

Parasitology Review Article

Review of *Dirofilaria* spp. infection in humans and animals in Iran

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ABSTRACT

Dirofilariasis is a metazooses transmitted by certain mosquito genera (*Culicidae: Diptera*). Chiefly canids are the reservoirs of *Dirofilaria* spp. This article analyzed all published records and researches relevant to *Dirofilaria* in Iran, to provide a basis for future studies in Iran and around the world. All of the important data from human and animal cases that included the pathogen and its reservoir, dispersion, and retrospective studies were investigated and analyzed. Furthermore, the natural history of parasites, pathogenicity, diagnosis, treatment, control, and the final status of the disease in the world was briefly mentioned. Two species of the genus *Dirofilaria*, *Dirofilaria immitis* (canine heartworm) and *Dirofilaria repens*, are detected in Iran. Till now, 13 human cases have been formally reported including seven subcutaneous and three ocular cases of *D. repens*, a four cases of *D. immitis*, including a rare case in testicular hydrocele, one ocular and one pre-ocular, a subconjunctival and two pulmonary cases suspected to be *D. immitis*. Animal and human infections have been recorded in 11 provinces of Iran. Different investigators have reported *D. immitis* in dogs (with the frequency of 0.95–62.8%), jackals (2.5–57.4%), foxes (5.7–50%), wolves (20–50%), and cats (0.8%) and *D. repens* in dogs (1.4–60.8%) and jackals (10%) in different areas of the country. The reports on *Dirofilaria* in Iran are to some extent scattered as regarded to distribution and other features of the disease. More studies should be taken in dirofilariasis in Iran, specifically in regions from where there are no reports.

Keywords: *Dirofilaria*, *Dirofilaria immitis*, *Dirofilaria repens*, Nematoda, Iran

INTRODUCTION

Dirofilariasis or dirofilariosis is transmitted by mosquitoes (*Culicidae: Diptera*) and it is a metazoanotic disease.^[1] Mostly canids are primary hosts to *Dirofilaria* spp. and they act as the reservoirs. This *Dirofilarinae* subfamily contains 10 genera, of which one is a pathogen for reptilians, one for aves, and the others are mammalian pathogens. Most species of *Dirofilaria* are transmitted by mosquitoes, while *Dirofilaria ursi* found in the brown bears is transmitted by the flies of family Simuliidae.^[2,3]

The genus *Dirofilaria* has at least 27 species in two subgenera which infect 111 mammalian species. Of these, two species of *Dirofilaria* are more important in human and veterinary medicine. The *Dirofilaria* subgenus includes *Dirofilaria immitis* (canine heartworm) and *Noctiella* subgenera *Dirofilaria repens*.^[3,4]

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Dirofilariosis, which is caused by *D. immitis*, has been reported from almost every tropical, subtropical, and temperate region of the world. It is more prevalent in North America, South America, Australia, Japan, and Italy.^[3,5] *D. immitis* is a nematode and its microfilaria is $258 \pm 7 \mu\text{m}$ long, infectious L₃ larva is $0/75\text{--}1/3 \mu\text{m}$ long, and the mature worm is about 250–300mm. Its reservoirs are dogs and other members of Canidae such as wolf, fox, jackal, dingo (Australian wild dog), coyote (North American desert wolf), and occasionally other mammals such as the domestic cats, bear, seal, deer, panda, horse, rabbit, and primates such as the orangutan.^[2,3]

D. repens has been reported from 36 countries around the world. Italy is one of the most important focuses of this disease.^[3,4] The microfilaria of *D. repens* is $290 \pm 20 \mu\text{m}$ long, infectious L₃ larva is $0/64\text{--}1/08 \text{ mm}$ long,^[2,3] and the mature worm is about $100\text{--}170 \times 0/4\text{--}0/7 \text{ mm}$.^[3,6] Mostly dogs are reservoirs of this species but in some cases, it was isolated from cat, lion, and fox. Humans are usually infected with *Dirofilaria* by accident and the parasite life cycle cannot be completed in human. A species that was named *Dirofilaria conjunctiva* previously is a synonym of *D. repens*.^[3,6]

