



## Research article

# Systemic review of strongyle infections in horses across Asia: prevalence, diagnosis, and management

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## Abstract

Strongylosis has been one of the most well-known diseases in the equine world. However, there is a lack of substantial knowledge regarding its prevalence in Asia. Hence, this study systematically reviewed data on strongyle species recorded in Asia and the main risk factors, diagnoses, treatment, and control. Four electronic databases were used to search the publications on strongyle species in Asia, and the inclusion and exclusion criteria were established. The chosen publications were accessed to discuss the risk factors, diagnoses, pathogenesis, treatment, and control in Asian countries. A total of 30 articles published between 2000 and 2024 were included. The main strongyle species reported is the large strongyle, with *Strongylus edentatus* and *Strongylus vulgaris* being the most prevalent. Small strongyles (cyathostomins) have become remarkably prevalent throughout the year, with *Gyalocephalus* sp. as the most pervasive. A diverse species prevalence is documented in the western countries with the weather playing an important role. Strongyles were mostly diagnosed by faecal floatation and quantified by the McMaster method, while further diagnosis was done using molecular techniques. Information on the use of anthelmintic drugs is still lacking. Subsequently, a progressive increase in the knowledge of strongyle species over the years in Asia countries has been noted. With the emergence of anthelmintic resistance, more research should be done, focusing on bridging the knowledge gaps to ensure the health of equine species and minimise economic losses associated with strongyle infections.

**Keywords:** Asia, Cyathostominae, Horse, Prevalence, Strongyles.

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## INTRODUCTION

Intestinal parasitic helminth infections are one of the most common issues in horses. Nematodes belonging to the *Strongylidae* family carry a particular significance as they can profoundly impact the health and performance of horses (Girma et al., 2017). The family *Strongylidae*, which includes large (*Strongylinae*) and small (*Cyathostominae*) strongyles, are some of the most pathogenic enteric parasites of horses, causing a clinical disease termed strongylosis (Hodgkinson et al., 2005). The most damaging and dangerous internal parasites in horses are typically known to be large strongyles: *Strongylus vulgaris*, *Strongylus edentatus*, and *Strongylus equinus* (Khan et al., 2019). Small strongyles, also known as cyathostomins, exist in more than 50 species, with 10 of those species thought to be the most common (Corning, 2009). The most common species are *Cyathostomum catinatum*, *Cylicocycclus nassatus*, and *Cylicostephanus* (Cys.; Bellaw and Nielsen, 2020). They are currently the most prevalent and important pathogen that infects horses worldwide (Macdonald et al., 2023; Halvarsson et al., 2024; Lightbody et al., 2024).

Khan et al. (2019) stated that the major pathophysiology of large strongyles involves injury to the visceral organs, embolism or thrombosis that results in mortality and is primarily ascribed to parasite larvae moving. Meanwhile, the small strongyle is detected by minor signs of diarrhoea, appetite loss, weight loss, poor hair coat, tiredness, peripheral oedema, and abnormal intestinal motility. These clinical signs can impair an equine's ability to grow and perform normally (Baran et al., 2019). Most studies mentioned that intestinal parasites, especially strongyle species, rank among the primary causes of colic, causing horses to suffer excruciatingly until they die due to a mechanical blockage of the gastrointestinal tract (Corning, 2009; Carminatti et al., 2023; Halvarsson et al., 2024).

Understanding the prevalence of these gastrointestinal parasites is crucial for developing effective control strategies. Cai et al. (2024) highlighted global resistant trends to anthelmintics, underscoring the importance of monitoring strongyle prevalence. Recent studies in Thailand using metabarcoding (Hamad et al., 2024) and in China and India (Sengupta, 2003; Maria et al., 2012; Singh et al., 2016; Ai et al., 2023; Jia et al., 2023) have provided valuable insights into strongyle species distribution and resistance patterns. Despite these efforts, there is a gap in systematic reviews, particularly in Southeast Asia, although recent studies in Indonesia (Tirtasari et al., 2021; Sinaga et al., 2022) indicate growing research interest.

Although many studies have focused on the prevalence of strongyles, systematic reviews in Asian countries are still lacking. The vast amount of research on strongyle species in Asia paves the way for a more thorough examination of the available information, and a systematic literature review (SLR) is one of the approaches.

This article aims to provide a systematic overview of the existing knowledge on the risk factors, pathology, and diagnosis of equine strongyle species in Asia and areas for future research that could fill the current knowledge gaps and enhance the understanding of these species.

## MATERIALS AND METHODS

This systemic review process was guided by the Preferred Reporting Items for Systemic Reviews and Meta-Analyses (PRISMA Statement) guidelines (Page et al., 2021). The PRISMA guidelines provide multiple benefits for authors by improving transparency and contributing to higher-quality scientific reporting (Page et al., 2021). Hence, the PRISMA Statement allows for a thorough search of terms related to strongyle species in Asia. The inclusion and exclusion criteria were made

clear to fulfil the primary objectives of this systematic review, indicating the significance of the references.

## Formulation of the research questions (RQ)

Research questions for this systematic review were formulated by applying the mnemonics of PICO, i.e., P for Population or Problem, I for Interest, and Co for Context (Lockwood et al., 2015). Three research questions for this systematic review were developed using the PICO mnemonics. According to the perspective of this study, the horses worldwide represent the population, strongyles and Asian countries represent the interests, and the current understanding of the prevalence, epidemiology, pathology, diagnostic techniques, and treatments represent the context. Based on the selected guidelines, the primary research question for this study is “What are the prevalence, epidemiology, pathology, diagnostic tools and treatment for strongyle species in horses, particularly in Asia?”

## Literature search

### Identification

The use of additional databases is crucial to prevent retrieval bias during the search process. Web of Science and ScienceDirect are highly regarded databases known for their reliability and extensive coverage of over 256 disciplines, including veterinary studies. (Shaffril et al., 2021). The author further justified that supporting databases are essential for conducting systematic searches to fill up any gaps left by the top databases such as Google Scholar and PubMed. Extensive coverage, comprehensive search query features, and reproducibility render these database search engines a good choice for systemic review. Hence, this review used Scopus, Science Direct, PubMed and Google Scholar web databases (the first search was done on 8 March 2024). A comprehensive search was conducted using the selected databases, and articles from 2000 to 2024 were chosen to identify reports in various publications documenting strongyle infections in horses in Asia. The 2000-2024 time frame was chosen to ensure the review's quality and depth, providing sufficient articles to be reviewed. The search strings used to screen the articles contained several terms that are tabulated in Table 1. The search using Scopus, Science Direct, PubMed, and Google Scholar resulted in 1494 articles.

**Table 1** Multiple keywords used in the search string

Database	Date of Acquisition	Search string
Scopus	28/3/2024	TITLE-ABS-KEY (("horse" OR "equine") AND ( "strongyle" OR "strongyle" OR "strongyle" OR "cyathostomins" ) AND ( "prevalence" OR "detection"))
Science Direct	29/3/2024	((("horse" OR "equine") AND ("strongyle" OR "strongylus" OR "strongylida" OR "cyathostomins") AND ("prevalence" OR "detection"))
PubMed	30/3/2024	((("horse" OR "equine" ) AND ("strongyle" OR "strongylus" OR "strongylida" OR "cyathostomins") AND ("prevalence" OR "detection"))
Google Scholar	31/3/2024	equine AND prevalence AND strongyle OR gastrointestinal parasite

### Screening

A total of 30 of the 1494 articles were excluded during the identification process as they turned out to be duplicates. The inclusion criteria (Kitchenham and Charters, 2007; Page et al., 2021) were automatically developed based on the database's available sorting mechanism to screen the remaining articles. The criteria used for admission were the year (2000–2024), document type (article), source type (journal), language (English), and study in the veterinary field. About 1399 research papers were eliminated during this process due to inclusion requirements. The subsequent procedure, eligibility, made use of the remaining 65 articles.

## Eligibility

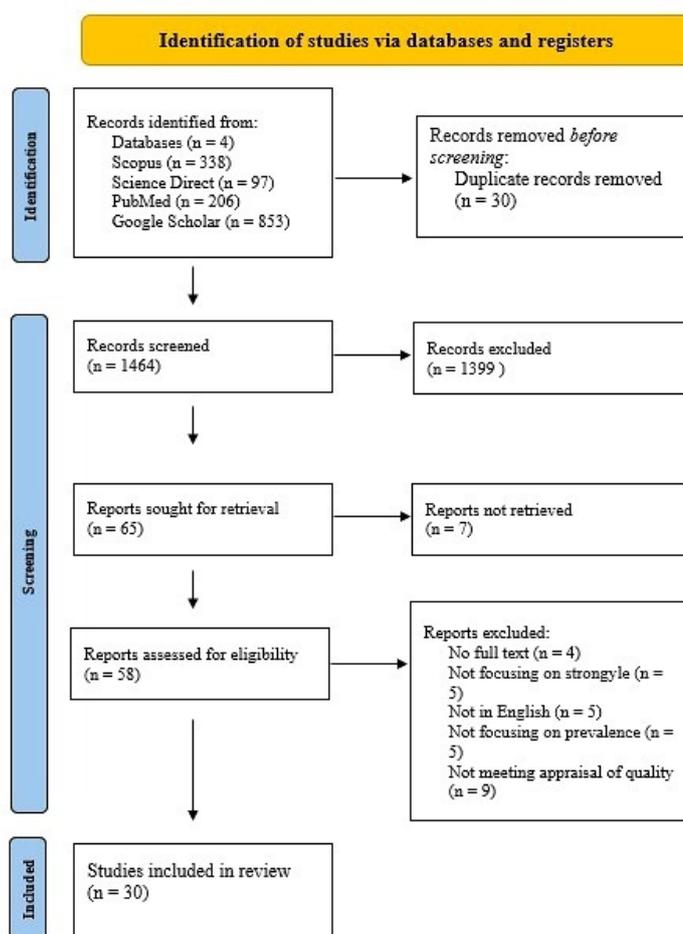
The titles and abstracts of the 65 screened articles were manually examined to determine whether they met the requirements to be included in the systematic review (Xiao and Watson, 2019). Seven of the articles could not be retrieved. We then continued to manually screen the country region and only included countries from Asia and strongyle related topics being discussed. Subsequently, the remaining articles underwent further manual screening to confirm their relevance to the study's focus. Specifically, articles were reviewed to ensure they discussed strongyle infections in horses, included topics related to prevalence, diagnostic methods, treatment, and preventive control of strongyle infections, and focused on countries within the Asia region. 59 articles made it through the manual review and advanced to the final stage: the quality assessment. The researchers continued to manually screen the countries involved and only included those from Asia and strongyle-related topics. Finally, 58 articles made it through the manual review and into the last stage, i.e., quality assessment.

