of vaccines against tick antigens, have been deployed in the control of ticks (Jonsson and Piper, 2007). Environmental management, such as seasonal dynamics of tick infestation and an extensive system of raising animals, when compared to an intensive system, increases the risk of tick infestation (Jonsson and Piper, 2007). The most conventional means used in the control of ticks is dipping or spraying with chemicals (Kyari et al., 2022).

4.1. Limitations of the study

The study included the different times of studies that could affect the prevalence and the heterogeneity between studies. From the 41 included papers, half of the studies are from the Oromia region, and this may affect the pooled estimate and tick genera types most prevalent in Ethiopia. Additionally, because the studies in this review were all cross-sectional in design, it is possible that other confounding variables could influence the outcome variable. Only studies conducted between 2010 and 2023 were included. Moreover, it was challenging to generalize the results due to a lack of information and data from other regions of Ethiopia.

4.2. Conclusions and recommendations

The current study demonstrated that there was a high prevalence of ixodid ticks in Ethiopia, with an overall prevalence of 64.42%, which indicates that ticks are a common and important ectoparasite of cattle in Ethiopia. In the present study, *Rhipicephalus* (*Boophilus*) and *Hyalomma* were the most abundant and least abundant ixodid tick genus in Ethiopia, respectively. The general trend prevalence of ixodid tick infestation among cattle has decreased, from 68.65% in 2010–2015 to 60.13% in 2021–2023. This study showed that there was a high burden and prevalence of ixodid ticks that still play a major role in reducing productivity and causing health problems of Ethiopian cattle. An appropriate tick control program should be designed and implemented in Ethiopia, taking into account the findings of this study. Further detailed studies on the role of different species of ixodid ticks in causing disease in cattle and their