More than 77 mosquito species of *Culex*, *Ochlerotatus*, *Anopheles*, *Aedes*, *Coquillettidia*, *Mansonia*, *Psorophora* genera, and probably *Culiseta* are known to play the role as the intermediate host.^[3,4,7,8] and are vectors especially for canine heartworm causing agent *D. immitis*. Around 20 mosquito species are vectors and intermediate hosts of *D. repens*.^[3,9] In recent years, due to people traveling to non-endemic regions and moving disease reservoirs to non-endemic areas, case reports show an alarmingly growing trend. The reported cases around the world are usually much less than real human and animal infection cases.^[3,10] Therefore, this disease is classified as an emerging zoonotic disease.^[3,4]

It has been more than 36 years since the first dirofilariosis case was reported from Iran^[3,11] and the World Health Organization in 1984 identified Iran as an infected region.^[3] During years until 2020, lots of studies have been conducted and numerous animal and human cases have been reported.

In this review, we tried to survey any previous researches, reports, and information related to human and animal cases in Iran retrospectively. Variables including parasite species, animal host, dissemination, infection percentage, and human cases extracted and processed. Furthermore, the parasite life cycle, pathogenesis, diagnosis, treatment, and control are briefly reviewed.

MATERIAL AND METHODS

In this study, the information obtained from the search databases of Scientific Information Database, Irandoc,

Civilica, Magiran, Scopus, PubMed, and Google Scholar were used. Through advanced search, it was possible to search for articles with the keywords “Iran” and “*Dirofilaria*.” Furthermore, the presence of the word *Dirofilaria* was included in the title of the mandatory search settings, and the search was performed by considering the year of publication as the next filter. For example, in the Scopus database, the latest information in this field is related to a case report from the south-eastern of Iran.^[12] Furthermore, by reviewing the search databases of Irandoc, Civilica, and Google Scholar, it was possible to include thesis, books, and abstracts of articles published in national and international congresses in the field of this study. By researching in these databases, important information about dirofilariosis in Iran was obtained and analyzed by comparison of interprovincial, intercity, and interspecies types in the following and presenting the latest status of the disease in the world was briefly mentioned.

RESULTS

Evolution of the parasite

Career mosquitoes receive microfilaria of *Dirofilaria* while blood feeding from peripheral blood containing the microfilaria of reservoirs. The worm grows and develops in the Malpighian tubules of the mosquito. This is the distinguishing feature of the genus *Dirofilaria* from others because the others often grow and develop in the flight muscle in chest or fat body cells of mosquito intermediate hosts. After about 2 or 3 weeks (according to environmental factors, especially temperature and mosquito genus), extrinsic incubation period has been passed and infective third-stage larva appears and migrates to the head and proboscis of the mosquito and while blood feeding, by perforating the lower lip proboscis, infects the next host through the created break or by actively perforating the skin. Forth stage larva, adult worms (male and female), and eggs are found in the body of the vertebrate host. The female worm is ovoviviparous. It takes about 7–9 months to observe an adult worm in the pulmonary artery and heart and microfilaria in peripheral blood in an infected dog. The worm life cycle is about 7 years and the reproduction period is 2–5 years in the body of a dog. *D. repens* genus life cycle is very similar to *D. immitis*.^[1–3] Microfilaria of *D. immitis* shows subperiods and this was examined in dog's blood samples in Tehran^[13,14] and Tabriz^[15,16] and Golestan.^[3,17]