## Appraisal of Quality

Two authors evaluated the quality of the 58 eligible publications to ensure that there was no bias in the articles accepted for evaluation and that the articles with inadequately defined methods were excluded (MacMillan et al., 2019). The criteria put forth by Kitchenman and Charters (2007) served as the foundation for the quality assessment and covered the following topics: methodology, concepts of the approach, objective, interest and utility, comparison with other studies, and study limits. Each guideline was assessed using a scoring system of Yes = 1, Partially = 0.5, and No = 0 (Kitchenham and Charters, 2007). A total of 30 of the 58 publications were included in the systematic review. Figure 1 shows the flow diagram that links the identification process to eligibility determination, screening, and quality assessment.

## Data extraction and analysis

After the articles had been finalised for inclusion in the systematic review, data extraction was performed using the research questions as a guide to choose studies that met the objectives (Xiao and Watson, 2019). For simpler data analysis, the retrieved data were arranged methodically in a table (Xiao and Watson, 2019). Qualitative synthesis of qualitative studies, qualitative analysis of quantitative studies, and qualitative analysis of mixed research designs combining qualitative and quantitative studies are the three forms of qualitative data typically utilised to analyse a study (Okoli, 2015). The author employed the third method to analyse qualitative data in this review.



**Figure 1** PRISMA (Page et al., 2021) flow diagram of study selection, showing the number of articles at each stage and the exclusion criteria used in the study.

## RESULTS

The 30 papers involved 11 countries in Asia, as stated in Figure 2. India has the most papers being published regarding the current state of strongyle prevalence (Figure 2). Data on gastrointestinal parasites and strongyle species prevalence infecting horses are tabulated in Table 2 according to the countries.

At least more than 3 species of large strongyle and 10 species of cyathostomins were documented across different climatic regions in Asia, such as South Asia, Southeast Asia, East Asia, and West Asia. The large strongyle is prevalent (47%,  $n = 14/30$  articles) among the horse populations in this study, mainly the *Strongylus* spp. (*S. vulgaris*, *S. edentatus*, and *S. equinus*) and *Tridontophorus* spp. (*Tridontophorus brevicauda*). In addition, more than 10 species of cyathostomins were represented by *Gylocephalus* spp., *Cyclicostephalus* spp. (*Cc. nassatus* and *Cc. longiburatus*), *Cyathostomum* spp. (*Cy. catinatum*), and *Poteriostomum* spp., with a prevalence of 37% ( $n = 11/30$ ). Location-wise, the prevalence of strongyle ranged from 4% to 62% in South Asian countries, with the most significant strongyle being *S. edentatus*. East Asian countries, such as China, have a prevalence of 75%, while West Asia has a variable range of 16% to 100%. Southeast Asia has the highest prevalence among the countries in Asia, with a range of more than 50% in all locations. In general, different locations showed different prevalences and significant strongyle species.

**Table 2** Data on prevalence and strongyle species infecting horses in the Asia region. (Studies from 2000-2024)

Country	Region	Prevalence (%)		Strongyle spp.	Prevalence (%)	References
<b>South Asia Countries</b>						
India	Himalayas	61.62	53/86	<i>S.edantatus</i>	56.6	Sengupta, 2003
				<i>S.equinus</i>	52.83	
				<i>S.vulgaris</i>	52.83	
				<i>Triondontophorus</i>	35.84	
				<i>Oesophagadontus spp</i>	16.98	
				<i>Gyalocephalus cipatatus</i>	7.54	
				Malwa, Madhya Pradesh	35.96 <sup>b</sup>	
	<i>S. vulgaris</i>	11.11				
	<i>S. edentatus</i>	2.22				
	Jammu	75.73 <sup>a</sup>	259/342	<i>Strongylus spp.</i>	62.93	Singh et al., 2012
	Kashmir Valley	89 <sup>a</sup>	25/28	<i>Strongylus spp.</i>	80	Maria et al., 2012
				<i>Cyathostomes spp.</i>	45	
				<i>Tridontophorus</i>	80	
	Bikaner, Rajasthan	39 <sup>a</sup>	39/100	<i>Strongylus spp.</i>	71.79	Khan et al., 2013
	Mumbai and Pune	20.62 <sup>a</sup>	17/86	<i>S. edantatus</i>	9.68	Matto et al., 2015
				<i>S. equinus</i>	22.58	
				<i>S. vulagris</i>	25.80	
<i>Cyathostomes spp.</i>				41.94		
Rajasthan	10.01 <sup>b</sup>	72/719	<i>S. edantatus</i>	46.86	Pilania et al., 2015	
			<i>S. equinus</i>	27.57		
			<i>S. vulgaris</i>	6.72		
			<i>Gyalocephalus capitatus</i>	5.38		
Central Plain Zone, Punjab	17.90 <sup>a</sup>	34/190	<i>S.edantatus</i>	12	Singh et al., 2016	
			<i>S.equinus</i>	9		
			<i>S.vulagris</i>	23		
			<i>Cyathostomes spp.</i>	56		
Shimoga, Karnataka State	84 <sup>a</sup>	84/100	<i>Strongylus spp</i>	52.3	Adeppa et al., 2016	
Rajasthan	35 <sup>b</sup>	44/125	<i>Strongylus spp</i>	68.18	Kachhawa and Dedar, 2017	
Udaipur, Rajasthan	30.85 <sup>a</sup>	54/175	<i>Strongylus spp</i>	48.18	Nagar et al., 2022	
Iran	Ardabil City	34 <sup>a</sup>	17/50	<i>Cylicocycclus nassatus</i>	22	Ali and Yagoob, 2015
				<i>Cylicostephanus longibursatus</i>	8	
				<i>Cylicostephanus goldi</i>	4	
				<i>Strongylus spp</i>	95	
East Azerbaijan Province	91 <sup>a</sup>	96/105	<i>Strongylus spp</i>	95	Baran et al., 2019	
Isfahan, Chaharmahal and Bakhtiari and Khuzestan	9.52 <sup>b</sup>	4/42	<i>S. vulgaris</i>	9.73	Alborzi et al., 2020	
Pakistan	Sahiwal, Lahore, Sargodha and Mandi Baha-ud-Din of Punjab	40.54 <sup>b</sup>	973/240	<i>Strongylus spp.</i>	-	Khan et al., 2020
	Lahore	60 <sup>a</sup>	120/200	<i>S. edantatus</i>	19.65	Saeed et al., 2010
<i>S. equinus</i>	23.07					
<i>S. vulgaris</i>	29.91					
			<i>Trichonema spp</i>	47.86		
Nepal	Thini, Muktinath, Surkhang and, Lomanthang of Mustang district	81.90 <sup>a</sup>	86/105	<i>Strongylus spp</i>	47.61	Devkota et al., 2021
<b>Southeast Asia</b>						
Malaysia	Selangor	35.2 <sup>a</sup>	31/88	<i>Strongylus spp</i>	-	Nu'man, 2024
	Selangor	100 <sup>b</sup>	100/100	<i>Strongylus spp</i>	2	Periyasamy, 2017
	Terengganu	87 <sup>a</sup>	27/31	<i>Cyathostomum spp.</i>	-	Embang, 2022
Indonesia	Mataram City	74 <sup>a</sup>	97/131	<i>Strongylus spp</i>	-	Tirtasari et al., 2021

Country	Region	Prevalence (%)		Strongyle spp.	Prevalence (%)	References
	Citra Pesona Ladangku Animal Park, Pancur Batu, Deli Serdang, North Sumatra	100 <sup>a</sup>	18/18	<i>Strongylus</i> spp	86	Sinaga and Tanjung, 2022
<b>Philippines</b>	The City of Baybay, Leyte	97.72 <sup>b</sup>	257/263	<i>Strongylus</i> spp	67.3	Amoto et al., 2022
<b>Vietnam</b>	Red River Delta and a mountainous area of North Vietnam	93 <sup>b</sup>	230/247	<i>Strongylus</i> spp	-	Holland et al., 2001
<b>Thailand</b>	Thammarat	50.6 <sup>a</sup>	40/79	<i>Strongylus</i> spp Cyathostomins	- -	Phetkarl et al., 2024
<b>East Asia</b>						
<b>China</b>	The Qinghai-Tibetan Plateau (QTP), Qinghai, Haixi)	75 <sup>a</sup>	24/32	<i>S. edantatus</i> <i>Cylicocycclus nassatus</i> <i>Cylicostephanus longibursatus</i> <i>Triodontophorus brevicauda</i> <i>Cyathostomum catinatum</i>	25 33 20 8 4	Ai et al., 2023
<b>West Asia</b>						
<b>Turkey</b>	Western Turkey Konya region	68.4 <sup>a</sup>	219/320	<i>Strongylus</i> spp <i>S. edantatus</i> <i>S. vulgaris</i> <i>Triodontophorus</i> spp <i>Poteriostomum</i> spp <i>Trichonema</i> spp	- 17.11 31.53 6.30 5.4 58.55	Çirak et al., 2004 Uslu, 2007
	Central Black Sea Region	91.57 <sup>a</sup>	76/83	<i>S. edantatus</i> <i>S. equinus</i> <i>S. vulgaris</i> <i>Cyathostomum</i> spp <i>Gyalocephalus</i> spp <i>Poteriostomum</i> spp <i>Triodontophorus</i> spp	31.05 6.11 3.52 33.88 12.0 5.88 1.41	Umur and Açıci, 2009
	Istanbul	16.2 <sup>a</sup>	33/204	<i>S. edantatus</i> <i>Triodontophorus</i> spp. <i>Poteriostomum</i> spp.	33.3 12.1 39.4	Ulutaş Esatgil and Efil, 2012

<sup>a</sup> Prevalence with strongyles reported in the study.

