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Review

Lungworm infection in small ruminants in Ethiopia: Systematic review and meta-analysis

Kassahun Asmare[a], Berhanu Sibhat[b], Aynalem Haile[c], Desie Sheferaw[a], Kassaye Aragaw[a], Mesele Abera[a], Rahmeto Abebe[a,*], Barbara Wieland[d]

[a] Faculty of Veterinary Medicine, Hawassa University, P.O. Box 005, Hawassa, Ethiopia
[b] College of Veterinary Medicine, Haramaya University, P.O. Box 138, Dire Dawa, Ethiopia
[c] International Center for Agricultural Research in the Dry Areas (ICARDA), Research Platform, Sub-Saharan Africa Regional Program, P.O. Box 5689, Addis Ababa, Ethiopia
[d] International Livestock Research Institute (ILRI), P.O. Box 5689, Addis Ababa, Ethiopia

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ABSTRACT

Lungworms are important parasitic nematodes of small ruminants that colonize the lower respiratory tract and cause high morbidity and economic loss throughout the world. This systematic review was conducted with the aim of estimating the pooled prevalence of lungworm infection in small ruminants in Ethiopia. Besides, it examines the predictors thought to be responsible for heterogeneity noted between the reports. The search databases used were PubMed, CAB direct, AJOL and Web of science. Eligible studies were selected based on predefined inclusion and exclusion criteria. Thirty two studies published between 2000 and 2016 were found eligible and data were generated on 14,257 small ruminants (12,310 sheep and 1947 goats). Predictors including the study area, type of small ruminants affected, parasitic species involved, a diagnostic test used, study design, management systems, breed, agroecology, and year article published were used as milestone of data extraction. The statistical tool employed were meta-analysis, univariable and multivariable meta-regression and Egger's and begg's statistics for sensitivity analysis. Accordingly, the estimated pooled prevalence of lung worm infection in small ruminants was 40.8% (95% CI: 36.1, 45.6) with a very high heterogeneity between the study reports (I^2 = 96.5%). However, diagnostic test used and administrative States were the only two predictors identified to explain 15.5% of the explainable heterogeneity (R^2 = 0.1545, tau^2 unexplained = 0.6032, tau^2 total = 0.7135) noted between studies. The reviewed studies showed that three genera of lungworms, namely *Dictyocaulus filaria*, *Mullerius capillaris* and *Protostrogylus rufescens* were prevalent both in sheep and goats in Ethiopia. Mixed infection with two or three species was reported in 4.4 to 48.6% of the total infected animals. Indeed this review is informative and provides a better picture on lungworm infection in Ethiopia; however, it is not exhaustively detailed as there was lack of clear data on the role of some important factors like age, flock size, management system and seasonal variation on lungworm infection. Thus, thorough epidemiological studies including all seasons are required for formulation of meaning full control strategies.

1. Introduction

Ethiopia has a huge potential of small ruminants which is estimated to be 29.33 million sheep and 29.11 million goats (CSA, 2015). Small ruminants play an important role in the national economy of the country as they provide 33% of meat and 14% of milk consumption (Asfaw, 1997). Moreover, they enable the country to earn substantial amounts of foreign currency through export of meat, skins and other by-products to Middle East countries. However, the productivity of these livestock is much less compared with their population size due to a multitude of factors among which the occurrence of endoparasitic infections including lungworms has great prominence.

Lungworms are a group of parasitic nematodes that colonize the lower respiratory tract of livestock. They cause high morbidity, high mortality, and high economic costs throughout the world especially temperate regions (Elsheikha and Khan, 2011) and in the highlands of tropical and sub-tropical countries (Hansen and Perry, 1994). Small ruminants can be infected by several lungworms but the most important species that are capable of causing respiratory diseases are *Dictyocaulus filaria*, *Muellerius capillaris*, and *Protostrongylus rufescens*. However, the

* Corresponding author.
E-mail address: rahmetoabe@gmail.com (R. Abebe).

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pathogenic effects of these parasites depend on their location within the respiratory tract, the number of infective larvae ingested and the immune system of the animals (Urquhart et al., 1996; Elsheikha and Khan, 2011; Ballweber, 2016).

Over the years a number of researchers have studied the occurrence of lungworm infections in small ruminants in Ethiopia. According to the studies, the apparent prevalence estimate falls within the range of 17.4 and 72.4% for sheep and 19.2 and 62.7% for goats based on coprological and post-mortem examinations. The common lungworm species reported to exist in the country are *D. filaria*, *M. capillaris* and *P. rufescens* (Alemu et al., 2006; Regassa et al., 2010; Addis et al., 2011; Fentahun et al., 2012; Garomsa et al., 2012; Denbarga et al., 2013; Eyob and Matios, 2013; Terefe et al., 2013; Kebede et al., 2014; Asaye and Alemneh, 2015; Abebe et al., 2016; Fentahun et al., 2016).