Pathogenesis

Microfilariae have not been observed in peripheral blood of humans and the adult stage is observed 6 months after infection with third-stage larva. Infertile adult and immature *D. immitis* genus stages have been observed in pulmonary artery and lungs, and in one case, fertile female has been

observed in the lungs of a man with lymphoid leukemia. About 65% of pulmonary infection is asymptomatic. Furthermore, cough, chest pain, fever, and inquietude are the symptoms of this disease. *D. repens* is usually found as painful subcutaneous nodules around or inside the eyes, male genital system, and rarely in lungs. The mature form has also been found in the chest. The subcutaneous nodules are caused by host defensive reactions and they might be soft or hard. These nodules may be painful on palpation or pressure [Figure 1]. Eye infection causes redness, epiphora, blepharitis, pain, and itching. The best and safest way to diagnose infection in humans is to bring out the nodules and study on morphological properties of the worm.^[3,4,6] The life cycle of *D. immitis* and *D. repens* shown in [Figures 1 and 2], respectively.^[18,19]

Diagnosis

Clinical signs of dirofilariasis are variable in dogs and include asymptomatic stage to mild symptoms such as cough, immobility, premature fatigue, and severe symptoms such as anemia, cardiac complications, and death. Blood tests by modified Knott's method, serological tests as ELISA and IFA, and molecular methods (PCR) can detect disease and infected dogs.^[3,4] Farzaneh has reviewed clinical aspects of dirofilariasis in dogs in 1991^[3,20] and Rafii has studied it on practical clinical aspects in 1996.^[3,21] In 2012, Tabrizi

stated that cases with dirofilariasis have a higher level of total bilirubin, alkaline phosphatase, and indirect bilirubin in comparison with non-infected cases that show that *Dirofilaria* can cause side effects on the liver, bile duct, and red blood cells.^[22] Mahdizadeatar has referred to complications and symptoms of the disease, its diagnosis and treatment methods in 1991 and 1992.^[3,23,24] Vahedi (1997) has reviewed various dirofilariasis diagnosis methods in humans and dogs.^[3,25] Eslami *et al.* (2003) referred to the symptoms and treatment of the disease.^[3,26] Ranjbar-Bahadori and Eslami (2005) compared two methods of diagnosing dirofilariasis, namely, modified Knott's and ELISA in dogs in Golestan Province.^[3,17] A study by Sharifdini (2012) discovered that the infection rate of *D. immitis* in dogs more than 2 years old is higher than others in Meshkinshahr, Iran.^[27] Jalali *et al.* (2016) recognized the outbreak of *D. immitis* by counter-immunoelectrophoresis besides modified Knott's method in 2013.^[28] Zarei *et al.* accomplished the molecular method based on cytochrome oxidase subunit 1 gene to find out the prevalence of dirofilariasis.^[29] Ranjbar-Bahadori *et al.* (2007) compared the specificity and sensitivity of two diagnostic methods of *D. immitis* (modified Knott's, Antigen Detecting Test Kit), and the McNemar (a statistical test used on paired nominal data) test showed that although the sensitivity of the second one was higher, differences were not significant ($P > 0.05$).^[30] Either in comparison of ELISA and immune complex disease (ICD) method, they stated that the ICD