<sup>b</sup> Prevalence with other nematodes reported in the study

Age and gender are significant contributors, with foals under two years old often exhibiting higher parasite burdens compared to adult horses (Umur and Açıci, 2009; Singh et al., 2016; Kachhawa and Dedar, 2017). Gender-specific prevalence remains inconsistent, as some studies reported higher infection rates in males (Baran et al., 2019), while others noted higher prevalence in females, though these findings were not statistically significant (Singh et al., 2016; Alborzi et al., 2020). Contributing factors include poor management practices and suboptimal diets, such as tofu waste concentrate, which facilitate parasite growth (Sinaga and Tanjung, 2022). Loose farming systems also showed higher infection rates compared to conventional farming (Nagar et al., 2022). Seasonal variations play a crucial role, with rainy or monsoon seasons linked to increased infection rates due to favourable environmental conditions (Singh et al., 2012; Matto et al., 2015; Sinaga and Tanjung, 2022). In regions with distinct winters, strongyle prevalence peaks during spring as hypobiotic larvae re-emerge following colder months (Maria et al., 2012).

Diagnostic methods used in the reviewed papers were gathered in Table 3. Traditional methods like faecal sedimentation and McMaster assessments were frequently used (Ulutaş Esatgil and Efil, 2012; Maria et al., 2012; Baran et al., 2019; Khan et al., 2020; Devkota et al., 2021). Morphological identification via coproculture and larval culture was also employed (Umur and Açıci, 2009; Adeppa

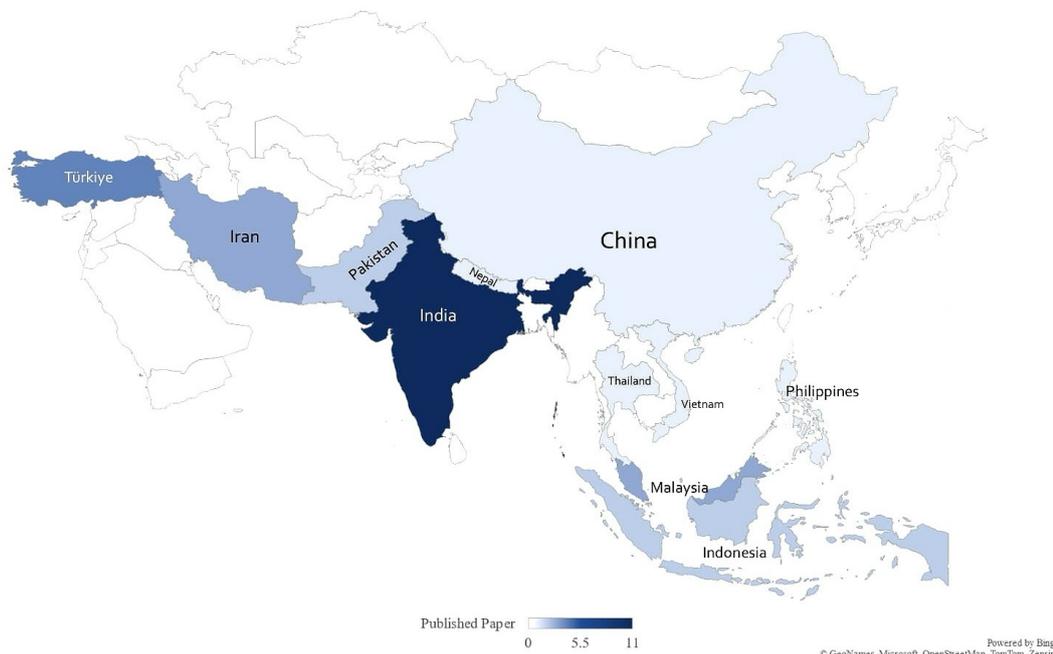
et al., 2016; Alborzi et al., 2020). Molecular diagnostics, particularly PCR, have become more common for species-level identification in recent years (Alborzi et al., 2020; Ai et al., 2023). Treatment strategies involve broad-spectrum anthelmintics like macrocyclic lactones, benzimidazoles, and tetrahydropyrimidines, with drugs such as pyrantel embonate, ivermectin, and moxidectin administered at recommended dosages to reduce parasite burdens (Saeed et al., 2010; Veli Yilgör Çirak and Ender Güleğen, 2005). However, most studies did not include post-mortem findings, as samples were collected from asymptomatic horses (Veli Yilgör Çirak and Ender Güleğen, 2005; Singh et al., 2016; Devkota et al., 2021).

**Table 3** Diagnostic method used in 30 papers involved in this review.

No.	Reference article	Diagnostic Method			
		FF	MM	ML	PCR
1	Holland et al., 2001	/	/	/	
2	Sengupta, 2003	/	/		
3	Çirak et al., 2005	/	/		
4	Uslu, 2007	/		/	
5	Umur and Açıci, 2009	/	/	/	
6	Saeed et al., 2010	/		/	
7	Sharma et al., 2011	/		/	
8	Singh et al., 2012	/	/	/	
9	Ulutaş Esatgil and Efil, 2012	/		/	
10	Maria et al., 2012	/	/	/	
11	Khan et al., 2013	/			
12	Matto et al., 2015	/		/	
13	Pilania et al., 2015	/			
14	Adeppa et al., 2016	/		/	
15	Singh et al., 2016	/	/	/	
16	Kachhawa and Dedar, 2017	/			
17	Periyasamy, 2017	/	/	/	
18	Ali and Yagoob, 2019	/	/		
19	Baran et al., 2019	/	/		
20	Alborzi et al., 2020	/	/	/	/
21	M. A. Khan et al., 2020	/	/		
22	Nagar et al., 2022	/			
23	Devkota et al., 2021	/			
24	Tirtasari et al., 2021	/	/		
25	Amoto et al., 2022	/	/		
26	Embang, 2022	/	/	/	
27	Sinaga and Tanjung, 2022	/	/		
28	Ai et al., 2023	/			/
29	Nu'man, 2024	/	/		
30	Phetkarl et al., 2024	/	/	/	/

FF: Faecal Floatation; MM: McMaster; LC; Morphological Diagnosis of L3; PCR: Polymerase Chain Reaction.

### Paper Published Based on Each Country in Asia Region



**Figure 2** Geographical distribution of studies in Asia (n=30) included in this systematic review.

## DISCUSSION

### Prevalence and distribution

Most morphological diagnosis studies revealed that the cyathostomins are the main strongyle species that have been infecting horses compared to the large strongyles (Umur and Açıci, 2009; Maria et al., 2012; Matto et al., 2015; Singh et al., 2016). There are no specific species in a particular country, as most strongyle species, either large or small, are present across Asia. The most prevalent species of large strongyles are *S. edentatus* and *S. vulgaris*, which occupy more than 30% of the gastrointestinal parasite infection. For cyathostomes, the most common is *Gyalocephalus* sp., but its prevalence depends on whether the study is a morphological or molecular diagnosis. With advanced technology, some new and rare species can be identified, such as the prevalence of *Cc. nassatus*, *Cylicostephanus longibursatus*, and *Cy. catinatum* in China (Ai et al., 2023).

India had the most research in terms of strongyle prevalence in South Asian countries. The prevalence is reported in more dispersed locations, such as the Himalayas (Sengupta, 2003), i.e., in the hills and mountains and Mumbai (Matto et al., 2015), i.e., in the city. The correlation of strongyle prevalence is minimal in South Asian countries, particularly in India, as there might be differences in the altitude of the location, weather, and even the advancement of technology utilised throughout the years. Nonetheless, the prevalence is considered high in Nepal, Pakistan, and Iran, as most of the data collected (47%, n = 7/15 articles) indicated more than 50% strongyle prevalence (Saeed et al., 2010; Baran et al., 2019; Alborzi et al., 2020; Khan et al., 2020; Devkota et al., 2021). Interestingly, the prevalence of

strongyles in the Southeast Asian region shows a similarly wide range, varying between 20% and 100% across studies (Holland et al., 2001; Tirtasari et al., 2021; Amato et al., 2022; Sinaga and Tanjung, 2022), mainly due to the almost identical tropical weather throughout the year such as monsoon season and dry season. Likewise, the prevalence of strongyle is also considered high (> 50%) in East and West Asian countries, e.g., China (Ai et al., 2023) and Turkey (Çirak et al., 2004; Uslu, 2007; Umur and Açıci, 2009; Ulutaş Esatgil and Efil, 2012).

In comparison with other continents, prevalence rates of strongyle infections vary significantly. In Africa, Ethiopia reports a prevalence of 53.13% (Negash et al., 2021), while Egypt (Salem et al., 2021) has a higher rate of 88.4%. In Europe, where four distinct seasons occur, the prevalence rates are not uniform where Ireland at 52.4% (Elghryani et al., 2023) and Italy at 39.5% (Scala et al., 2020). In North America, the United States reports a prevalence of 67.9% (Nielsen et al., 2018), while in South America, Brazil records 74% (Martins et al., 2024). These variations are mostly likely due to the environmental temperature and weather factors that have been affecting the growth and survival of strongyle. More discussion will be elaborated in the environmental factors sections.

## Epidemiology and contributing factors

### Host factors

Age and gender are examples of host factors that may substantially impact strongylosis infection. Studies have revealed that foals (less than two years old) are often more vulnerable than adult horses to greater parasite burdens of nematode infection (Umur and Açıci, 2009; Singh et al., 2016; Kachhawa and Dedar, 2017; Phetkarl et al., 2024). Previous research by Kachhawa and Dedar (2017) stated that horses under two years old have the highest intestinal parasite prevalence (71.42% in males and 70.83% in females), followed by those aged two to five years old (25% in males and 27.90% in females) and those older than five years (10% in males and 20.68% in females). The statistical results indicate that gender is most likely not a risk factor in strongyle infection, as most studies revealed contradicting results. For instance, Baran et al. (2019) revealed a significant correlation between animal gender to infection prevalence, where the males had an infection rate of 3.42 times higher than that of the females. Contrarily, Singh et al. (2016) and Alborzi et al. (2020) reported that females exhibited much greater prevalence rates than males, although they were not statistically significant ( $p > 0.05$ ). Similar results has been seen in Ethiopia where gender is not highly consider as the contributing factor, as the correlation between parasite infection and sex could be attributed to the grazing systems or physiologic differences, anthelmintic therapy and husbandry techniques (Negash et al., 2021).

Age is a significant factor in the incidence and prevalence of strongyle in horses, particularly in foals, whereby their immune systems are still developing. Similarly, older horses are more susceptible to infection because of immunosenescence (Singh et al., 2016). The poor immune system of the animals, their co-grazing behaviour with multiple species and the age of the horses, the use of inefficient medications, and low-dose anti-parasite treatments are some potential causes of the high incidence in young animals (Tahir et al., 2016), rendering them coincidence factors. Additionally, the age of horses has a significant impact on the number of species belonging to the small (*Cyathostominae*) and large (*Strongylinae*) strongyles (Kuzmina et al., 2016). This can be explained by the fact that older horses develop immunity to strongylids and by the long-term effects of anthelmintic therapy, which significantly lower the diversity of strongylid species in horses. Similar findings have been observed across other continents such as in Ethiopia (Negash et al., 2021), Brazil (Martins et al., 2023) and United States (Nielsen et al., 2018), highlighting the significant role of age in strongyle infections.

