






REVIEW

Prevalence of endo- and ecto-parasites of equines in Iran: A systematic review

Faham Khamesipour^{1,2}  | Taghi Taktaz-Hafshejani³  | Kwenti E. Tebit⁴  |
Seyed Mostafa Razavi²  | Seyed Reza Hosseini⁵ 

¹Cellular and Molecular Research Center, Sabzevar University of Medical Sciences, Sabzevar, Iran

²Department of Pathobiology, School of Veterinary Medicine, Shiraz University, Shiraz, Iran

³Department of Clinical Sciences, Faculty of Veterinary Medicine, Shahrekord Branch, Islamic Azad University, Shahrekord, Iran

⁴Department of Microbiology and Parasitology, University of Buea, Buea, Cameroon

⁵Department of Pathobiology, Faculty of Veterinary Medicine, Shahrekord Branch, Islamic Azad University, Shahrekord, Iran

Correspondence

Seyed Reza Hosseini, Department of Pathobiology, Faculty of Veterinary Medicine, Shahrekord Branch, Islamic Azad University, P.O. Box 166, Shahrekord, Iran.
Email: dr.s.reza@gmail.com

Abstract

Equines are subject to infection with many parasites, which threaten their health. In the present study, we systematically reviewed existing literature on the prevalence of endo- and ectoparasites of equines in Iran. Major electronic databases, including PubMed, PubMed Central, Google Scholar, Science Direct and Scientific Information Database (SID), were searched (Last updated 11/05/2018) for relevant literature of parasites that have been identified from equines in Iran. Of the 1809 titles produced by bibliographic search, 38 were included in the review. Twenty-seven of the studies were on horses, six on donkeys, three on both horses and donkeys, and one study was on both horses and mules. Furthermore, 24 of the studies reported infections caused by protozoa, thirteen by helminths, two by ectoparasites, and one by both protozoa and helminths. The overall pooled prevalence of parasitic infection was 28.8% (95%CI: 22.9–35.7, $I^2 = 93.4\%$). Helminths were the most prevalent parasites 46.7% (95% CI: 24.1–70.7, $I^2 = 96.0\%$). Furthermore, donkeys were the most affected equine, with a prevalence of 70.7% (95% CI: 53.2–83.7, $I^2 = 92.5\%$). The protozoa frequently reported included nine species belonging to the genera: *Neospora*, *Toxoplasma*, *Theileria*, *Babesia* and *Eimeria*. Also, the helminths frequently reported included 21 species belonging to the genera: *Strongylus*, *Dicrocoelium*, *Oxyuris*, *Habronema*, *Echinococcus*, *Dictyocaulus*, *Cyathostomum*, *Probstmayria*, *Anoplocephala*, *Setaria* and *Fasciola*. Ticks were the only ectoparasites frequently reported. Parasitic fly species of the genera *Gasterophilus* were also reported. The study-level risk of bias was likely to be high because of differences in study design. Parasitic infections of equines in Iran are frequent and caused by a diversity of parasites, which threatens the health and well-being of these animals. Further research is needed in the area to identify the risk factors of infection for effective control of the parasites.

KEYWORDS

ectoparasites, equine, helminths, Iran, parasitic infections, prevalence, protozoa

This is an open access article under the terms of the Creative Commons Attribution License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.

© 2020 The Authors. *Veterinary Medicine and Science* Published by John Wiley & Sons Ltd

1 | INTRODUCTION

"Equine" is often used to refer to members of the genus *Equus*, which include horses (*Equus ferus caballus*), donkeys (*Equus africanus asinus*), mules, zebra (*Equus zebra*), etc. There are an estimated 110 million equines in the developing world (Ali & Yagoob, 2015). More than 90% of the estimated 44 million donkeys in the world are in developing countries (Matthee, Krecek, & Milne, 2000). In developing countries, equines contribute greatly to the development of the agricultural economy, being used as a means of transportation due to economic and/or topographical constraints (Ali & Yagoob, 2015; Pritchard, Lindberg, Main, & Whay, 2005), and also are used in recreational activities such as sport, gaming and entertainment.

Equines are often subjected to many diseases which affect their performance (Khamesipour, Dida, Anyona, Razavi, & Rakhshandehroo, 2019; Moazeni, Khamesipour, Anyona, & Dida, 2019; Nejat et al., 2015; Pritchard et al., 2005; Taktaz-Hafshejani et al., 2015). Among these, parasitic diseases stand out as a major challenge to the health and welfare of horses, especially in developing countries (Pritchard et al., 2005). Parasites can be grouped as ectoparasites (i.e. parasites living on the body surfaces of the host) or endoparasites (i.e. parasites living inside the host), the latter can be further classified as protozoa or helminths (Kwenti, 2017). Ticks, especially the hard ticks (Ixodidae), are the most frequent ectoparasites reported in equines (Davari et al., 2017). Protozoa commonly infecting equines include *Eimeria sp.*, *Neospora sp.*, *Theileria (Babesia) equi*, *Babesia caballi*, *Cryptosporidium sp.* and *Toxoplasma gondii* (Foster, 1942). Helminths commonly infecting equines include *Trichostrongylus sp.*, *Paramphistomatidae*, *Fasciola sp.*, *Strongylus sp.*, *Dicrocoelium sp.*, *Moniezia sp.*, *Trichuris sp.*, *Oxyuris sp.*, *Parascaris sp.*, *Prostomaria sp.*, *Strongyloides sp.* and the Cyathostomins (Hosseini et al., 2009). Helminths, notably the gastrointestinal parasites, have been recognized as one of the most critical problems of equines in developing countries (Perry, Randolph, McDermott, Sones, & Thornton, 2002) and infection rates have been estimated to be as high as 90% in equines (Fikru, Reta, Teshale, & Bizunesh, 2005; Valdez-Cruz, Hernandez-Gil, Galindo-Rodriguez, & Alonso-Diza, 2006). It has been estimated that over 80% of donkeys in an area can be infected (Burden, du Toit, Hernandez-Gil, Prado-Ortiz, & Trawford, 2010; duToit, Burden, & Dixon, 2008; Getachew, Trawford, Feseha, & Reid, 2010). Studies of parasitic infection in equines have uncovered a diversity of helminth species (Hosseini et al., 2009; Trawford & Getachew, 2008). Nearly all equines have internal parasites, and if left untreated, these parasites can deprive the animal of precious blood nutrients and energy, thereby affecting their performance. Parasites mainly affect the digestive system of equines; however, the respiratory system and other organs may also be affected (Al-Qudari, Al-Ghamdi, & Al-Jabr, 2015). The consequences of parasitic infection in equine may range from diarrhea, anemia, fever, colic, weight loss, weak growth, emaciation, impaired growth, increased susceptibility to other infectious

diseases and sudden death (Arfaei et al., 2013; Taylor, Coop, & Wall, 2007).