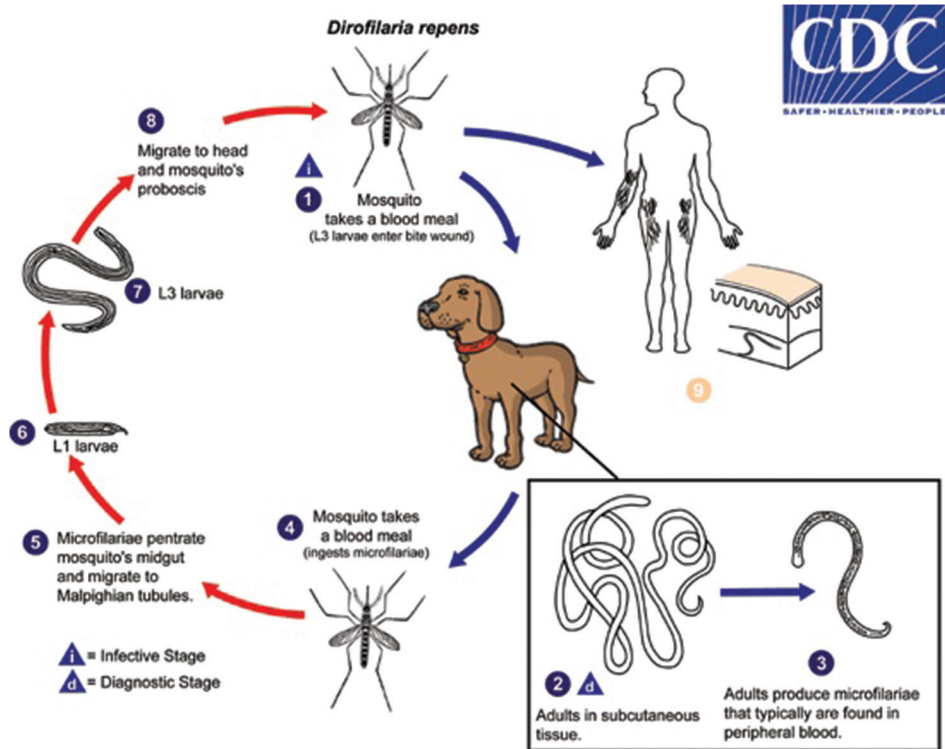


Figure 1: *Dirofilaria repens* life cycle.^[19] https://www.cdc.gov/parasite/WWWs/dirofilariasis/biology_d_repens.html

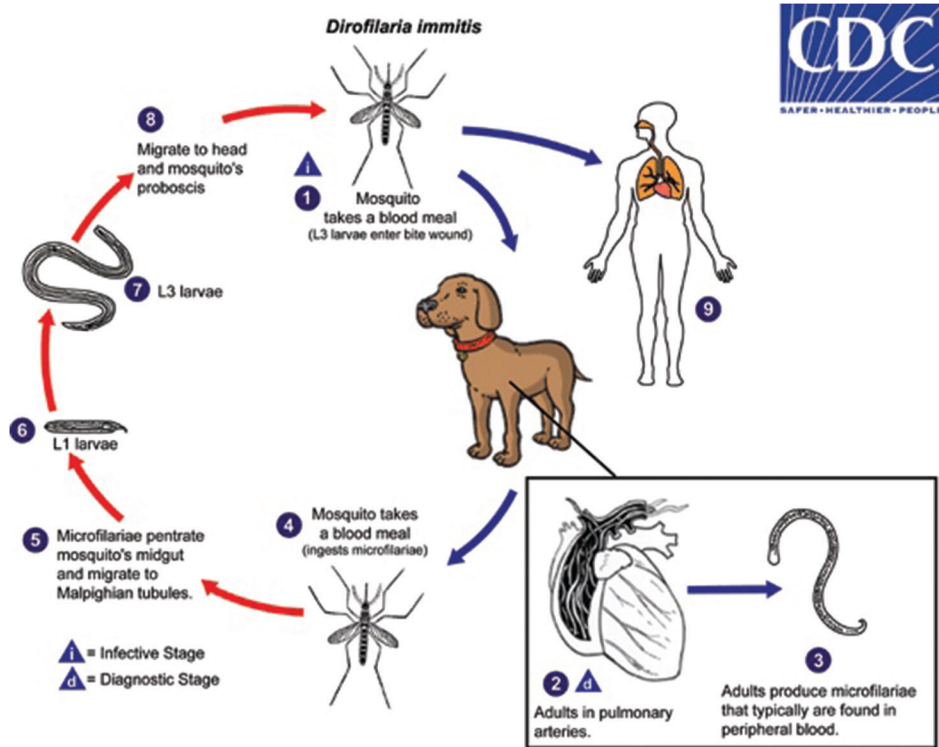


Figure 2: *Dirofilaria immitis* life cycle.^[18] https://www.cdc.gov/parasites/dirofilariasis/biology_d_immitis.html

method is not recommended for the beginning of diagnosis, it may be a valuable secondary way for detecting dirofilariasis in dogs.^[31]