Meanwhile, even though gender is not considered the main risk factor, the predisposition of female horses to succumb to strongyle infection might be the result of stress factors such as nursing and the immune system relaxing later in pregnancy, increasing their vulnerability to certain parasite infections (Maria et al., 2012). Additionally, the close and prolonged contact between mares and their foals, who are more efficient at shedding eggs, may further contribute to the higher prevalence in females (Scala et al., 2020). However, several studies found that the pressures placed on male horses in the workplace were a significant source of stress, which compromised immunity and facilitated the spread of parasites (Baran et al., 2019).

### Environmental factors

Several environmental variables, including seasons, management (captive, semi-captive, or free-range), and dietary components, may impact the likelihood of strongyles infecting the horse population (Khan et al., 2019). Pasture management, dietary nutrient deficiency, fodder availability, host immunity to counter parasitic infection, seasonal variation, availability of intermediate host on pasture, grazing habits, the number of third-stage larvae, poor reproductive performance, gastrointestinal difficulty, and prolonged emaciation are the predisposing factors responsible for the establishment of endoparasites infection (Kaur et al., 2019).

Diet management also plays a role, as Sinaga and Tanjung (2022) observed that using protein and fiber rich tofu waste in the Citra Pesona Ladangku Animal Park diet supported strongyle growth. Even so, Laroche (2024) reported that horses fed high-starch diets shed more strongyle eggs compared to those on high-fiber diets. The findings indicate that a high-starch diet contributes to increased egg shedding due to its impact on the intestinal ecosystem. Starch fermentation induces a loss of microbial  $\alpha$ -diversity and reduces the abundance of several bacterial taxa, altering the proportions of volatile fatty acids (VFAs) produced by the microbiota. The resulting reduction in intestinal pH creates an environment conducive to enhanced parasite fecundity, leading to higher egg shedding. Another study also reported that the type of farming would affect strongyle infection. Nagar et al. (2022) demonstrated that loose farming (34.44%) yielded a higher prevalence rate of strongyle infection compared to well-managed or conventional farms (27.05%). Moreover, the most basic contributing factor, i.e., poor management, is also reported in two studies (Amato et al., 2022; Sinaga and Tanjung, 2022).

Several studies reported higher occurrences of strongyle infection during the rainy or monsoon seasons (Singh et al., 2012; Matto et al., 2015; Singh et al., 2016; Singh et al., 2019; Sinaga and Tanjung, 2022). Nagar et al. (2022) stated an increase in positive strongyle cases during the transition towards the monsoon or rainy season. Likewise, a higher peak of strongyle prevalence with significant findings ( $p < 0.005$ ) was reported during the monsoon and summer seasons (Khan et al., 2020). In contrast, Tirtasari et al. (2021) stated that the climatic weather of rain and humidity in Southeast Asia, where the rainy season occurs all year long, helped in terms of survivability of the strongyle egg in the environment. Contrary to the four-season countries, the peak mean egg per g (EPG) in March and April may have resulted from the hypobiotic larval (L4) developing again following a cold winter (Maria et al., 2012). Meanwhile, regarding the location of the horses geographically, a study revealed that mountains are the perfect habitat for parasites (Baran et al., 2019).

The optimal environmental temperature for strongyles to grow is during the monsoon season's high relative humidity and ideal temperature, which fosters the growth of free-living pre-parasitic stages (Baran et al., 2019). Reduced infection rates occur during these seasons because cold and dry circumstances are rather unfavourable for the development of parasite stages (Kaur et al., 2019). However, there are some debates regarding the frequency of strongyle infections not impacted by seasons but the degree of strongyle egg shedding (Khan et al., 2015).

Egg production fluctuates with the seasons; the least number of eggs are produced in the winter, more in the spring, and most in August and September (Khan et al., 2015). The proportion of viable giant strongyle eggs peaked in May and continued to be high throughout the summer. Higher egg-laying was reported in the spring and summer. Although the season has little effect on the frequency of strongyle infections, it has a considerable impact on the degree of strongyle egg shedding. A study found that in cold conditions, small strongyle eggs do not develop into L3 but can survive and resume development in better weather while in tropical conditions, eggs develop quickly into L3 but have a shorter survival time (Merlin, 2024). Hence, this may explain the high prevalence of strongyles in Southeast Asia, where the weather is typically hot and humid all year round. Data collected from different dates and regions consistently show high prevalence rates exceeding 90%, likely due to the shared climatic conditions of the region.

The anticipated duration of L3 survival on the pasture during the summer rainy season was 2–4 weeks but became prolonged (8–12 weeks) during the autumn-winter dry season (April–August). The most detrimental conditions for larval growth, migration, and survival are hot and dry springtime (pre-wet season) weather, which is highly likely favoured in summer and spring. Faeces deposited on the pasture in September of the preceding year will lead to the highest percentage of larvae that successfully survived the winter. According to Kuzmina et al. (2016), L3 larvae have been reported to survive the winter in the soil beneath the faecal pats by withstanding extremely cold temperatures, particularly when covered in a layer of snow that helps to moderate the fluctuations in the weather. However, this finding is contradicted by Scala et al. (2020), who reported lower egg per gram (EPG) values during summer compared to winter in a study conducted in Italy. This was attributed to increased awareness and the effectiveness of deworming practices during the summer months.

Nielsen et al. (2007) found that L3 larvae incubated in faeces at temperatures between 7.5°C and 37°C matured at different rates: very slowly at the lower temperatures (33–48 days at 7.5°C–8°C) and rapidly at the higher temperatures (1.7 days at 37°C). Outside this temperature range, the survival rate of pre-infective stages declines. Hence, in tropical countries with higher EPG rates of strongyle infection, management practices such as feeding management are likely a significant contributing factor, as stated by Sinaga and Tanjung, (2022).

In terms of feeding management, *Strongylus* spp. are photophobic; thus, the larvae will climb to the grass surface in the morning and descend to the grass bottom throughout the day to escape high temperatures (Sinaga and Tanjung, 2022). Thus, horses that graze in the morning may expose themselves to the contaminated green in temperate regions like South Asia. However, this problem may be resolved by feeding wilted grass to horses to lower the number of viable strongyle infectious larvae (Sinaga and Tanjung, 2022). In comparison with a 4 season country, winter are presumably has a shorter daylight compare to winter, hence shorter grazing time will decrease the risk of strongyle infection (Relf, 2013).

Humid settings can also aid in the growth and life cycle of nematode worms in captivity. Sinaga and Tanjung (2022) reported a high incidence of nematode worm illnesses in Indonesia due to the unclean cages, which contributed to the nematode worm life cycle. Unlike open cages, closed cages are intended to have high humidity levels and moderate temperatures. High humidity conditions might be detrimental to the growth and development of worms. It was discovered that horses with shed coats had an 8-fold and 12-fold increased risk of infection compared to horses housed in corrals free of *Strongylus* sp. (Amato et al., 2022). The primary source of infection, horse faeces, is concentrated and has less moisture, which raises the number of worm eggs (Amato et al., 2022).

## Pathology

Most of the studies in this review did not report any post-mortem results (Veli Yilgor Cirak and Ender Gulegen, 2005; Singh et al., 2016; Devkota et al., 2021;

Amato et al., 2022; Ai et al., 2023). The samples were taken randomly from horses that showed no sign of clinical gastrointestinal parasite infestation.

There is a fair amount of data available regarding the clinicopathology of strongyle infestation. The complex process of strongyle infection causes an inflammatory enteropathy that reduces intestinal motility and microcirculation (Khan et al., 2015). Although intestinal parasites have long been thought to be a potential cause of horse colic, there is doubt about the evidence that small strongyles cause intestinal disorders or colic in horses (Stancampiano et al., 2017). Cyathostomins can create a condition known as larval cyathostominosis, which is characterised by the simultaneous inflow of mucosa-dwelling larval phases into the lumen and the synchronised restart of growth of numerous encysted third-stage larvae, resulting in significant tissue damage. Small strongyle infections have been linked to lethargy, weight loss, oedema, diarrhoea, pyrexia, colic, intussusception, infarction, and eventually equine mortality (Amato et al., 2022).

According to Stancampiano et al. (2017), only the larval stage of the large strongyle, *S. vulgaris*, is known to produce colic syndrome among strongyles. This is because thromboembolism and arteritis occur during the parasite's larval stage's movement within the host. Large strongyles are different compared to the small strongyles as they migrate (Amato et al., 2022.) Thus, lesions caused by *Strongylus* sp. have been reported in several organs, including the liver, lungs, pancreas, omentum, cecum, and colon (Khan et al., 2015; Stancampiano et al., 2017; Kaur et al., 2019).

For instance, *S. vulgaris* can severely damage the cranial mesenteric artery and its branches, preventing blood flow to the intestines. Colic, necrosis, decreased intestinal motility, intestinal twisting, intussusception, infarction, bleeding, and intestinal perforation are possible outcomes of this infection (Amato et al., 2022). In the review by Khan et al. (2015), *S. equinus* migrated to the pancreas and liver, while *S. edentatus* migrated to the liver and flank region. Interestingly, the cause of mortality in 10% to 33% of stomach crisis cases in horses was identified as verminous arteritis in the cranial mesenteric artery and its branches (Khan et al., 2015). There is a phenomenon called arrested development, which is a complicated issue (Stancampiano et al., 2017). Limited research suggests that the early development of stage 3 larvae strongyles in equines is likely governed by a negative feedback mechanism that luminal adults worms impose on the mucosa. Stancampiano et al. (2017) further explained that the negative feedback may be a natural mechanism regulating the amount of parasites in horses, which helps to explain why intestinal strongyles are often well-tolerated by their hosts without obvious clinical symptoms.