In Iran, there are over two million equids, of which about 75% are donkeys (Hosseini et al., 2009). Like in other parts of the world, equines contribute to the agricultural economy of Iran and are a valuable means of transportation in some areas of the country. Parasites are also a menace to the health and welfare of equines, but a systematic review of the parasite status of equine in Iran is not readily available. The objective of the present study was to systematically review the existing literature on the prevalence and aetiology of parasitic diseases affecting equines in Iran to inform control policies.

2 | MATERIALS AND METHODS

A literature review was carried out between 1st of April and 11th of May 2018, to identify scientific articles reporting parasitic infections of equines in Iran. The current study conforms to the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines (Moher et al. 2009) (File S1).

2.1 | Search strategy and selection criteria

Relevant studies were searched in electronic databases, including PubMed, PubMed Central, Google Scholar, ScienceDirect and Scientific Information Database (SID) using the keywords: Parasites OR Infection OR Equine OR Horse OR Donkey OR Mule OR Iran.

No time limits were defined, and articles reporting parasitic infections of equine irrespective of the methods used for identification (i.e. serology, coprology or molecular methods) were selected. Subsequently, the titles and abstracts of the selected articles were examined by two reviewers independently (parallel method), to identify articles reporting parasitic infections in equines in Iran. Where there was any discrepancy in their report, a third reviewer was brought in to resolve it. Relevant papers were also manually cross-checked to identify further references. In the articles selected, the following data were extracted by one reviewer and crosschecked by a second: Type of parasitic infection, the prevalence of infection, species of parasites identified and their frequencies, host type involved (horses, donkeys, mules, etc.), the geographical location of study, association with host factors (age, sex or season) and the method used to identify the parasite. Articles were excluded when they did not report any parasite species. The selection process is detailed in Figure 1.

2.2 | Statistical analysis

Pooled prevalence was determined using Comprehensive Meta-Analysis V3.3.070 software (Biostat, USA). Data were pooled using a Fixed and random-effect model. The heterogeneity between these

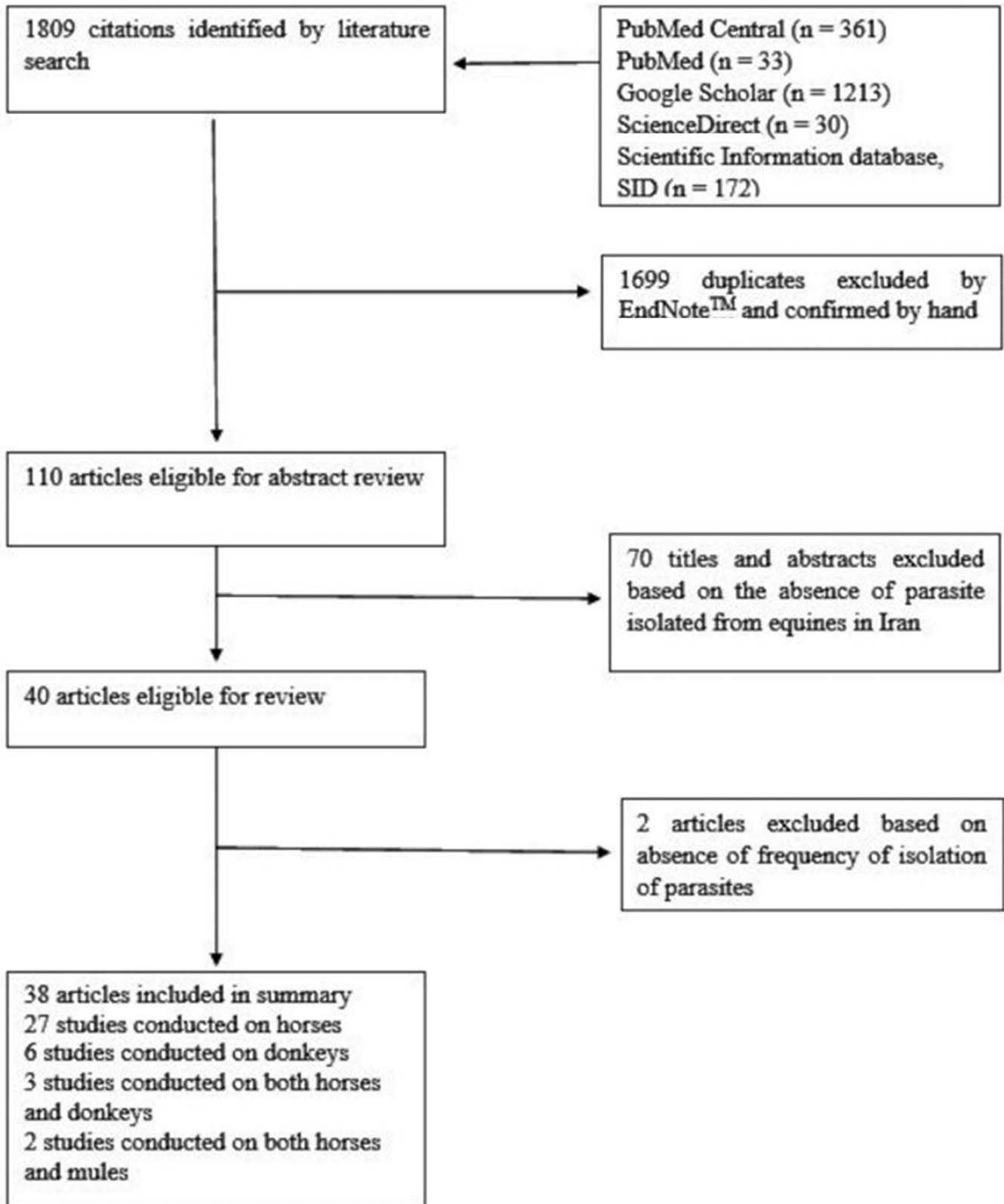


FIGURE 1 Flowchart of the selection process for publications included in this review

studies was assessed with the I^2 test. An I^2 value of >50% indicated substantial heterogeneity. For the pooling of the results, a more conservative random-effect model was used as heterogeneity was substantial.