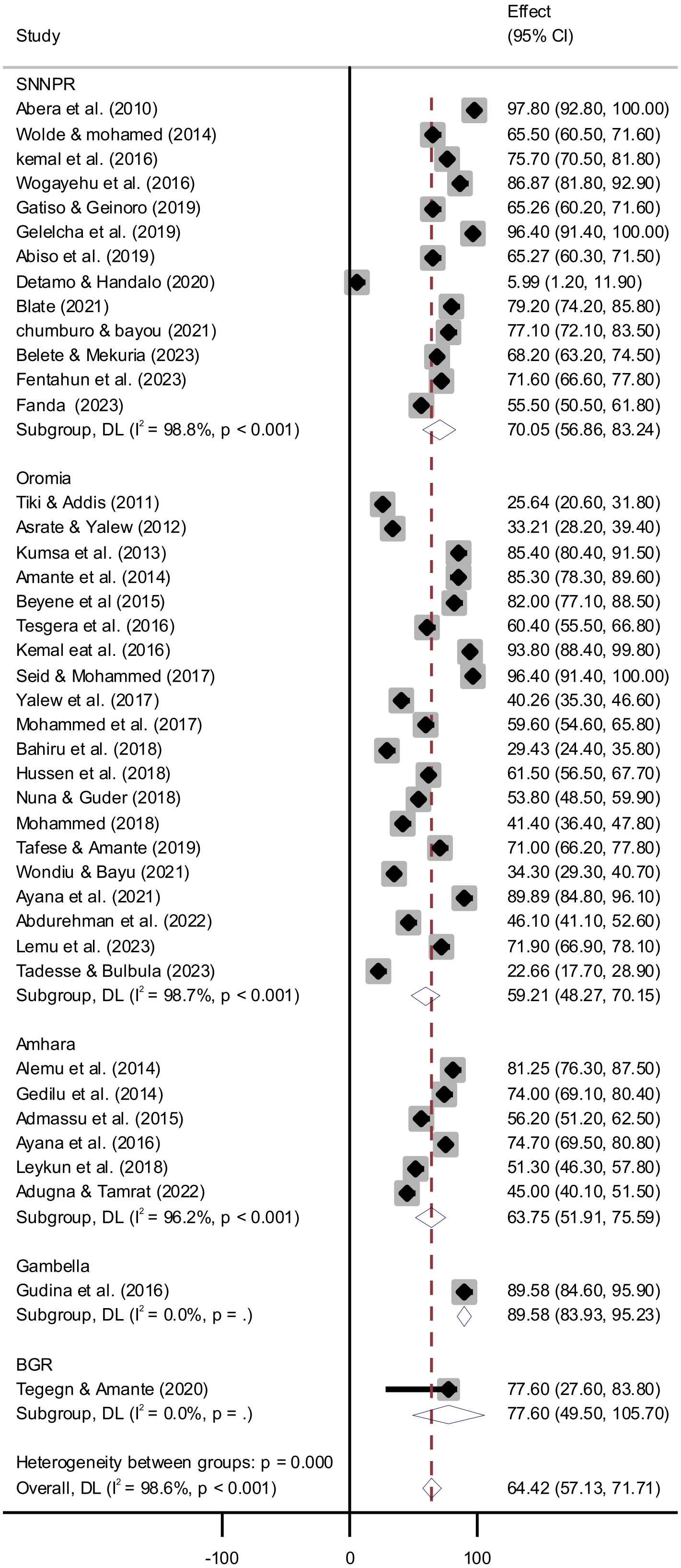

Fig. 4. Subgroup analysis by region on the pooled prevalence of ixodid tick among cattle in Ethiopia.