A post-mortem examination conducted by Lyons et al. (2018) revealed significant findings related to large strongyle infections. The study found that *Strongylus vulgaris* caused an aneurysm in the branching arteries, while an encysted *Strongylus edentatus* was found in the ventral abdominal wall of one of the horses. These findings suggest that both large strongyle species can be present in horses without causing apparent clinical parasitic disease. Additionally, other signs can also be observed other than the gastric area is infarction of left ventral colon, where non-strangulated colic could occur (Pihl et al., 2017). Phil et al. (2017) further discovered the chronic lesions in the cranial mesenteric artery and its branches, which were observed in all horses at necropsy, included visible fibrin deposits, thickening and roughening of the arterial walls, and the inflammation of the vessel lumen (verminous aneurysms).

## Diagnosis method

Identification of strongyles can be divided into quantitative, qualitative, and molecular diagnoses. Six studies focused more on the qualitative and quantitative aspects, where faecal sedimentation and Mc Master assessment were conducted (Ulutaş Esatgil and Efil, 2012; Maria et al., 2012; Baran et al., 2019; Khan et al., 2020; Devkota et al., 2021; Tirtasari et al., 2021). Meanwhile, other studies did

additional examinations of coproculture and larvae culture, where a morphological diagnosis can be done to see the species level of the strongyle (Umur and Açici, 2009; Adeppa et al., 2016; Singh et al., 2016; Alborzi et al., 2020; Amoto et al., 2022). Meanwhile, the molecular assessment incorporating polymerase chain reaction (PCR) has become more common in recent years (Alborzi et al., 2020; Ai et al., 2023).

Strongyle infections in live horses are often diagnosed with a straightforward faecal flotation test with several saturated floatation solutions. Nonetheless, it is frequently challenging to assess the clinical relevance of infection, and the absence of parasitic eggs in the faeces does not rule out parasitic illness (Saeed et al., 2019). The suitable specific gravity (1.200) of a flotation solution, such as sucrose, sodium nitrate, sodium sulphate, sodium chloride, zinc sulphate, or magnesium sulphate, aids in the separation of parasite eggs from faeces (Saeed et al., 2019). Several methods of faecal egg counting methods, such as Mc Master, modified Wisconsin technique (MW) FLOTAC®, Mini-FLOTAC®, FECPAK®, and Parasight System ® (Cain et al., 2020) are available, which help in quantifying the number of eggs in an individual horse and estimating the parasite burden. The estimated result is presented as EPG, which could be categorised into stages of infections. Mild infection in horses is indicated by an EPG of 500, a moderate infection of 800–1000, and a severe infection of 1500–2000 (Singh et al., 2016). However, Saeed et al. (2019) stated that as the pathogenic stages are typically larvae rather than EPG, the results of faecal exams should be taken cautiously because egg counts are not helpful as clinical diagnostic tools.

Larva culture and larva morphological diagnosis may offer more thorough details regarding the common parasitic species or genus. Several studies have utilized this method to identify species, ensuring appropriate treatment, assessing anthelmintic resistance levels, and furthering analysis through Polymerase Chain Reaction (PCR) (Sharma et al., 2011; Adeppa et al., 2016; Alborzi et al., 2020; Phetkarl et al., 2024). The identification of the cyathostomin and strongyle species can be done by measuring the size and the wall of the eggs. For further species-specific determination, morphological diagnosis can be done by observing the total length, extension of tail sheath beyond the tail, and the tail shape. The morphometric data for strongyle species that were previously documented are organised in Tables 4.

**Table 4** Morphometric characteristics of strongyle spp reported by Kachhawa and Dedar (2017)

Strongyle spp.	Total length (µm)	Extension of tail sheath beyond tail (µm)	Tail sheath shape	Remarks
<i>Strongylus vulgaris</i>	959.00-1164.50	191.80-287.70	Long and pointed	28-32 intestinal cells triangular shape
<i>Strongylus edentatus</i>	698.70-876.80	123.30-178.10	Blunt	20 indistinct intestinal cells
<i>Strongylus equinus</i>	776.20-890.50	192.80-274.00	Small trilobed process	long thin larvae
<i>Trichostrongylus axei</i>	589.10-657.60	82.20-123.30	Short and conical	More than 16 intestinal cells
<i>Gyalocephalus capitatus</i>	506.90-602.80	137-178.10	Long	12 triangular intestinal cells
<i>Oesophogodontus</i> spp.	917.90-1000.10	205.50-274.00	Long and filamentous	More than 16 triangular intestinal cells

Tables 5 present the previously documented morphometric data for *Oesophogodontus robustus*, *Bidentostomum ivashkini*, *Skrjabinodontus caragandicus*, and *Petrovinema skrjabini*, which are new discovery of strongylid species in China by Jia et. (2023). This research highlights the importance of morphological identification in discovering previously undocumented species, which can serve as a reference for other countries seeking to expand their understanding of strongyle diversity. Furthermore, sequencing the ITS2 genetic

marker in *P. skrjabini* enriches phylogenetic knowledge and provides a valuable tool for molecular diagnostics and evolutionary studies.

Speaking of molecular diagnostics, PCR is widely utilised in the molecular determination of strongyle species as it serves as the foundation for other molecular techniques employed in equine parasitology (Ghafar et al., 2023). The test relies on identifying variations between different species in the internal transcribed spacer (ITS)-2 sequences of *Strongylus* spp. (Saeed et al., 2019). Molecular techniques are utilised to detect *S. vulgaris* eggs and larval stages based on the high ribosomal DNA (rDNA) concentration in these organisms and minimal genetic variation within strongyle species. Different methods for DNA extraction in PCR have been employed, but the most preferred samples are faecal or larval samples (Alborzi et al., 2020; Ai et al., 2023; Phetkarl et al., 2024). Despite variations in extraction techniques, primer choices for *S. vulgaris* by Nielsen et al. (2008) have remained consistent and have yielded robust results (Alborzi et al., 2020; Martins et al., 2023). Hamad et al. (2024) used the NC1 and NC2 primers (Table 5), and the ITS-2 gene area was amplified by PCR, followed by a nemabiome metabarcoding, where the species of strongyle can be shown. A list of primers being used and targeted genes is shown in Table 6.

**Table 5** Morphometric characteristics of cyathostomins species found in China (Jia et al., 2023)

Morphological diagnosis	Strongylid species							
	<i>Oesophagodontus robustus</i>		<i>Bidentostomum ivashkini</i>		<i>Skrjabinodentus caragandicus</i>		<i>Petrovinema skrjabini</i>	
	M	F	M	F	M	F	M	F
Body length (mm)	14.2–15.4	19.0–23.0	7.6–9.1	9.0–24.0	7.9–9.6	8.3–10.9	12.1	13.5–16.8
Buccal capsule width (µm)	212.9–335.9	390.6	72.6	46.0–58.0	57.1	64.8	57.1	46.0–58.0
Buccal capsule depth (µm)	259.5	329.2	70.4	17.0–25.0	29.7	26.8	135.0–153.0	145.0–180.0
No. of external leaf crown	18	18	8	8	8	8	28	28

**Table 6** Primers used to detect strongyle species

Strongyle spp	Gene	Primers	BP	References
<i>S. vulgaris</i>	ITS-2	Fwd: 5-GTATACATTAAATAGTGTCCTCCCATCTAG-3 Revs: 5-GCAAATATCATTAGATTGATTCTCCG-3	186	(Phetkarl et al., 2024)
<i>Strongylids</i> spp.	ITS-2	Fwd: TAGCTTCAGCGATGGATCGGT Revs: CTTTTCTCCGCTAAAT	500	Ai et al., 2023
<i>Cyathostomins</i> spp.	ITS-2	Fwd: ACGTCTGGTTCAGGGTTGTT-3 Revs: TTAGTTTCTTTCTCCGCT-3	300	Hamad et al., 2024
	rRna	Fwd: GACTAGCTTCAGCGATGGA Revs: AACGYTGTCATACAGGCACT	350-480	Phetkarl et al., 2024

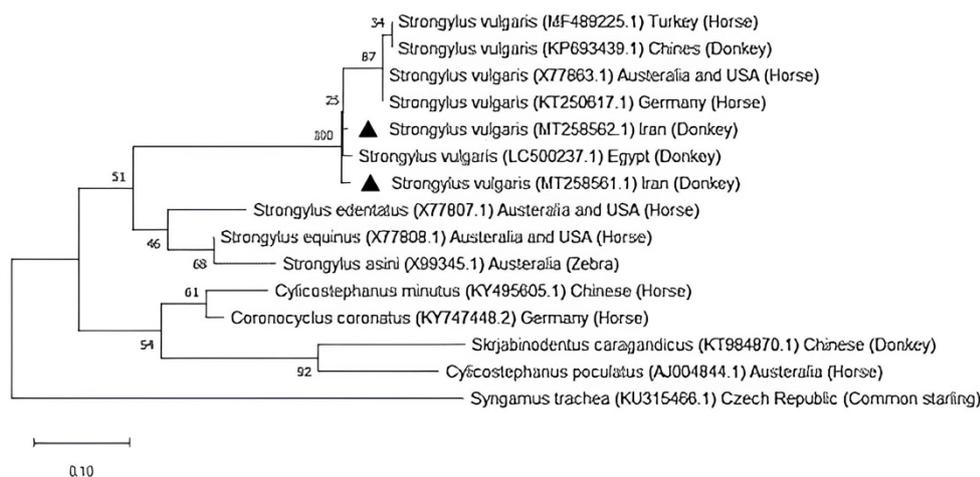
\*BP: Base pair size

Identical methods have been employed to identify and conduct phylogenetic analyses of various strongyle and cyathostomin parasites, as well as to distinguish closely related cyathostomin species (Saeed et al., 2019). Molecular identifications were employed to examine the evolutionary history of the parasite due to the unavailability of sequences in GenBank for additional molecular analysis. Additionally, these identifications were used to study the genetic link between species within the same genus (Alborzi et al., 2020).