3 | RESULTS

The results revealed publications from 2005 to 2017. The review of the literature provided 1809 titles (361 on PubMed Central, 33 on

TABLE 1 Summary of the prevalence of parasitic infections affecting equines in Iran

Parasitic infection/disease	Aetiology	Method of detection	Site of isolation	Host type affected	Prevalence (%)	Reference
Protozoa						
1 Neosporosis	<i>Neospora caninum</i> , <i>Neospora hughesi</i>	Serology	Tissues	Horse	20–40.8	(Charekhani & Heidari, 2014; Gharekhani et al., 2013; Hosseini et al., 2011; Moraveji et al., 2011; Tavalla et al., 2015; Yagoob, 2011)
2 Toxoplasmosis	<i>Toxoplasma gondii</i>	Serology	Tissues	Horse	11.5–71.2	(Charekhani et al., 2013)
3 Cryptosporidiosis	<i>Cryptosporidium parvum</i> , <i>C. hominis</i> , <i>C. felis</i>	Faecal, molecular		Horse	10.56–26.66	(Hajjalilo, Ziaali, Harandi, Saraei, & Hajjalilo, 2010; Raeghi et al., 2011; Razmi et al., 2016; Tavalla et al., 2015)
4 Equine coccidiosis	<i>Eimeria leuckarti</i>	Faecal	Tissues, GIT	Mule	12.5	(Ghadrdan-Mashhadi et al., 2013; Naghibi & Vahedi, 2002; Rasuli et al., 2012; Tavassoli et al., 2007)
5 Equine piroplasmosis	<i>Theileria (Babesia) equi</i> , <i>Babesia caballi</i>	Blood smears and molecular	Tissues, GIT	Donkey	7.68	(Rasuli et al., 2012)
			Tissues	Donkey	7.68	(Ghahfarrokhi et al., 2014)
			Tissues	Donkey	50.94	(Ghahfarrokhi et al., 2014)
				Horse	4.1–96.77	(Abedi et al., 2015)
				Horse		(Arfaei et al., 2013; Davoodi et al., 2010; Habibi et al., 2016; Hassanpour & Nematollahi, 2014; Hosseini, Taktaz-Hafshejani, & Khamesipour, 2017; Malekifard et al., 2014; Sakha, 2007)
Nematode						
6 Oxyuriasis	<i>Oxyuris equi</i>	Faecal, necropsy	GIT	Horse	3.84–26	(Eslami et al., 2005; Ghahfarrokhi et al., 2014; Hosseini et al., 2009; Hossien et al., 2008; Khosravi et al., 2012)
7 Strongylosis	<i>Strongylus vulgaris</i> , <i>Strongylus equinus</i> , <i>Strongylus edentatus</i> ,	Faecal, necropsy		Donkey	11.53	(Ghahfarrokhi et al., 2014)
	<i>Cyathostomum pathatum</i> , <i>Cylicocycylus elongatus</i> , <i>Cylicostephanus longibarsatus</i> , <i>Cylicostephanus goldi</i> , <i>Cylicocycylus nassatus</i>			Horse	28.3–34	(Ali & Yagoob, 2015; Eslami et al., 2005; Hossien et al., 2008; Khosravi et al., 2012)
8 Cyathostominosis		Faecal, necropsy	GIT	Donkey	100	(Borji, Moosavi, & Ahmadi, 2014; Hosseini et al., 2009; Tavassoli et al., 2016)
			GIT	Donkey	53.3	(Hosseini et al., 2009; Oryan, Kish, & Rajabloo, 2015)
				Horse	4–22	(Ali & Yagoob, 2015)

(Continues)

TABLE 1 (Continued)

Parasitic infection/disease	Aetiology	Method of detection	Site of isolation	Host type affected	Prevalence (%)	Reference
9 Parascartosis	<i>Parascaris equorum</i> ,	Faecal, necropsy	GIT	Horse	10–44	(Eslami et al., 2005; Ghahfarrokhi et al., 2014; Hossien et al., 2008; Khosravi et al., 2012)
10 Summer Sores (Cutaneous Habronemosis)	<i>Habronema muscae</i> , <i>Habronema majus</i> , <i>Draschia</i> (<i>Habronema megastoma</i>)	Faecal, necropsy	GIT	Donkey	3.84–20	(Hosseini et al., 2009; Ghahfarrokhi et al., 2014; Tavassoli et al., 2016)
11 Equine hydatidosis or echinococcosis	<i>Echinococcus granulosus</i>	Necropsy	Liver	Horse, donkey	1.72–66.6	(Hosseini et al., 2009; Tavassoli et al., 2016)
12 Lungworm infection	<i>Dictyocaulus arnfieldi</i>	Faecal	GIT	Horse	-	(Eslami, Shayan, & Bokaei, 2014; Sakhaee, Golchin, Amiri, Fayed, & Eydi, 2016)
13 Probstmayriosis	<i>Probstmayria vivipavra</i>	Necropsy	GIT, Liver	Donkey	20	(Sharifi, Borji, & Milani, 2010)
14 Trichostrongylosis	<i>Trichostrongylus axei</i>	Necropsy	GIT, Liver	Donkey	6.6	(Hosseini et al., 2009)
15 Filariasis	<i>Setaria equina</i>	Necropsy	GIT, Liver	Donkey	6.6	(Hosseini et al., 2009)
16 Equine parafilariosis	<i>Parafilaria multipapillosa</i>	Blood smears	Tissues	Horse and Donkey	1.4–41.3	(Maloufi, 1995)
Trematode						
17 Dicrocoeliosis	<i>Dicrocoelium dendriticum</i>	Faecal, necropsy	Intestines	Horse	17.14–56	(Khosravi et al., 2012)
				Donkey	6.6	(Hosseini et al., 2009)
18 Fasciolosis	<i>Fasciola hepatica</i>	Necropsy	GIT, Liver	Donkey	6.6	(Hosseini et al., 2009)
Cestode						
19 Anoplocephalosis	<i>Anoplocephala perfoliata</i>	Necropsy	GIT, Liver	Donkey	12.3	(Hosseini et al., 2009)
Ascari						
20 Tick infestation	<i>Hyalomma</i> spp., <i>Rhipicephalus</i> spp., <i>Boophilus</i> spp.	Hand-picking	Body surfaces	Horse	16.45–52	(Davoodi et al., 2010; Khosravi et al., 2012)
Insect (Parasitic fly)						
21 Gasterophilosis	<i>Gasterophilus intestinalis</i> , <i>G. nasalis</i> , <i>G. inermis</i>	Necropsy	GIT, liver	Horse, Donkey, Mule	16.07–66.6	(Hosseini et al., 2009; Mashayekhi & Ashtari, 2013; Tavassoli & Bakht, 2012)

PubMed, 1213 on Google Scholar, 30 on ScienceDirect and 172 on SID), 1699 of which were discarded as they were found to be duplicated using a reference manager software (EndNote™) and confirmed manually (Figure 1). During the review of the remaining 110 works, 70 abstracts were discarded because they did not contain information on the parasites detected. The remaining 40 studies were analysed, rejecting two articles that were not written in English and did not contain an abstract in English (Figure 1).