Treatment

The most practical human treatment is the surgical removal of a nodule with a nematode, and chemotherapy is not recommended, since the worm is often dead inside the nodule, and no microfilaria is found in the human peripheral blood. In dogs, thiacetarsamide or melarsomine and ivermectin, milbemycin oxime, or levamisole are used as a filaricide and a microfilaricide respectively.^[3,4,64] In Iran, melarsomine in 2.5 mg/kg and ivermectin in 0.05 mg/kg have been used successfully in the treatment of dirofilariasis in cats.^[3,48]

Control

Control and reduction of human dirofilariasis (HD) depend on the reduction of the infection of its reservoir hosts. Infected dogs should be treated with nematicides after accurate diagnosis. In endemic areas of the disease, treatment of all infected reservoirs (domestic and wild) should be on the agenda. Furthermore, chemoprophylaxis (using drugs for prevention) with the use of ivermectin should be used. It is important to inform and create awareness among dog owners about ways of transmission and preventing it. Reducing the

population of mosquitoes and their larvae and personal protection of individuals and dogs against mosquito bites is effective in reducing human and animal infection.^[3,4]

HD in Iran

Among the human cases of the disease, we can mention one case of eye infection of *D. repens* in Tehran,^[3] one case in Mazandaran,^[32] two cases of subcutaneous infection in Bandar Anzali and Lahijan,^[33] and one case in Karaj (Tehran Province).^[3,34] One rare case of testicular hydrocele infection with *D. immitis* in Bandar Abbas (Hormozgan Province)^[35] and a subcutaneous dirofilariasis case of an Iranian man who traveled to Belgium have been reported.^[36] Two pulmonary cases (probably *D. immitis*) based on the observation of coin lesion on radiography and also several cases of subcutaneous dirofilariasis from Ardebil Province have been reported.^[37] There was an unreported eye infection of *D. immitis* from Gonbad (Mobedi, personal communication).^[3] Maraghi *et al.* (2006) reported three cases of human infection with the *D. repens* in Ahvaz, two of which were diagnosed as subcutaneous nodules and the last, as an eye infection.^[38] Tavakolizadeh and Mobedi (2009) presented the first report of ocular dirofilariasis in Tehran, by adult female *D. repens* worm in 2009.^[39] Parsa *et al.* reported ocular infection with *D. immitis* by the molecular characterization method in Kerman in 2020.^[12] Ashrafi *et*

al., 2010, reported a subcutaneous nodule of *D. immitis* in Gilan that was suspected as cutaneous fascioliasis.^[40] A paranasal subcutaneous nodule of *D. repens* was reported in Ahvaz from a 31-year-old man.^[41] Tabatabaei et al. (2017), a case with the sub-conjunctival presence of *D. immitis* was detected in Tabriz.^[42] Maraghi, 2019, discovered breast dirofilariasis with *D. repens* in a 40-year-old woman resident of Khuzestan.^[43] Furthermore, Mirahmadi et al. (2017) reported ocular dirofilariasis by *D. immitis* in a 2-year-old child in Chabahar city located at Sistan and Baluchestan Province.^[44] Negahban et al. (2007) presented a case with a subcutaneous nodule of *D. immitis* in Shiraz that was obtained with the fine needle aspiration method.^[45] Tafti et al. (2010) discovered an ocular dirofilariasis by *D. repens* in Tehran.^[46] *Dirofilaria* prevalence in human in Iran reported summarized in [Table 1].

Animal dirofilariasis in Iran

In Iran, animal dirofilariasis has been reported in dogs, jackals, foxes, wolves, and cats. *D. immitis* has been detected in all the animals above. However, *D. repens* was only found in dogs and jackals [Table 1].

The prevalence of *D. immitis* in a global study shows (11.45%) a total weighted prevalence in Iran.^[47]

The first natural infection in stray dogs with *D. immitis* and *D. repens* in the country was reported in 1969 in Mazandaran Province, Tonekabon (former Shahsavari).^[11] In that year, infection with *D. immitis* was seen in a domestic dog imported to Iran from the United States.^[50] Darijani et al.