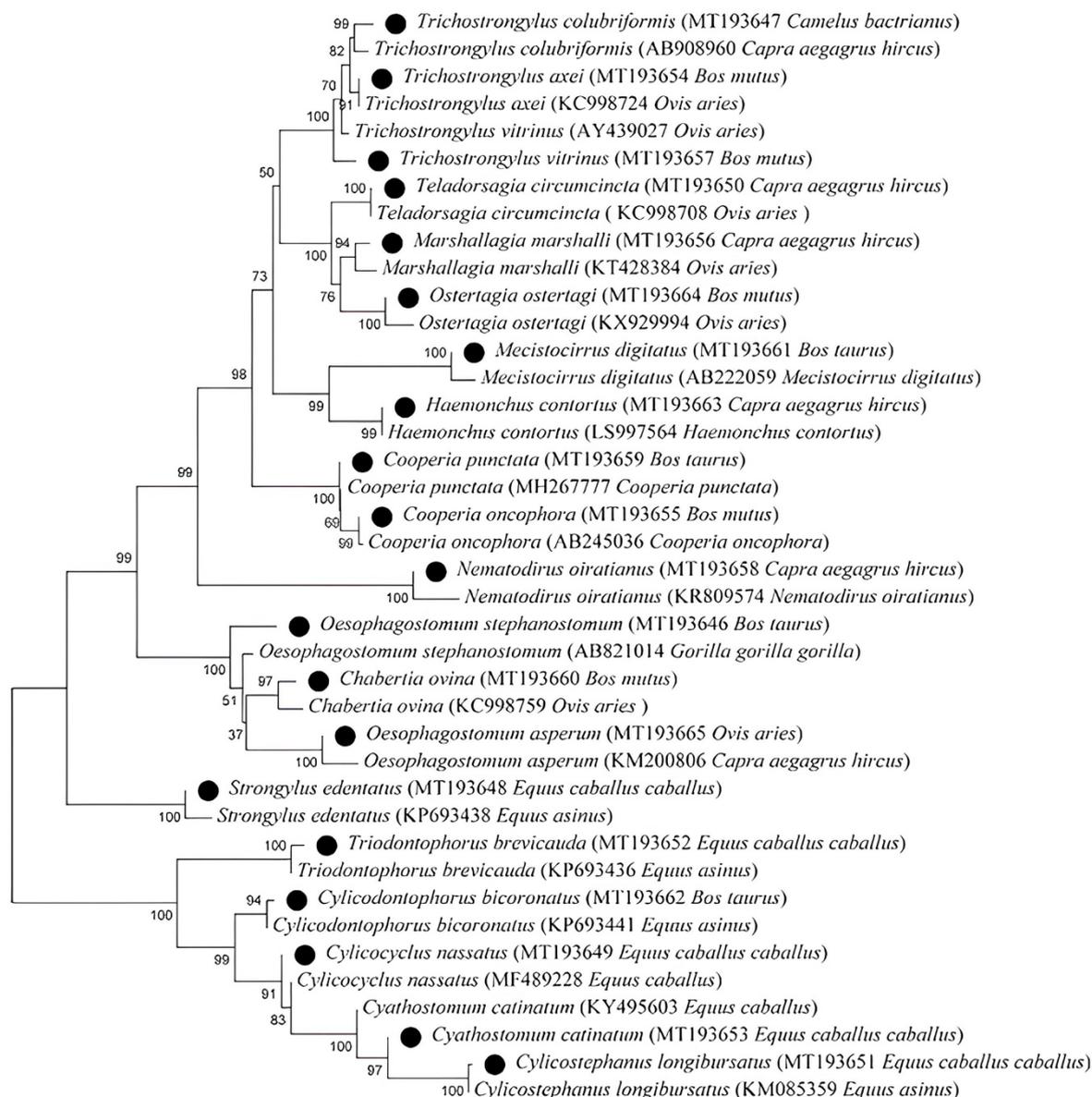
In this review, only two studies conducted phylogenetic analysis. A study by Alborzi et al. (2020) in Iran found that the phylogenetic analysis did not show significant differences between the positive samples in the current investigation and previous records of *Strongylus vulgaris* (Figure 3). However, the Sv1 sample

was placed in a separate branch from the main *S. vulgaris* cluster, likely due to a higher number of nucleotide variations in this particular sample. Similarly, a study by Ai et al. (2023) in China showed clear genetic differences between large and small strongyles, with each forming distinct but closely related clades in the phylogenetic tree (Figure 4). This suggests that, although they share a common progenitor, these parasites have evolved to occupy different ecological or physiological niches within their equine hosts. In contrast, the phylogenetic tree from Brazil (Figure 5) shows less genetic variation among the Brazilian isolates, which form a genetically conserved population (Martins et al., 2023). This may be due to their relative isolation or recent introduction to the region. This diversity is likely influenced by geographic and host-specific factors, with evidence of interactions between local populations and neighbouring regions.

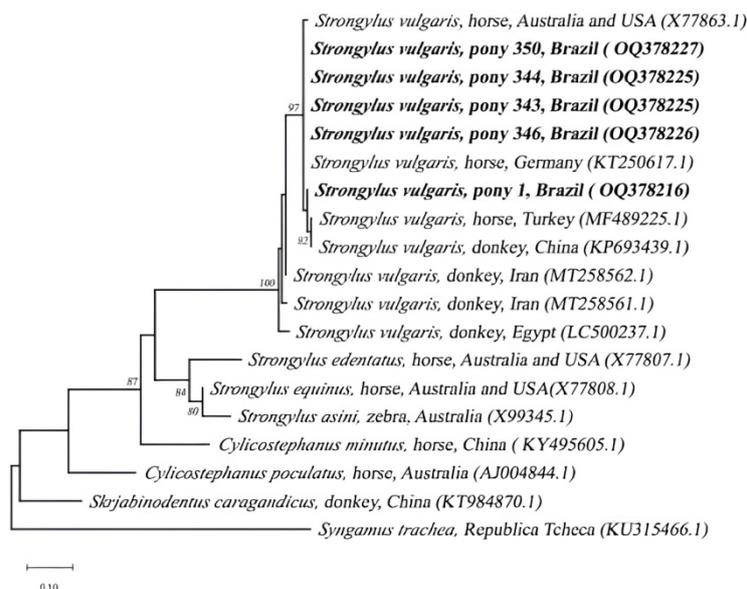
The outcomes of the study by Alborzi et al. (2020) conformed with other studies, which revealed the superiority of the PCR approach to the larval culture. Also, it was highlighted that the PCR approach was the most accurate, sensitive, rapid, and practicable tool to detect *S. vulgaris* helminth. It can be employed for large-scale screening programmes of horse populations, while other approaches such as reverse line blot (RLB) hybridisation and PCR-enzyme-linked immunosorbent assay (PCR-ELISA) methods are used to recognise several parasites such as cyathostomin species concurrently.



**Figure 3** Phylogenetic tree of *S. vulgaris* isolates from Iranian donkeys with other strongyle nematodes based on partial ITS2 sequences (Alborzi et al., 2020).



**Figure 4** Phylogenetic tree of large and small strongyles from Chinese isolates, illustrating the genetic differences between the two groups based on partial ITS2 sequences.



**Figure 5** Phylogenetic tree of *S. vulgaris* isolates from Brazilian equines, showing a genetically conserved population with limited variation.

## Treatment and control

The use of broad-spectrum anthelmintics, such as macrocyclic lactones and benzimidazoles, has led to a sharp decline in the number of giant strongyle worms (Saeed et al., 2010). Tetrahydropyrimidines, macrocyclic lactones, and milbemycins are the three anthelmintic drug classes identified in the studies included in this systematic literature review. In the study by Çirak and Gülegen (2005), the horses were orally given pyrantel embonate (19 mg/kg body weight) ivermectin (0.2 mg/kg body weight) or moxidectin (0.4 mg/kg body weight) based on the recommended dose. Given that *S. vulgaris* has a lengthy prepatent period of 6–7 months, treating horses with an efficient anthelmintic every three months would eradicate this parasite (Martins, et al., 2023)

Various types of anthelmintic drugs are used for the prevention and treatment of strongyle and it is listed out in Table 7. Antiparasitic drugs classified under the benzimidazole group, such as fenbendazole, aid in the treatment of lungworm and migratory strongyle infections, as well as gastrointestinal helminthiasis (Gokbulut and McKellar, 2018). It was discovered that the benzimidazoles and colchicine, a chemical known to stop cell division in the metaphase, fought for the attachment point on  $\beta$ -tubulin. Imidazothiazoles are the class drug group of pyrantel, morantel, and oxantel. Pyrantel, which is known as a well-used drug, is administered orally as a paste or granule at a therapeutic dose of 6.6–13.2 mg/kg after a single oral administration and is highly effective (95%–97%) against adult *cyathostomins* and *S. vulgaris*, with moderate activity against *S. edentatus* (70%) (Gokbulut and McKellar, 2018). Natural and semisynthetic compounds such as ivermectin, abamectin, moxidectin, doramectin, eprinomectin, selamectin, and milbemycin oxime are examples of macrocyclic lactones. Meanwhile, ivermectin is incredibly effective in adult *Strongylus* species, arterial stages of *S. vulgaris*, and migrating *S. edentatus* (Gokbulut and McKellar, 2018). Praziquantel is usually being used in combination with other anthelmintic groups such as macrocyclic lactones. These combinations may broaden the spectrum of effectiveness and postpone the development of medication resistance against equine parasites (Gokbulut and McKellar, 2018).

**Table 7** Anthelmintics used for horse management, reference from [Cirak and Gulagen \(2005\)](#) and [Gokbulut and McKellar \(2018\)](#)

Anthelmintics	Dosage & Administration Route
<b>Tetrahydropyrimidines/Imidazothiazoles</b>	
Pyrantel Embonate	19 mg/kg, PO
Pyrantel tartrate	6.6 mg/kg, PO
Morantel	7.5-12.5, PO
<b>Macrocylic Lactones</b>	
Ivermectin	0.2 – 0.5 mg/kg, PO .
Doramectin	0.2 mg/kg, PO; 0.2 mg/kg IM.
Abamectin	0.2 mg/kg, PO
<b>Milbemycins</b>	
Moxidectin	0.4 mg/kg,PO
<b>Benzimidazoles</b>	
Cambendazole	20 mg/kg, PO
Parbendazole	2.5 mg/kg, PO
Thiabendazole	50 mg/kg, PO
Mebendazole	8.8 mg/kg, PO
Fenbendazole	7.5 mg/kg, PO
Oxfendazole	10 mg/kg, PO
Oxibendazole	10 mg/kg, PO
Albendazole	5 mg/kg,PO
Triclabendazole	12 mg/kg, PO
<b>Isoquinoline</b>	
Praziquantel	1.0 mg/kg, PO
<b>Organophosphates</b>	
Trichlorfon	40 mg/kg, PO

PO: per os (orally); IM: intramuscular

In terms of prevention and control, [Amoto et al. \(2022\)](#) stated that poverty could be linked to exposure to parasitic infestations. Therefore, it is necessary to develop and implement a herd health management system and an efficient, methodical, and sustainable deworming programme in an environment with limited resources to lower the prevalence and relative burden of the disease, as well as manage the nutrition of the horses ([Amoto et al., 2022](#)). In Vietnam, faeces are used as a fertiliser, leading to more pasture contamination of strongyle species ([Holland et al., 2001](#)).