A total of 38 articles were selected, all written in English. Twenty-seven of the studies were conducted on horses (71.1%, 95% CI [54.1–84.6]), six (15.8%, 95% CI [6.0–31.3]) conducted on donkeys, three (7.9%, 95% CI [1.7–21.4]) conducted on both horses and donkeys and two (5.3%, 95% CI [0.6–17.8]) conducted on both horses and mules.

Fifteen studies reported intestinal parasites 15 (39.5%, 95% CI [24.0–56.6]), 20 (52.6%, 95% CI [35.8–69.0]) reported blood parasites, three (7.9%, 95% CI [1.7–21.4]) reported tissue parasites. Twenty-four studies reported protozoa 24 (63.2%, 95% CI [46.0–78.2]), 13 (34.2%, 95% CI [19.6–51.4]) reported helminths, two (5.3%, 95% CI [0.6–17.8]) reported ectoparasites and one (2.6%, 95% CI [0.07–14.8]) reported both helminth and protozoa parasites.

Five of the studies were performed in the Northern (13.2%, 95% CI [4.4–298.1]), 11 (29.0%, 95% CI [15.4–45.9]) in the Northeastern, 10 (26.3%, 95% CI [13.4–43.1]) in the Northwestern, three (7.9%, 95% CI [1.7–21.4]) in Western, one (2.6%, 95% CI [0.07–14.8]) in the

Southern, and eight (21.1%, 95% CI [9.6–37.3]) in the Southwestern regions of Iran.

Overall, the prevalence of parasitic infection in equine varied between 1.72% and 96.77% (Table 1). The pooled prevalence was 28.8% (95%CI: 22.9–35.7, $I^2 = 93.4\%$). The pooled prevalence of protozoa, helminth and ectoparasite (ticks were the only species identified) was 26.2% (95% CI: 20.06–32.7, $I^2 = 91.9\%$), 46.7% (95% CI: 24.1–70.7, $I^2 = 96.0\%$) and 14.8% (95% CI: 9.5–22.2, $I^2 = 0.0\%$), respectively. The prevalence of parasitic infection was higher in donkeys 70.7% (95% CI: 53.2–83.7, $I^2 = 92.5\%$) compared to horses 23.4% (95% CI: 18.3–29.4, $I^2 = 92.3\%$) or mule 12.5%. Furthermore, the prevalence of helminthic infection was highest in the northwestern region meanwhile prevalence of protozoa infection was highest in the western region of the country (Figure 2). Generally, the helminth parasite species reported were very diverse compared to protozoa parasites (21 species versus nine species).

4 | DISCUSSION

This review revealed a generally high prevalence of parasitic infections in equine in Iran. Among the parasites infecting equines in Iran, the helminth parasites, especially the nematodes, were the most frequent (up to 100%) and diverse group of parasites (Table 1). A majority of the parasites reported in this study were observed to infect the gastrointestinal tract (GIT). Gastrointestinal parasitism is