(2009) presented the first report of *Dirofilaria* in domestic dogs in Kerman.^[51] For the 1st time, the animal epidemic form of dirofilariasis infection in dogs was reported in the western villages of Meshginshahr, Iran city with 26.7% infection.^[3,52] Alborzi et al. (2010) reported a domestic short hair cat, 2.5 years old in Ahvaz, Iran, with *D. immitis* infection.^[53] In a study, the prevalence of *D. immitis* evaluated with modified Knott’s and immunochromatography was 10% and 11.7%, respectively.^[54]

Various researchers from Fars, Khuzestan, Ardebil, Tehran, West Azerbaijan, East Azerbaijan, Golestan, Garmsar, Gilan, Kerman, Kermanshah, Chaharmahal-Bakhtiari, Sistan and Baluchestan, Hamedan, and Mazandaran Province have reported infections in dogs with *D. immitis* with the frequency of 0.95–62.8% and in Tehran, Khorasan Razavi, Mazandaran infection with *D. repens* was reported 1.4–60.8% [Table 2].

In 2004, Moulavi reviewed the micro-anatomy of parasites including *D. immitis* and *D. repens* in Iran.^[3,55] In 2005, Lee and Wong introduced a new species *Dirofilaria* that the infected dog had lived in Germany and Iran before settling in the United States and being diagnosed, making it possible for it to become infected in Iran.^[3,56]

Furthermore, in 1974, Javadian and Macdonald investigated the effect of *D. repens* species infection on *Stegomyia aegypti* (*Aedes aegypti*) mosquito egg production. Thus, one feeding from an infected dog statistically, significantly reduced egg production compared to mosquitoes fed from the blood of an uninfected dog.^[3,57] So far, the species *D. immitis* has

Table 1: Prevalence of *Dirofilaria* in human and animals in Iran.

Province	<i>Dirofilaria immitis</i>	<i>Dirofilaria repens</i>	Human infection	Animal infection	References
Ardebil	+	+	+	Dog, cat, fox, jackal	[3,29,49,52,58,59,65,66,67,68]
Chaharmahal-Bakhtiari	+	-	-	Dog	[69]
East Azerbaijan	+	-	+	Dog, fox, jackal, wolf, cat	[3,42,48,49,58,59,70-77]
Fars	+	+	+	Dog	[3,43,45,76-80]
Gilan	+	+	+	Dog, jackal	[33,40,59,81-84]
Golestan	+	-	+x	Dog, jackal	[17,58,59,81-83,85]
Hamedan	+	-	-	Dog	[86]
Hormozgan	+	-	+	Jackal	[3,35,59,87-89]
Kerman	+	-	+	Dog	[12,51,90-92]
Kermanshah	+	-	-	Dog	[93]
Khorasan Razavi	+	+	-	Dog	[3,94-96]
Khuzestan	+	+	+	Dog, cat, jackal, fox	[3,38,41,43,54,58,59,97-104]
Mazandaran	+	+	+	Dog, jackal	[3,11,32,58,59,81-84,105,106]
Qazvin	+	-	-	Dog	[84]
Semnan	+	-	-	Dog	[107,108]
Sistan and Baluchestan	+	-	+	Dog	[44,91,109,110]
Tehran	+	+	+	Dog	[3,36,39,50,82,111,112,114]
West Azerbaijan	+	-	-	Dog, jackal	[3,59,115,117]

Table 2: Prevalence of *Dirofilaria* among dogs in Iran.