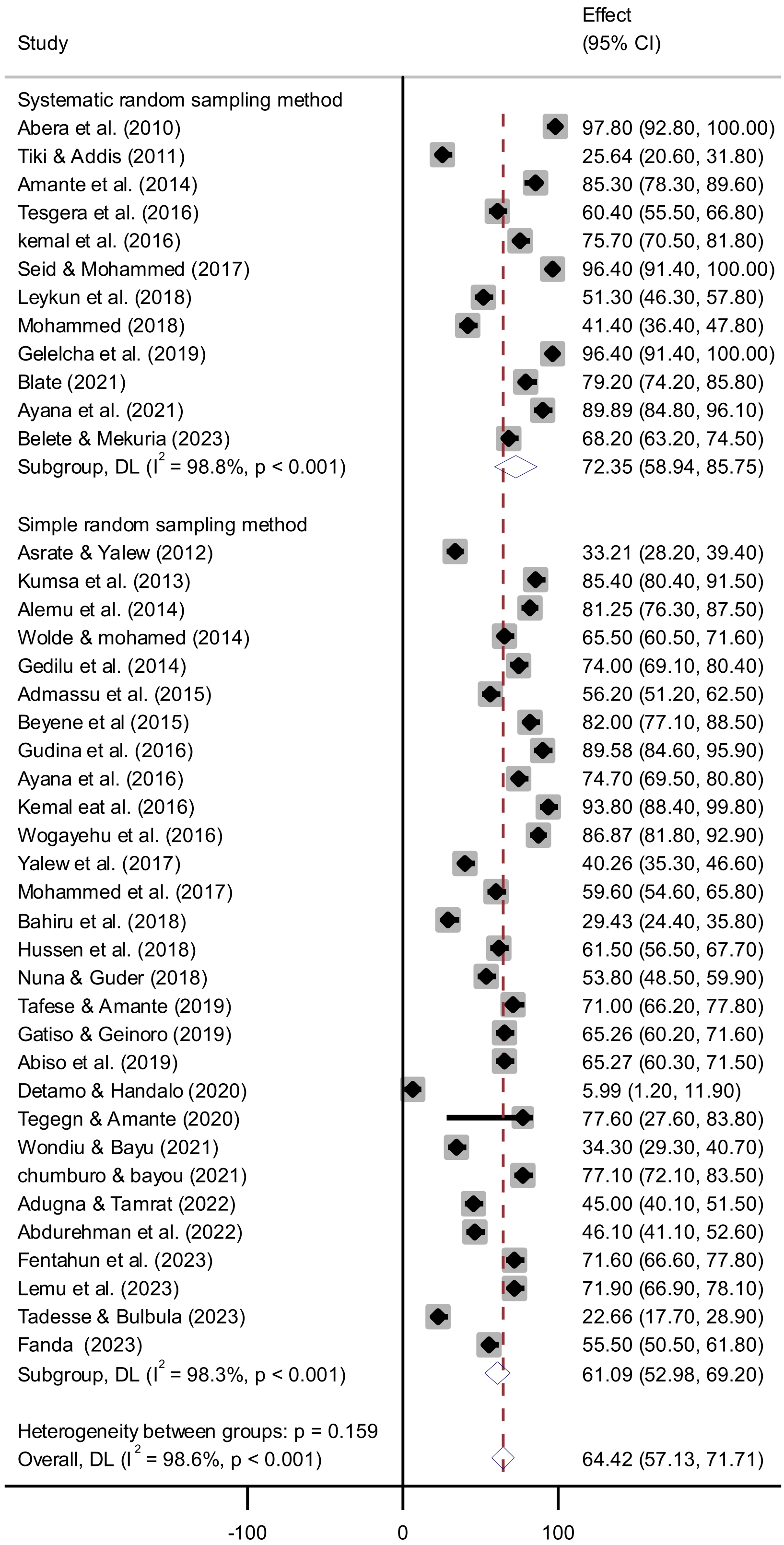

Fig. 5. Subgroup analysis by sampling method on the pooled prevalence of ixodid tick among cattle in Ethiopia.