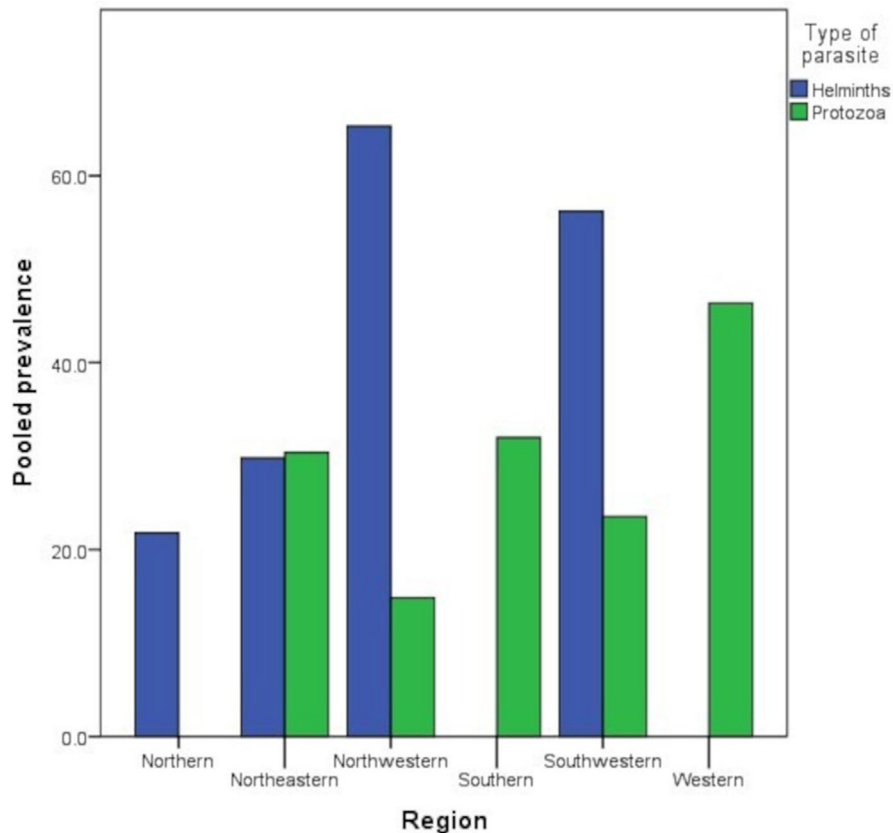


FIGURE 2 Pooled prevalence of parasitic infection by region

known to be acquired passively (i.e., through the ingestion of infective larvae on pasture). However, in some species, larvae burrow through the skin or are transmitted by invertebrate intermediate hosts (Anderson, 2000). Ticks were the only ectoparasite frequently isolated from equines in Iran. Ticks are non-permanent obligate and the most frequent ectoparasites of terrestrial vertebrates constituting a serious threat to animal and human health in many parts of the world. They are capable of exerting direct damage as well as act as vectors of many parasitic, viral, and bacterial pathogens (De la Fuente, Estrada-Pena, Venzal, Kocan, & Sonenshine, 2008; Allan 2001). From this review, one notable equine parasitic disease transmitted by ticks in Iran was piroplasmiasis caused by *Theileria equi* and *Babesia caballi* (Abedi, Razmi, Seifi, & Naghibi, 2015; Arfaei et al., 2013; Davoodi, Rauli, & Jafari, 2010; Habibi et al., 2016; Hassanpour & Nematollahi, 2014; Malekifard, Tavassoli, Yakhchali, & Darvishzadeh, 2014; Sakha, 2007). Control of ticks and tick-borne diseases of equine is therefore vital for the protection of the health of the animals and an increase in their productivity in the area. Control of parasites of animals is equally important in protecting human health as some of these parasites are zoonotic. At least one of the studies reviewed showed a higher rate of *Cryptosporidium* infection in persons who were in contact with infected animals (Naghibi & Vahedi, 2002). Another study in France reports of three cases of acquired toxoplasmosis in humans caused by the consumption of raw horse meat (Pomares et al., 2011). Although this does not fit in the traditional classification of parasites (as either ectoparasite or endoparasite), the larvae of parasitic flies, *Gasterophilus intestinalis*, *G. nasalis*, *G. inermis*, have also been reported to cause serious health problems to equines in Iran (Davari et al., 2017; Hosseini et al., 2009; Tavassoli & Bakht, 2012).

The parasitic infections frequently reported from this review included neosporosis, equine piroplasmiasis, and strongylosis. Neosporosis is caused by *Neospora caninum*, an Apicomplexan protozoan parasite with a worldwide distribution (Hosseini et al., 2011). The parasites can infect a wide range of animal species, including cattle, sheep, goats, horses, dogs, and cats, and have been associated with abortion, protozoal myeloencephalitis, and neuromuscular disorder signs in equine (Finno, Aleman, & Pusterla, 2007). Equine piroplasmiasis is a haemolytic disease caused by two intra-erythrocytic hemo-protozoan, *Theileria equi* and *Babesia caballi* (Mahmoud et al., 2016). The disease is characterized by fever, anaemia, red urine, jaundice, oedema, weight loss and even death in equine (Mahmoud et al., 2016). On the other hand, strongylosis is caused by several nematodes, often referred to as the small and large strongyles (Tavassoli, Yamchi, & Hajipour, 2016). They are frequently responsible not only for poor health, but also for gastrointestinal dysfunction, including colic, and infection with some such as acute larval cyathostomiasis may be fatal (Love, Murphy, & Mellor, 1999).

Reports of vector-borne parasitic diseases such as filariasis (Lia et al., 2017; Radwan, Ahmed, Elakabawy, Ramadan, & Elmaway, 2016) and trypanosomiasis (Luckins, 1994), known to cause major problems in equines worldwide, have not been reported in Iran. The only filarial species that has been reported in equines in

Iran are *Setaria equina* (Hosseini et al., 2009) and *Parafilaria multipapillosa* (Maloufi 1995). The under-reporting of filarial parasites in equines in the country may be due to individual study level biases in the design of the different studies, pertaining to the methods used to detect the presence of parasites; serology was used to detect exposure to most of the protozoa parasites meanwhile concentration techniques, culture and molecular methods were not used in all the studies, constituting a major limitation to the study. At least one study has reported a higher detection rate of parasitic infection using molecular methods compared with serological and standard parasitological techniques (Habibi et al., 2016; Mahmoud et al., 2016). The differences in the diagnostic methods may also explain the variability in the observed prevalence of the parasitic infections from one area to another.

This study demonstrates heterogeneity in the distribution of parasitic infection in Iran. The pooled prevalence of protozoa infection was highest in the western region meanwhile, the prevalence of helminth infection was highest in the northwestern region. The discrepancy in the prevalence of parasitic infection in the different areas of Iran could also be attributed to the inter-regional differences in the endemicity of the parasites. Climatic and cultural differences may also be a contributing factor to these inter-regional differences.

This review also revealed that most (but not all [Eslami, Bokai, & Tabatabai, 2005; Hossien, Bokaei, & Roudgari, 2008; Khedri, Radfar, Borji, & Azizzadeh, 2014; Razmi, Abedi, & Yaghfoori, 2016]) of the studies failed to observe a significant association between prevalence of parasites and age of the animals (Armand, Solhjoo, Shabani-Kordshooli, Davami, & Sadeghi, 2016; Eslami et al., 2005; Ghaddran-Mashhadi, Hamidienjat, & Alizadehnia, 2013; Gharekhani, Tavoosidana, & Naderisefat, 2013; Malekifard et al., 2014; Tajik, Mirshahi, Razmi, & Mohammadi, 2010; Tavalla et al., 2015; Tavassoli, Sodagar-Skandarabadi, & Soltanilinejad, 2007). Also, most (but not all [Khedri et al., 2014]) of the studies failed to observe any significant association between the prevalence of parasites and sex (Hossien et al., 2008; Hosseini et al., 2009; Hosseini et al., 2011; Raeghi, Akaberi, & Sedeghi, 2011; Rasuli, Khodadadi, Sadagiyani, Moradpoor, & Salmanzadeh, 2012; Gharekhani et al., 2013; Ghahfarrokhi, Ahmadi, Shahraki, & Azizi, 2014; Hassanpour & Nematollahi 2014; Mcallister, 2014; Tavassoli et al., 2016). And lastly, most (but not all [Hossien et al., 2008; Khedri et al., 2014]) of the studies failed to observe any significant association between the prevalence of parasites and season (Armand et al., 2016; Tavassoli et al., 2007).

As evident from this review, no study has been conducted to determine risk factors for parasitic infections of equines in Iran, which therefore presents a major challenge for the successful implementation of control strategies in the area. There is, therefore, a need for more empirical research to establish risk factors associated with parasitic infections to develop appropriate control strategies for parasites in equines in Iran.

Control of parasitic infections of equines and other livestock can be achieved using chemical and biological control methods (Kwenti, 2017). Many biological products are available in the markets that have a proven track record to effectively reduce

parasite infections in livestock, including the nematopathogenic fungi (*Duddingtonia flagrans*) (Kwenti, 2017), which make a more suitable alternative to the chemical methods. For example, feeding or field trials in sheep have shown that dosing with a few hundred thousand spores per kilogram of live birth weight of *D. flagrans* not only reduced the number of infective larvae but also increased the birth weight of lambs compared with controls (Larsen, 2006).

Furthermore, many vaccines have been developed against parasites of livestock, including vaccines against *Eimeria spp.*, *Theileria spp.*, *Toxoplasma gondii*, *Babesia spp.*, *Neospora spp.* etc. (McAllister, 2014; Sharma, Singh, & Shyma, 2015). Vaccines might present a cheaper and more effective alternative to control parasite infection, thereby improving animal production. However, more research is required to develop and evaluate more effective vaccines against parasites.