However, different approaches to management can be taken, such as measuring the efficacy of the drug and avoiding anthelmintic resistance by implementing programmes such as an egg reappearance period (ERP). The ERP is the period following anthelmintic treatment during which egg counts do not exceed a given threshold, like 200 EPG. A reading over this threshold suggests that additional therapy is required. Another strategy for control involves applying the 80:20 rule, which states that 80% of strongyle egg shedding originates from 20% of the horses on a farm. A study by ([Stoughton et al., 2023](#)) supported this concept and demonstrated the effectiveness of administering anthelmintic drugs specifically to high shedders, thereby reducing the risk of anthelmintic resistance. In addition, conducting occasional Faecal Egg Count Reduction Tests (FECRT) can help monitor anthelmintic resistance by comparing the eggs per gram (EPG) of faeces before and after the administration of anthelmintic drugs

$$FECR (\%) = ((\text{mean EPG Day 0} - \text{mean EPG Day 0} + Y) / \text{mean EPG Day 0}) \times 100$$

With Day 0 + Y meaning the respective sampling date post-treatment ([Çirak et al., 2004](#))

It is generally recommended to avoid treating strongyles during the winter in cold temperate areas and during the summer in warm/hot climates to prevent anthelmintic resistance from developing. Further research is required for a comprehensive quantitative description of strongyle larval bionomics and a better

understanding of their basic epidemiology, as knowledge of larval ecology is a requirement for the establishment of logical anthelmintic control programs (Khan et al., 2015).

## CONCLUSIONS

In conclusion, the present review reveals that although large strongyles are still dominant, cyathostomin species are re-emerging due to anthelmintic resistance. The geographical location plays a significant role in the presence of strongyle species as it is affected by the weather. The prevalence of strongyles correlates with a few of the predisposing factors listed in the studies. However, findings on treatments across Asia are still limited, and strongyles remain the major health concern in horses worldwide as it could lead to fatality. While the included studies cover important topics such as prevalence, diagnostic methods, therapy, and preventive management, certain locations are under-represented. Despite these limitations, this review provides a solid framework for identifying patterns, highlighting knowledge gaps, and proposing areas for further research on strongyles as it remain the major health concern in horses worldwide. More extensive studies should be done in terms of determining the prevalence of strongyle, treatment and management across Asia to discover even more species as well as more treatment protocols used.

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## AUTHOR CONTRIBUTIONS

**Noraniza Mohd Adzahan** : provided oversight and direction throughout the project.

**Puteri Rose Camelia binti Roselan** : was responsible for gathering the data and writing the initial draft of the manuscript.

**Nor Azlina binti Abdul Aziz** : contributed by reviewing the selected articles and discussing the topic.

**Zulfitri** : helped screen the paper chosen to be a part of this review.

**Nur Mahiza Md Isa** : verified the content related to the Strongyle species, while

**Mohammed Babatunde Sadiq** : assisted with the systematic literature review (SLR) methodology. All authors have read and approved the final version of the manuscript.

## CONFLICT OF INTEREST

All authors have no conflict of interest concerning the work reported in this paper.

## REFERENCES

Adeppa, J., Ananda, K.J., Krishna murthy, C.M., Satheesha, G.M., 2016. Incidence of gastro-intestinal parasites in horses of Shimoga region, Karnataka state. J. Parasit. Dis. 40, 919–921.

- Ai, S., Zhang, Z., Wang, J., Wang, X., Liu, C., Duan, Z., 2023. Prevalence and molecular identification of gastrointestinal nematodes in Qinghai-Tibetan Plateau of China. *Vet. Med. Sci.* 9, 2693–2702.
- Alborzi, A., Larki, S., Zeinali, A., 2020. Evaluation of larval culture and conventional PCR methods for the detection of *Strongylus vulgaris* in equines of Iran. *Turk. J. Vet. Anim. Sci.* 44, 814–820.
- Ali, S., Yagoob, G., 2015. Survey on fecal gastrointestinal parasitic helminthes in horses of jokey clubs in Ardabil city, Iran. *Biol. Forum. Int. J.* 7, 106–110.
- Amoto, M.G., Leonard, C., Pradera, M., 2002. Prevalence and risk factors associated with equine strongylosis in Baybay City, Leyte, Philippines. *Ann. Trop. Med. Parasitol.* 44, 104–118.
- Baran, A.I., Akbari, H., Rafat, S.A., 2019. Coprological prevalence and the intensity of gastrointestinal nematodes infection in working equines, east azerbaijan of Iran. *J. Anim. Plant. Sci.* 29, 1269–1278.
- Bellaw, J.L., Nielsen, M.K., 2020. Meta-analysis of cyathostomin species-specific prevalence and relative abundance in domestic horses from 1975–2020: Emphasis on geographical region and specimen collection method. *Parasite. Vectors.* 13, 1–15.
- Cain, J.L., Slusarewicz, P., Rutledge, M.H., McVey, M.R., Wielgus, K.M., Zynda, H.M., Wehling, L.M., Scare, J.A., Steuer, A.E., Nielsen, M.K., 2020. Diagnostic performance of McMaster, Wisconsin, and automated egg counting techniques for enumeration of equine strongyle eggs in fecal samples. *Vet. Parasitol.* 284, 109199.
- Carminatti, A., Chitolina, M.B., Ribeiro, A.B., Forest, M., Collet, S.G., Prestes, A.M., Camillo, G., 2023. Occurrence and risk factors associated with gastrointestinal parasitism in horses reared in different systems. *Vet. Parasitol. Reg. Stud. Rep.* 42, 100890.
- Çirak, V.Y., Güleğen, E., Bauer, C., 2004. Benzimidazole resistance in cyathostomin populations on horse farms in western Anatolia, Turkey. *Parasitol. Res.* 93, 392–395.
- Çirak, V.Y., Güleğen, E., Bauer, C., 2005. The prevalence of strongyle infections and persistent efficacy of pyrantel embonate, ivermectin, and moxidectin in Turkish horses. *Turk. J. Vet. Anim. Sci.* 29(1), 28.
- Corning, S., 2009. Equine cyathostomins: a review of biology, clinical significance and therapy. *Parasite. Vectors.* 2 (Suppl 2), S1.
- Devkota, R.P., Subedi, J.R., Wagley, K., 2021. Prevalence of gastrointestinal parasites in equines of Mustang district, Nepal. *Biodiversitas.* 22, 3958–3963.
- Embang, J.L., 2022. Identification of gastrointestinal nematode species in an equestrian park in Terengganu (Thesis). *Universiti Malaysia Kelantan*, pp. 32.
- Elghryani, N., McOwan, T., Mincher, C., Duggan, V., de Waal, T., 2023. Estimating the prevalence and factors affecting the shedding of helminth eggs in Irish equine populations. *Animals.* 13(4), 581.
- Ghafar, A., Abbas, G., Beasley, A., Bauquier, J., Wilkes, E.J.A., Jacobson, C., McConnell, E., El-Hage, C., Carrigan, P., Cudmore, L., Tennent-Brown, B., Hurley, J., Nielsen, M.K., Gauci, C.G., Beveridge, I., Hughes, K.J., Jabbar, A., 2023. Molecular diagnostics for gastrointestinal helminths in equids: Past, present and future. *Vet. Parasitol.* 313, 109851.
- Girma, S., Tilahun, B., Gurmu, G., Hassennur, I., Fufa, G., Godana, J., Moa, M., Ayalew, S.M., 2017. Prevalence of equine strongyle infection and its associated risk factors in Jimma Town, Southwest Ethiopia. *Int. J. Livest. Prod.* 8, 187–191.
- Gokbulut, C., McKellar, Q.A., 2018. Anthelmintic drugs used in equine species. *Vet. Parasitol.* 261, 27–52.
- Halvarsson, P., Grandi, G., Hägglund, S., Höglund, J., 2024. Gastrointestinal parasite community structure in horses after the introduction of selective anthelmintic treatment strategies. *Vet. Parasitol.* 326, 11011.