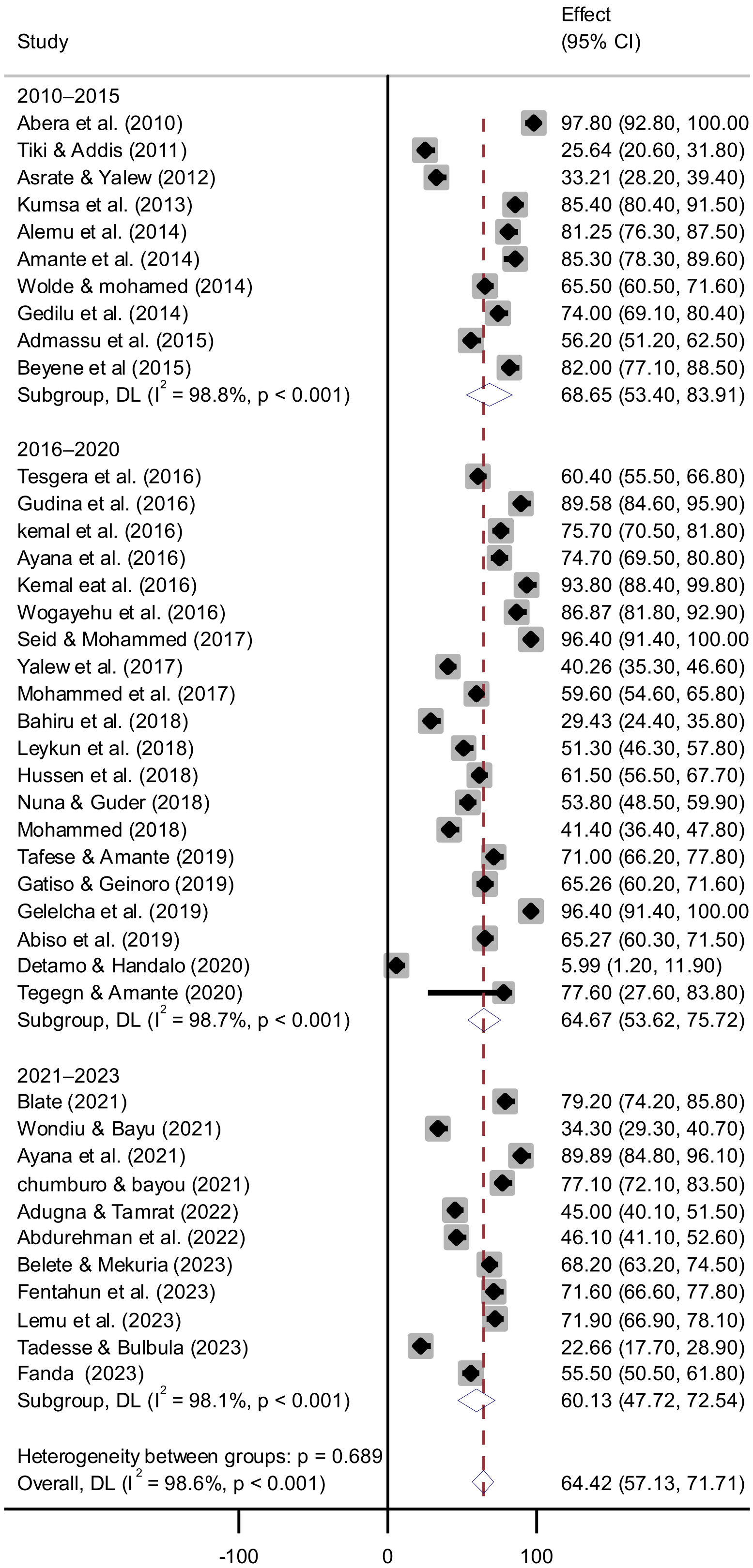

Fig. 6. Subgroup analysis by publication year on the pooled prevalence of ixodid tick among cattle in Ethiopia.

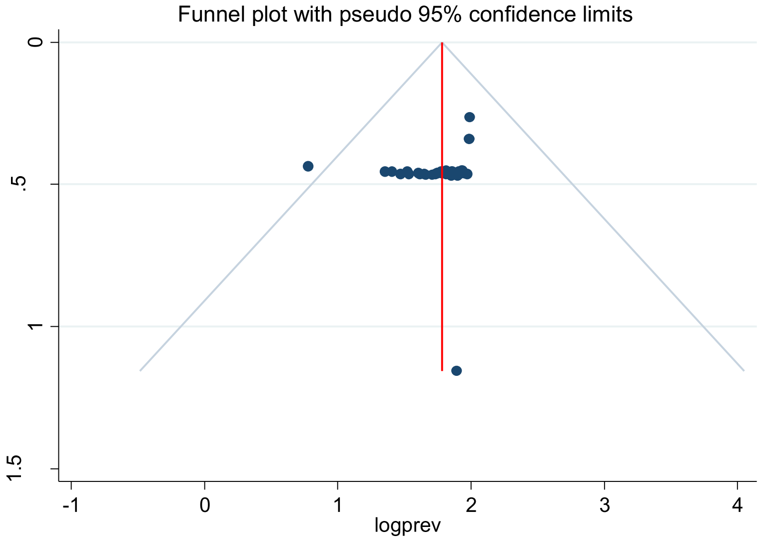

Fig. 7. The funnel plot in this meta-analysis indicates publication bias across studies.

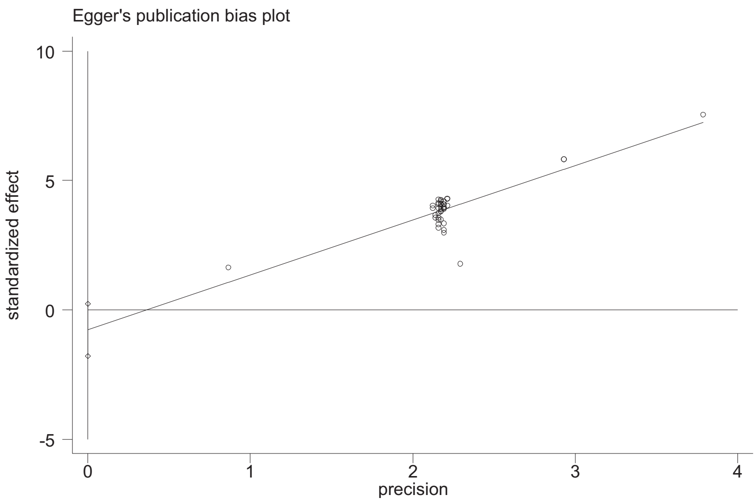

Fig. 8. Egger's publication bias plot of included studies on the impact of ixodid ticks on cattle pooled magnitude.

economic consequences on livelihoods need urgent attention.