In conclusion, our work revealed that parasite infections and infestations of equines in Iran are frequent and caused by a diversity of parasites (ectoparasites, protozoa, helminths and parasitic flies), which threatens the health and welfare of the animals. Further research is needed in the area to identify the risk factors of infection for effective control of the parasites.

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

AUTHORS' CONTRIBUTIONS

All authors have read and approved the final version of the paper.

AUTHOR CONTRIBUTION

Faham Khamesipour: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Project administration; Resources; Supervision; Validation; Visualization; Writing-original draft; Writing-review & editing. **Taghi Taktaz Hafshejani:** Validation; Visualization; Writing-review & editing. **Kwenti Emmanuel Tebit:** Data curation; Formal analysis; Investigation; Methodology; Resources; Software; Validation; Writing-review & editing. **Seyed Mostafa Razavi:** Resources; Validation; Writing-review & editing. **Seyed Reza Hosseini:** Investigation; Resources; Writing-review & editing.

DATA AVAILABILITY STATEMENT

The original research articles included in this systematic review are publicly available.

PEER REVIEW

The peer review history for this article is available at <https://publons.com/publo/n/10.1002/vms3.321>.

ORCID

Faham Khamesipour  <https://orcid.org/0000-0003-0678-2528>

Taghi Taktaz-Hafshejani  <https://orcid.org/0000-0002-9944-7421>

Kwenti E. Tebit  <https://orcid.org/0000-0001-5526-9179>

Seyed Mostafa Razavi  <https://orcid.org/0000-0003-3765-1563>

Seyed Reza Hosseini  <https://orcid.org/0000-0002-2553-4004>

REFERENCES

- Abedi, V., Razmi, G. H., Seifi, H., & Naghibi, A. (2015). Molecular detection of equine piroplasms in donkeys (*Equus asinus*) in North Khorasan province, Iran. *IJVR*, *16*(2), 202–204.
- Ali, S., & Yagoob, G. (2015). Survey on fecal gastrointestinal parasitic helminthes in horses of Jokey clubs in Ardabil city, Iran. *BFAIJ*, *7*(1), 106–110.
- Allan, S. A. (2001). Ticks (Class Arachnida Order Acarina). In W. M. Samuel, M. J. Pybus, & A. A. Kocan (Eds.), *Parasitic diseases of wild mammals* (2nd ed., pp. 72–106). Iowa: Iowa State University Press.
- Al-Qudari, A., Al-Ghamdi, G., & Al-Jabr, O. (2015). Prevalence of gastrointestinal parasites in horses in the eastern province of Saudi Arabia. *SJKFU*, *16*(2), 37–47.
- Anderson, R. C. (2000). *Nematode parasites of vertebrates: Their development and transmission* (2nd ed.). Wallingford, UK: CABI Publishing.
- Arfaei, A. A., Rasooli, A., Razi, J. M., Hamidinejad, H., Rouhizadeh, A., & Raki, A. R. (2013). Equine theileriosis in two Arab mares in Ahvaz. *Iranian Journal of Veterinary Research*, *9*(1), 103–108.
- Armand, B., Solhjoo, K., Shabani-Kordshooli, M., Davami, M. H., & Sadeghi, M. (2016). Toxoplasma infection in sheep from south of Iran monitored by serological and molecular methods; risk assessment to meat consumers. *Veterinary World*, *9*(8), 850–855.
- Borji, H., Moosavi, Z., & Ahmadi, F. (2014). Cranial mesenteric arterial obstruction due to *Strongylus vulgaris* larvae in a donkey (*Equus asinus*). *Iranian Journal of Parasitology*, *9*(3), 441–444.
- Burden, F. A., du Toit, N., Hernandez-Gil, N., Prado-Ortiz, O., & Trawford, A. F. (2010). Selected health and management issues for working donkeys in rural Mexico. *Tropical Animal Health and Production*, *42*, 597–605.
- Davari, B., Alam, F. N., Nasirian, H., Nazari, M., Abdigoudarzi, M., & Salehzadeh, A. (2017). Seasonal distribution and faunistic of ticks in the Alashtar county (Lorestan Province), Iran. *Pan African Medical Journal*, *27*, 284.
- Davoodi, J., Rauli, S., & Jafari, K. (2010). Babesia infection in single-toxic case study in horses in Miyaneh. *Journal of Veterinary Pathobiology*, *1*(3), 49–57.
- De la Fuente, J., Estrada-Pena, A., Venzal, J. M., Kocan, K. M., & Sonenshine, D. E. (2008). Overview: Ticks as vectors of pathogens that cause disease in humans and animals. *Frontiers in Bioscience*, *13*, 6938–6946.
- duToit, N., Burden, F. A., & Dixon, P. M. (2008). Clinical dental findings in 203 donkeys in Mexico. *The Veterinary Journal*, *178*, 380–386.
- Eslami, A., Bokai, S., & Tabatabai, V. (2005). Equine parasites in Iran. *Journal of Equine Veterinary Science*, *25*(4), 143–144.
- Eslami, A., Shayani, P., & Bokaei, S. (2014). Morphological and genetic characteristics of the liver hydatid cyst of a donkey with Iran origin. *Iranian Journal of Parasitology*, *9*(3), 302–310.
- Fikru, R., Reta, D., Teshale, S., & Bizunesh, M. (2005). Prevalence of equine gastrointestinal parasites in western highlands of Oromia, Ethiopia. *Bulletin of Animal Health and Production in Africa*, *53*(3), 161–166.
- Finno, C. J., Aleman, M., & Pusterla, N. (2007). Equine protozoal myeloencephalitis associated with neosporosis in 3 horses. *Journal of Veterinary Internal Medicine*, *21*(6), 1405–1408. <https://doi.org/10.1111/j.1939-1676.2007.tb01966.x>
- Foster, A. O. (1942). Internal parasites of horses and mules. *Yearbook of Agriculture*, *1942*, 459–475. <https://www.cabdirect.org/cabdirect/abstract/19420800898>
- Getachew, A. M., Trawford, A. F., Feseha, G., & Reid, S. W. J. (2010). Gastrointestinal parasites of working donkeys in Ethiopia. *Tropical Animal Health and Production*, *42*, 27–33.
- Ghadrdan-Mashhadi, A., Hamidienjat, H., & Alizadehnia, P. (2013). A survey on frequency of equine cryptosporidiosis in Ahvaz. *Veterinary Clinical Pathology*, *6*(4), 1723–1727.
- Ghahfarrokhi, E. K., Ahmadi, A., Shahraki, S. G., & Azizi, H. R. (2014). *Eimeria leuckarti* (Flesch, 1883; Reichenow, 1940) from worker horses and donkeys of Shahrekord, Iran. *IJABBR*, *2*(6), 1980–1984.