- Hamad, M.H., Islam, S.I., Jitsamai, W., Chinkangsadarn, T., Naraporn, D., Ouisuwan, S., Taweethavonsawat, P., 2024. Patterns of equine small strongyle species infection after ivermectin intervention in Thailand: egg reappearance period and nemabiome metabarcoding approach. *Animals*. 14, 574.
- Hodgkinson, J.E., Freeman, K.L., Lichtenfels, J.R., Palfreman, S., Love, S., Matthews, J.B., 2005. Identification of strongyle eggs from anthelmintic-treated horses using a PCR-ELISA based on intergenic DNA sequences. *Parasitol. Res.* 95, 287–292.
- Holland, W.G., Geurden, T., Do, T.T., Dorny, P., Vercruyse, J., 2001. Strongyle infections in horses from North Vietnam. *Rev. Elev. Med. Vet. Pays Trop.* 54, 29–31.
- Kachhawa, J.P., Dedar, R.K., 2017. Epidemiological studies on helminthiasis in horses in Bikaner region of Rajasthan. *Indian Vet. J.* 92, 100–101.
- Kaur, S., Singh, E., Singla, L., 2019. Strongylosis in equine: an overview. *J. Entomol. Zool. Stud.* 7(5), 43–46.
- Khan, M.A., Roohi, N., Rana, M.A.A., 2015. Strongylosis in equines: a review. *J. Anim. Plant. Sci.* 25, 1–9.
- Khan, M.A., Ruhi, N., Qaiser, H., 2020. Presence of strongyle infection in thoroughbred horses of Punjab Province, Pakistan. *Chiang Mai Univ. J. Nat. Sci.* 19, 222–234.
- Khan, S., Ashfaq, M., Fakhrudin, Tanwar, R.K., 2013. Prevalence of gastrointestinal parasites in horses (*EQUUS caballus*) in and around Bikaner. *Vet. Pract.* 14, 294–295.
- Kitchenham, B., Charters, S., 2007. Guidelines for performing systematic literature reviews in software engineering, technical report EBSE. *J. Softw. Eng. Appl.* 001
- Kuzmina, T.A., Dzeverin, I., Kharchenko, V.A., 2016. Strongylids in domestic horses: Influence of horse age, breed and deworming programs on the strongyle parasite community. *Vet. Parasitol.* 227, 56–63.
- Laroche, N., Grimm, P., Julliand, S., Sorci, G., 2024. Diet modulates strongyle infection and microbiota in the large intestine of horses. *PLoS ONE*. 19(4), e0301920.
- Lightbody, K.L., Austin, A., Lambert, P.A., von Samson-Himmelstjerna, G., Jürgenschellert, L., Krücken, J., Nielsen, M.K., Sallé, G., Reigner, F., Donnelly, C.G., Finno, C.J., Walshe, N., Mulcahy, G., Housby-Skeggs, N., Grice, S., Geyer, K.K., Austin, C.J., Matthews, J.B., 2024. Validation of a serum ELISA test for cyathostomin infection in equines. *Int. J. Parasitol.* 54, 23–32.
- Lockwood, C., Munn, Z., Porritt, K., 2015. Qualitative research synthesis: Methodological guidance for systematic reviewers utilizing meta-aggregation. *Int. J. Evid. Based Healthc.* 13, 179–187.
- Lyons, E.T., Bolin, D.C., Bryant, U.K., Cassone, L.M., Jackson, C.B., Janes, J.G., Kennedy, L.A., Loynachan, A.T., Boll, K.R., Burkhardt, A.S., Langlois, E.L., Minnis, S.M., Welsh, S.C., Scare, J.A., 2018. Postmortem examination (2016–2017) of weanling and older horses for the presence of select species of endoparasites: *Gasterophilus* spp., *Anoplocephala* spp., and *Strongylus* spp. in specific anatomical sites. *Vet. Parasitol. Reg. Stud. Rep.* 13, 98–104
- Macdonald, S.L., Abbas, G., Ghafar, A., Gauci, C.G., Bauquier, J., El-Hage, C., Tennent-Brown, B., Wilkes, E.J.A., Beasley, A., Jacobson, C., Cudmore, L., Carrigan, P., Hurley, J., Beveridge, I., Hughes, K.J., Nielsen, M.K., Jabbar, A., 2023. Egg reappearance periods of anthelmintics against equine cyathostomins: The state of play revisited. *Int. J. Parasitol.* 21, 28–39.
- MacMillan, F., McBride, K.A., George, E.S., Steiner, G.Z., 2019. Conducting a systematic review: a practical guide. In: Liamputtong, P. (Ed.), *Handbook of research methods in health social sciences*. Springer, Singapore, pp. 805–826.

- Maria, A., Shahardar, R.A., Bushra, M., 2012. Prevalence of gastrointestinal helminth parasites of equines in central zone of Kashmir Valley. *Indian J. Anim. Sci.* 82, 1276–1280.
- Martins, A.V., Coelho, A.L., Corrêa, L.L., Ribeiro, M.S., Lobão, L.F., Palmer, J.P.S., Moura, L.C., Molento, M.B., Barbosa, A.D.S., 2023. First microscopic and molecular parasitological survey of strongylus vulgaris in brazilian ponies. *Rev. Bras. Parasitol. Vet.* 32(3), e006323.
- Matto, T.N., Bharkad, G.P., Bhat, S.A., 2015. Prevalence of gastrointestinal helminth parasites of equids from organized farms of Mumbai and Pune. *J. Parasitol. Dis.* 39, 179–185.
- Merlin, A., Ravinet, N., Briot, L., Chauvin, A., Hébert, L., Valle-Casuso, J.C., Delerue, M., 2024. Prevalence and seasonal dynamics of gastrointestinal parasites in equids in France during two years. *Prevent. Vet. Med.* 223, 106100
- Nagar, S.R., Khatoon, S., Alam, H.M., Purohit, K., Kumar, J., Dixit, A.K., 2022. Epidemiological studies on gastrointestinal helminths of horses of Udaipur Rajasthan. *J. Pharma Innov. J.* 11, 82-86.
- Negash, W., Wossene, E., Dubie, T., 2021. Prevalence of strongyle infection and associated risk factors in horses and donkeys in and around Mekelle City, Northern Part of Ethiopia. *Vet. Med. Int.* 2021, 1–7
- Nielsen, M.K., Kaplan, R.M., Thamsborg, S.M., Monrad, J., Olsen, S.N., 2007. Climatic influences on development and survival of free-living stages of equine strongyles: Implications for worm control strategies and managing anthelmintic resistance. *Vet. J.* 174(1), 23–32.
- Nielsen, M.K., Branan, M.A., Wiedenheft, A.M., Digianantonio, R., Scare, J.A., Bellaw, J.L., Garber, L.P., Koprak, C.A., Phillippi-Taylor, A.M., Traub-Dargatz, J.L., 2018. Risk factors associated with strongylid egg count prevalence and abundance in the United States equine population. *Vet. Parasitol.* 257, 58–68
- Nu'man, N.N.S., 2024. Detection of strongyles in horses in Klang Valley and Selangor (Thesis). Faculty of Veterinary Medicine, Universiti Putra Malaysia.
- Okoli, C., 2015. A Guide to conducting a standalone systematic literature review. *Commun. Assoc. Inf. Syst.* 37, 43.
- Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., Shamseer, L., Tetzlaff, J.M., Akl, E.A., Brennan, S.E., Chou, R., Glanville, J., Grimshaw, J.M., Hróbjartsson, A., Lalu, M.M., Li, T., Loder, E.W., Mayo-Wilson, E., McDonald, S., McGuinness, L.A., Stewart, L.A., Thomas, J., Tricco, A.C., Welch, V.A., Whiting, P., Moher, D., 2021. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ.* 372, n71.
- Periyasamy, U.D., 2017. Prevalence of gastrointestinal nematodes among horses from various establishments (Thesis). Faculty of Veterinary Medicine, Universiti Putra Malaysia.
- Phetkarl, T., Fungwithaya, P., Lewchalermvong, K., Sontigun, N., 2024. Prevalence of gastrointestinal and blood parasites in horses of Nakhon Si Thammarat province, Thailand. *Vet. World.* 17(11), 2460–2468
- Pihl, T.H., Nielsen, M.K., Olsen, S.N., Leifsson, P.S., Jacobsen, S., 2017. Nonstrangulating intestinal infarctions associated with *Strongylus vulgaris*: clinical presentation and treatment outcomes of 30 horses (2008-2016). *Equine Vet. J.* 50(4), 474–480
- Relf, V.E., Morgan, E.R., Hodgkinson, J.E., Matthews, J.B., 2013. Helminth egg excretion with regard to age, gender and management practices on UK Thoroughbred studs. *Parasitology.* 140(5), 641–652
- Saeed, K., Qadir, Z., Ashraf, K., Ahmad, N., 2010. Role of intrinsic and extrinsic epidemiological factors on strongylosis in horses. *J. Anim. Plant. Sci.* 20, 277–280.
- Salem, S.E., Abd El-Ghany, A.M., Hamad, M.H., Abdelaal, A.M., Elsheikh, H.A., Hamid, A.A., Saud, M.A., Daniels, S.P., Ras, R., 2021. Prevalence of gastrointestinal nematodes, parasite control practices and anthelmintic

- resistance patterns in a working horse population in Egypt. *Equine. Vet. J.* 53(2), 339-348.
- Scala, A., Tamponi, C., Sanna, G., Predieri, G., Dessì, G., Sedda, G., Buono, F., Cappai, M.G., Veneziano, V., Varcasia, A., 2020. Gastrointestinal strongyles egg excretion in relation to age, gender, and management of horses in Italy. *Animals.* 10(12), 2283.
- Sengupta, P.P., 2003. Prevalence of gastro-intestinal helminths in equines in some hilly pockets of western Himalayas. *Indian J. Anim. Sci.* 73 (4), 394-396.
- Shaffril, H.A.M., Samah, A.A., Samsuddin, S.F., 2021. Guidelines for developing a systematic literature review for studies related to climate change adaptation. *Environ. Sci. Pollut. Res.* 28, 22265–22277.
- Sharma, S., Shukla, P.C., Dixit, P., Dixit, A.K., 2011. Prevalence of gastrointestinal helminths in horses in Malwa Region of Madhya Pradesh. *Vet. Pract.* 12(1), 68-69.
- Sinaga, L., Tanjung, M., 2022. Manifestation of endoparasitic helminths in Sumba Horse (*Equus caballus*) in Citra Pesona Ladangku Animal Park. *OP Conf. Ser. Earth Environ. Sci.* 1115, 110048.
- Singh, G., Angad, G., Soodan, J.S., 2012. Epidemiological studies on gastrointestinal helminths in horses and mules. *Vet. Pract.* 13 (1). 24-27.
- Singh, G., Singh, N.K., Singh, H., Rath, S.S., 2016. Assessment of risk factors associated with prevalence of strongyle infection in equines from Central Plain Zone, Punjab. *J. Parasit. Dis.* 40, 1381–1385.
- Stancampiano, L., Usai, F., Marigo, A., Rinnovati, R., 2017. Are small strongyles (*Cyathostominae*) involved in horse colic occurrence? *Vet. Parasitol.* 247, 33–36.
- Stoughton, W.B., Begin, S., Outman, S., Stryhn, H., Yu, J., Conboy, G., Nielsen, M.K., 2023. Occurrence and control of equine strongyle nematode infections in Prince Edward Island, Canada. *Vet. Parasitol. Reg. Stud. Rep.* 40, 100856.
- Tennent-Brown, B., Nielsen, M.K., Jabbar, A., 2019. A systematic review of gastrointestinal nematodes of horses from Australia. *Parasite. Vectors.* 12 (1), 188
- Tirtasari, K., Atma, C.D., Kholik., 2021. Prevalence and degree of gastrointestinal nematode infection of horses (*Equus caballus*) used as public transport in Mataram city, Indonesia. *IOP Conf. Ser. Earth Environ. Sci.* 712.
- Ulutaş Esatgil, M., Efil, İ., 2012. A coprological study of helminth infections of horses in Istanbul, Turkey. *Kafkas Univ. Vet. Fak. Derg.* 18, A1–A6.
- Umur, Ş., Açıci, M., 2009. A survey on helminth infections of equines in the Central Black Sea region, Turkey. *Turk. J. Vet. Anim. Sci.* 33, 373–378.
- Uslu, U., 2007. Prevalence of endoparasites in horses and donkeys in Turkey. *Bull. Vet. Inst. Pulawy.* 51, 237-240.
- Xiao, Y., Watson, M., 2019. Guidance on conducting a systematic literature review. *J. Plan. Educ. Res.* 39, 93–112.

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