Ethics approval and consent to participate

Formal consent or ethics approval was not required for this review.

Funding statement

This work did not receive specific grants from funding agencies in the public, commercial or nonprofit sectors.

CRediT authorship contribution statement

Abayeneh Girma: Conceptualization, Software, Formal analysis, Investigation, Validation, Visualization, Supervision, Writing – review & editing. **Indiris Abdu:** Methodology, Resources, Data curation, Validation, Visualization, Project administration, Writing – original draft. **Kasaye Teshome:** Methodology, Resources, Data curation, Validation, Visualization, Project administration, Writing – original draft. **Amere Genet:** Methodology, Resources, Data curation, Validation, Visualization, Project administration, Writing – original draft. **Dessalew Tamir:** Methodology, Resources, Data curation, Validation, Visualization, Project administration, Writing –

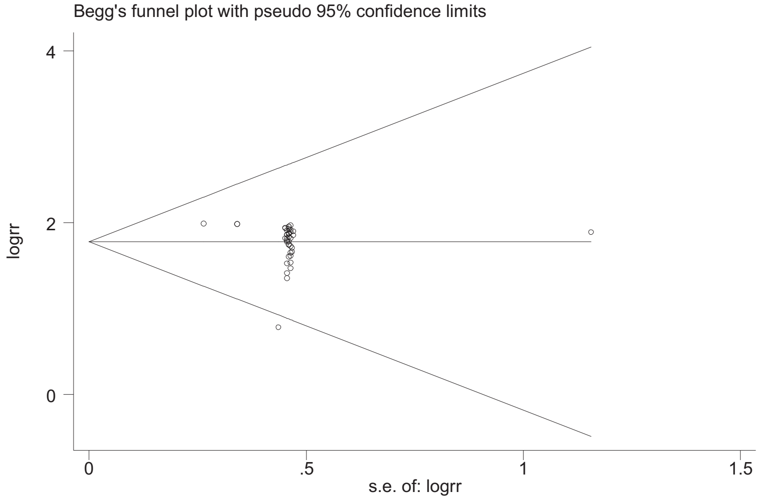

Fig. 9. Begg's publication bias plot of included studies on the impact of ixodid ticks on cattle pooled magnitude.

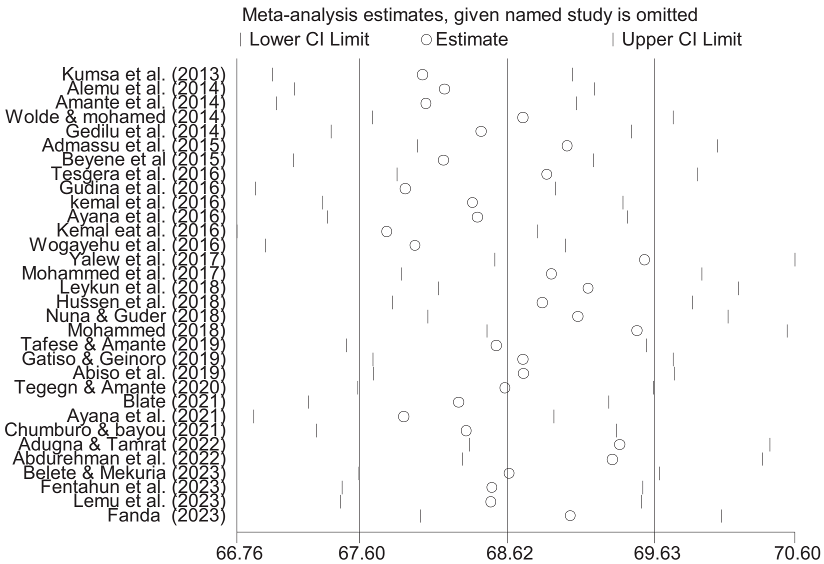

Fig. 10. Sensitivity analysis results of the included studies showing the impact of each study on the pooled magnitude.

original draft.

Declaration of competing interest

The authors declare that they have no competing interests.

Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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