- Gharekhani, J., & Heidari, H. (2014). Serology based comprehensive study of *Neospora* infection in domestic animals in Hamedan province, Iran. *Journal of Advanced Veterinary and Animal Research*, 1(3), 119–124.
- Gharekhani, J., Tavosidana, G.-R., & Naderisefat, G.-R. (2013). Seroprevalence of *Neospora* infection in horses and donkeys in Hamedan province, Western Iran. *Veterinary World*, 6(9), 620–622.
- Habibi, G., Esmaeilnia, K., Hablolvarid, M., Afshari, A., Zamen, M., & Bozorgi, S. (2016). Microscopic and molecular detection of *Theileria (Babesia) Equi* infection in equids of Kurdistan province, Iran. *Iranian Journal of Parasitology*, 11(1), 86–90.
- Hajjalilo, E., Ziaali, N., Harandi, M. F., Saraei, M., & Hajjalilo, M. (2010). Prevalence of anti-*Toxoplasma gondii* antibodies in sport horses from Qazvin, Iran. *Tropical Animal Health and Production*, 42(7), 1321–1322.
- Hassanpour, A., & Nematollahi, A. (2014). Evaluation of serum levels of vitamin C, vitamin E, selenium and the activity of glutathione peroxidase enzyme in the horses with piroplasmosis. *Journal of Large Animal Clinical Sciences Research*, 7(1), 35–41.
- Hosseini, M. H., Moraveji, M., Tahamtan, Y., Rahimian, A., Mohammadi, G. H., & Namavari, M. M. (2011). Seroprevalence of *Neospora* spp. in horses in north east of Iran. *Iranian Journal of Parasitology*, 6(2), 64–68.
- Hosseini, S. H., Meshgi, B., Eslami, A., Bokai, S., Sobhani, M., & Ebrahimi, S. R. (2009). Prevalence and biodiversity of helminth parasites in donkeys (*Equus asinus*) in Iran. *International Journal of Veterinary Research*, 3(2), 95–99.
- Hosseini, S. R., Taktaz-Hafshejani, T., & Khamesipour, F. (2017). Molecular detection of *Theileria equi* and *Babesia caballi* infections in horses by PCR method in Iran. *Kafkas Universitesi Veteriner Fakultesi Dergisi*, 23(1), 161–164.
- Hossien, H. S., Bokaei, S., & Roudgari, R. (2008). A survey of helminth infection of racehorses in Tehran. *IJVR*, 4(2), 32–39.
- Khamesipour, F., Dida, G. O., Anyona, D. N., Razavi, S. M., & Rakhshandehroo, E. (2019). Tick-borne zoonoses in the order Rickettsiales and Legionellales in Iran: A systematic review. *PLoS Neglected Tropical Diseases*, 12(9), e0006722. <https://doi.org/10.1371/journal.pntd.0006722>
- Khedri, J., Radfar, M. H., Borji, H., & Azzadeh, M. (2014). An Epidemiological survey of setaria in the abdominal cavities of Iranianistani and brahman cattle in the Southeastern of Iran. *Iranian Journal of Parasitology*, 9(2), 249–253.
- Khosravi, M., Kavosh, F., Taghavi-Moghadam, A., Ghaem-Maghami, S., Pirali-Kheirabadi, K., Rahimi-Feyli, P., ... Arbabi, F. (2012). Comparison of helminth and hard tick infestation between riding and workhorses in Ahwaz, Iran. *Comparative Clinical Pathology*, 21, 333–336.
- Kwenti, E. T. (2017). Biological control of parasites. In: Hanem Khater (Ed.), *Natural remedies in the fight against parasites* (pp. 23–58). Croatia: InTech.
- Larsen, M. (2006). Biological control of nematode parasites in sheep. *Journal of Animal Science*, 84, E133–E139.
- Lia, R. P., Mutafchiev, Y., Veneziano, V., Giannelli, A., Abramo, F., Santoro, M., ... Riccio, B. (2017). Filarial infection caused by *Onchocerca boehmi* (Supperer, 1953) in a horse from Italy. *Parasitology Research*, 116(1), 191–198.
- Love, S., Murphy, D., & Mellor, D. (1999). Pathogenicity of cyathostome infection. *Veterinary Parasitology*, 85, 113–122.
- Luckins, A. G. (1994). Equine trypanosomiasis. *Equine Veterinary Journal*, 6(5), 259–262.
- Mahmoud, M. S., El-Ezz, N. T., Abdel-Shafy, S., Nassar, S. A., El Namaky, A. H., Khalil, W. K., ... Suarez, C. E. (2016). Assessment of *Theileria equi* and *Babesia caballi* infections in equine populations in Egypt by molecular, serological and hematological approaches. *Parasit Vectors*, 9, 260.
- Malekifard, F., Tavassoli, M., Yakhchali, M., & Darvishzadeh, R. (2014). Detection of *Theileria equi* and *Babesia caballi* using microscopic and molecular methods in horses in suburb of Urmia, Iran. *Veterinary Research Forum*, 5(2), 129–133.
- Maloufi, F. (1995). Equine parafilariosis in Iran. *Veterinary Parasitology*, 56(1–3), 189–197.
- Mashayekhi, M., & Ashtari, B. (2013). Study of *Gasterophilus* role in equine gastric ulcer syndrome in Tabriz area. *Bulletin of Environment, Pharmacology and Life Sciences*, 2(12), 169–172.
- Matthee, S., Krecek, R. C., & Milne, S. A. (2000). Prevalence and biodiversity of helminth parasites in donkeys from South Africa. *Journal of Parasitology*, 86, 756–762.
- Mcallister, M. M. (2014). Successful vaccines for naturally occurring protozoal diseases of animals should guide human vaccine research. A review of protozoal vaccines and their designs. *Parasitology*, 141, 624–640.
- Moazeni, M., Khamesipour, F., Anyona, D. N., & Dida, G. O. (2019). Epidemiology of taeniosis, cysticercosis and trichinellosis in Iran: A systematic review. *Zoonoses and Public Health*, 66(1), 140–154. <https://doi.org/10.1111/zph.12547>
- Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & the PRISMA Group. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Med*, 6(6), e1000097.
- Moraveji, M., Hosseini, M. H., Amrabadi, O., Rahimian, A., Namazi, F., & Namavari, M. (2011). Seroprevalence of *Neospora* spp. in horses in South of Iran. *Tropical Biomedicine*, 28(3), 514–517.
- Naghbi, A., & Vahedi, H. (2002). Prevalence of cryptosporidial infection in horse and man in Mashhad, Iran. *Archives of Razi Institute*, 54, 101–106.
- Nejat, S., Momtaz, H., Yadegari, M., Nejat, S., Safarpour, D. F., & Khamesipour, F. (2015). Seasonal, geographical age and breed distribution of equine viral arteritis in Iran. *Kafkas Universitesi Veteriner Fakultesi Dergisi*, 21, 11–116.
- Oryan, A., Kish, G. F., & Rajabloo, M. (2015). Larval cyathostominosis in a working donkey. *Journal of Parasitic Diseases*, 39(2), 324–327.
- Perry, B. D., Randolph, T. F., McDermott, J. J., Sones, K. R., & Thornton, P. K. (2002). *Investing in animal research to alleviate poverty*. Nairobi: International Livestock Research Institute. <http://hdl.handle.net/10568/2308>.
- Pomares, C., Ajzenberg, D., Bornard, L., Bernardin, G., Hasseine, L., Darde, M. L., & Marty, P. (2011). Toxoplasmosis and horse meat, France. *Emerging Infectious Diseases*, 17, 1327–1328.
- Pritchard, J. C., Lindberg, A. C., Main, D. C., & Whay, H. R. (2005). Assessment of the welfare of working horses, mules and donkeys, using health and behaviour parameters. *Preventive Veterinary Medicine*, 69, 265–283.
- Radwan, A. M., Ahmed, N. E., Elakabawy, L. M., Ramadan, M. Y., & Elmadawy, R. S. (2016). Prevalence and pathogenesis of some filarial nematodes infecting donkeys in Egypt. *Veterinary World*, 9(8), 888–892.
- Raeghi, S., Akaberi, A., & Sedeghi, S. (2011). Seroprevalence of *Toxoplasma gondii* in sheep, cattle and horses in Urmia north-west of Iran. *Iranian Journal of Parasitology*, 6(4), 90–94.
- Rasuli, S., Khodadadi, A., Sadagiyani, M., Moradpoor, A., & Salmazadeh, R. (2012). Equine cryptosporidium prevalence in border line villages of Urmia province. *Journal of Veterinary Research*, 3(1), 41–49.
- Razmi, G. R., Abedi, V., & Yaghfoori, S. (2016). Serological study of *Toxoplasma gondii* infection in Turkoman horses in the North Khorasan Province, Iran. *Journal of Parasitic Diseases*, 40(2), 515–519.
- Sakha, M. (2007). Successful treatment of babesiosis in a horse. *Journal of Veterinary Research*, 62(4), 155–157.
- Sakhaee, E., Golchin, M., Amiri, H., Fayed, M. R., & Eydi, J. (2016). First serological study of equine hydatidosis in Iran. *Journal of Parasitic Diseases*, 40(4), 1567–1570.
- Sharifi, K., Borji, H., & Milani, P. (2010). First report of *Dictyocaulus arnfieldi* infestation in a horse in Mashhad, Iran. *Journal of Veterinary Science & Technology*, 2(1), 45–50.
- Sharma, N., Singh, V., & Shyma, K. P. (2015). Role of parasitic vaccines in integrated control of parasitic diseases in livestock. *Veterinary World*, 8(5), 590–598.