Despite the fact that the studies have shown that lungworms are one of the major constraints of small ruminant production in the country that needs attention, to date no quantitative synthesis of the reports was conducted to describe precisely the spatial-temporal distribution and the most important host, management and environmental risk factors influencing the occurrence of lungworm infection in both sheep and goats in the country. Such information could be of significant importance in the development of feasible intervention measures aimed at reducing the burden of infection and productivity losses associated with the parasites in question. Therefore, the objective of this systematic review was to estimate the pooled prevalence of lungworm infection in small ruminants and identify the relevant predictors that could possibly account for heterogeneity in prevalence estimates between the reports.

2. Materials and methods

2.1. Literature search strategy

This review identified literature from online sources. Google scholar and Yahoo were the two search engines used to retrieve articles from PubMed, CAB direct, AJOL and Web of science databases. Searches were conducted between 15th of November 2016 to December 30, 2016. Articles were all written in English language and published after January 2000. In order to retrieve the published reports a serious of strings or keywords including small ruminants, sheep, goat, lungworms, parasitic pneumonia, verminous pneumonia, and Ethiopia were used. However, the keywords were rearranged to phrase as close as "Lungworm infection in small ruminants in Ethiopia."

2.2. Inclusion and exclusion criteria

The articles retrieved through the indexed databases were assessed as per predefined criteria. This assessment was conducted at two levels, first the title and the abstract were checked to assure relevance to the review question. Articles that passed the initial screening were assessed in detail using the following criteria: i) originality of the report, ii) the time of publishing, iii) clarity of study objective, iv) appropriateness of the methodology including study design, sampling technique, the diagnostic technique used, and clarity of result presentation. Articles published before 2000, review articles, articles with a clear methodological flaw, case reports, and case series studies were rejected as they were not suitable to derive representative prevalence estimates or risk factor identification for small ruminant lungworm infection.

2.3. Data extraction

The data extraction template was drafted by the first author of the manuscript and co-authors commented to ensure the template allows consistent recording of predictors. The data were extracted independently by two authors. Data for variables related to study area, type of small ruminants affected, parasitic species involved, the diagnostic test used, study design, management systems, breed, and agroecology were recorded qualitatively. Quantitative data were extracted for year article published, sample size, number positive, number negative, point prevalence and confidence interval of the estimate at animal level. Finally, the extracted data were all cross-checked against the source articles.

2.4. Pooled prevalence (effect size) estimate

The data were transformed into a logarithmic scale to normalize the distribution using the formula $\text{lp} = \ln \frac{p}{1-p}$ where lp = the logit event estimate, ln = the natural logarithm and p = study level estimate. Variance of the logit-estimate was calculated using the formula, $\text{V(lp)} = \frac{1}{np} + \frac{1}{n(1-p)}$ where v = variance and n = sample size. The standard error of logit-prevalence (SE) was generated using the formula ln-p = Sqrt (1/sample - n × p × (1-p)). The pooled estimate was computed in transformed values, as per the formula, $p = 1/(1 + \text{e-lp})*100$, where 'e' is the base of natural logarithm. Forest plot in random effect model was used to present the effect size and associated weight for each report included in the review. All transformations and data analysis were made with STATA 14 software (Stata/ SE 14 for Windows, Stata Corp, College Station, TX).

2.5. Heterogeneity assessment

Forest plot was used to depict the level of existing difference beyond chance in Cochran's statistics (Q). The standard variation between the studies was also computed (τ^2). The Higgins (I^2) statistics was used to compute the observed proportion of variability attributed to heterogeneity of studies and meta-regression was conducted to assess the level of variation among the predictors considered and overall explainable heterogeneity quantified by the final model (Sterne et al., 2009). Multicollinearity assessment for predictors was made using kruskal gamma statistics in univariable regression and predictors with a gamma value between - 0.6 and + 0.6 were subjected to multiple meta-regression (Higgins and Thompson, 2002; Hox and de Leeuw, 2003). This approach allowed to identify the explainable proportion of the heterogeneity (R^2) attributed to predictors that have significant statistical association ($p < .05$). When the calculated R^2 value become negative or above 1, an adjustment was made either to "0" or "1" (Borenstein et al., 2009).

2.6. Literature bias assessment

For the selection of literature and extraction of data, objectivity and consistency were a priority. To assess any remaining bias data were analyzed using Begg's and Egger's tests statistics and funnel plot and influence plot analysis were constructed for visual interpretation (Sterne et al., 2009; Borenstein et al., 2009).

3. Result

3.1. Literature search results

The electronic search resulted in a total of 60 peer reviewed articles. However 28 of them were rejected for one or the other reasons. Fourteen of the articles were redundant, eight were rejected based on the title and abstract content and six articles were left out due to substandard methodology and lack of valid data. From the remaining 32 articles, 65 animal level data sets were extracted (Fig. 1).

3.2. Characteristics and quality of the reports

In line with the predefined inclusion criteria, title and abstract of the articles were used for preliminary screening. Articles thought to reflect the review question were included in the full length assessment.