- Tajik, J., Mirshahi, A., Razmi, G., & Mohammadi, G. (2010). A Survey of helminth infection of Turkmen horses in Jargalan region, North Khorasan. *Veterinary Research*, 2(87), 53–56.
- Taktaz Hafshejani, T., Nekoei, S., Vazirian, B., Doosti, A., Khamesipour, F., & Umunna, A. M. (2015). Molecular detection of equine herpesvirus types 1 and 4 infection in healthy horses in Isfahan central and Shahrekord Southwest Regions, Iran. *BioMed Research International*, 2015, 1–7. <https://doi.org/10.1155/2015/917854>
- Tavalla, M., Sabaghan, M., Abdizadeh, R., Khademvatan, S., Rafiei, A., & Piranshahi, A. R. (2015). Seroprevalence of *Toxoplasma gondii* and *Neospora spp.* Infections in Arab Horses, Southwest of Iran, Jundishapur. *Journal of Microbiology*, 8(3), e14939.
- Tavassoli, M., & Bakht, M. (2012). *Gastrophilus spp.* myiasis in Iranian equine. *Scientia Parasitologica*, 13(2), 83–86.
- Tavassoli, M., Sodagar-Skandarabadi, M., & Soltanalinejad, F. (2007). A survey on cryptosporidial infection in horse in Urmia area, north-western Iran. *Iranian Journal of Veterinary Research*, 8, 18.
- Tavassoli, M., Yamchi, J. A., & Hajipour, N. (2016). A survey on the prevalence of strongyles species in working donkeys in North-West of Iran. *Journal of Parasitic Diseases*, 40(4), 1210–1212.
- Taylor, M. A., Coop, R. L., & Wall, R. L. (2007). *Veterinary parasitology*. London: Wiley-Blackwell.
- Trawford, A., & Getachew, M. (2008). Parasites. In J. Duncan, & D. Hadrill (Eds.), *The professional handbook of the donkey* (4th ed., pp. 82–101). Yatesbury, Wiltshire, UK: Whittet Books Limited, South House.
- Valdez-Cruz, M. P., Hernandez-Gil, M., Galindo-Rodriguez, L., & Alonso-Diza, M. A. (2006). Gastrointestinal parasite burden, body condition and haematological values in equines in the humid tropical areas of Mexico. In R. A. Pearson, C. J. Muir, & M. Farrow (Eds.), *Proceedings of the 5th international colloquium on working equines. The future for working equines*. Ethiopia: Addis Ababa.
- Yagoob, G. (2011). Seroepidemiology of *Neospora sp.*, in horses in East Azerbaijan Province of Iran. *Research Journal of Biological Sciences*, 6(5), 224–226.

How to cite this article: Khamesipour F, Taktaz-Hafshejani T, Tebit KE, Razavi SM, Hosseini SR. Prevalence of endo- and ecto-parasites of equines in Iran: A systematic review. *Vet Med Sci*. 2021;7:25–34. <https://doi.org/10.1002/vms3.321>