Species	Province	Location	Infection rate (%)	References		
<i>Dirofilaria immitis</i>	Ardebil	Meshkinshahr	20.87	[29]		
			62.80	[65]		
			7.90	[3,52,118-120]		
			36.80	[3,52,118-120]		
			23.07	[68]		
			Chaharmahal and Bakhtiari East Azerbaijan	Shahrekord (Jolfa, Kaleybar) Marand	1.49	[69]
					21.20	[71]
					15.90	[71]
					18.02	[121]
					13.50	[73]
	30	[74]				
	11.60	[70,121]				
	20.02	[71]				
	8.40	[3,122]				
	31.60	[3,123]				
	Fars	Shiraz	15	[75]		
			14	[76]		
			14.70	[3,49]		
			30	[3,67]		
			0.95	[3,80]		
			9.60	[3,78]		
			Gilan	Gilan	51.42	[81,82]
					4.41	[83]
			Golestan	Golestan	15.38	[81,82]
					14.55	[3,17]
	18.18	[3,17]				
	3.94	[83]				
	15.45	[85]				
	Hamedan	Hamedan	19.27	[86]		
			2	[51]		
	Kerman	Kerman	5.40	[90]		
			5	[92]		
	Kermanshah	Kermanshah	15.15	[91]		
18.30			[93]			
Khuzestan	Ahvaz	12.61	[100]			
		5	[97]			
		8	[99]			
		8.70	[3,102]			
		10, 11.7	[54]			
Mazandaran	Sari Tonekabon	6	[105]			
		7.69	[81,82]			
		4	[3,11]			
		5.37	[83]			
		15	[106]			
Semnan	Garmsar	12.29	[107]			
		5.20	[108]			
Sistan and Baluchestan	Zabol	27.50	[91]			
		3	[82]			
Tehran	Tehran	2.30	[111]			
		1.40	[3,124]			
		25	[116]			
		West Azerbaijan	(Targavar, Margavar, Kolshin, and Hovarchin) Uromie	3	[115]	
				4	[3,115]	

(Contd...)

Table 2: (Continued)

Species	Province	Location	Infection rate (%)	References
<i>Dirofilaria repens</i>	Ardebil	Meshkinshahr	3.84	[68]
	Khorasan	Mashhad	6.40	[3,96]
	Razavi		6.50	[3,95]
	Mazandaran	Tonekabon	60.80	[3,11]
	Tehran	Tehran	26	[111]
			1.40	[3,113]

Table 3: Infection rate of *Dirofilaria* among jackals in Iran

Species	Province (location)	Infection rate (%)	References
<i>Dirofilaria immitis</i>	East Azerbaijan	20, 57.1	[3,49,58,67]
		57.4, 28	[77]
	Khuzestan	11.1	[3,58]
		28.5	[3,102]
	Golestan	12.5	[3,58]
	Mazandaran	10	[3,58]
	North Khorasan	8.9	[125]
	Zone 1*	3.8	[59]
	Zone 2**	2.5	[59]
	Zone 3***	5%	[59]
11 Provinces****	7.5	[3,58]	
<i>Dirofilaria repens</i>	Mazandaran (Tonekabon)	10	[3,11]

*Gilan, Mazandaran, and Golestan, **West Azerbaijan, East Azerbaijan, Ardebil, Markazi, and Esfahan, ***Khuzestan and Hormozgan, ****infected cases were in East Azerbaijan, Khuzestan, Golestan, and Mazandaran

been isolated in cats only once from Tabriz. From 234 cats, microfilaria was obtained in two cases (0/8%) of peripheral blood.^[48] There are two official reports about identifying *D. immitis* in wolves in East Azerbaijan. The first was a reported infection of one out of five wolves (20%)^[49] and the other was infection of one out of two.^[3]

The first report of jackal infection to *D. repens* (10%) was in Mazandaran Province.^[3,11] Jackal infection to *D. immitis* was reported from 2.5% to 57.4% in East Azerbaijan, Ardabil, Khuzestan, Golestan, and Mazandaran Provinces by different researchers [Table 3], but in 2003, the infection rate reported by Meshgi *et al.* in 11 provinces was 7.5% in total, that in East Azerbaijan, Khuzestan, Golestan, and Mazandaran Provinces, five out of 66 trapped jackals were infected.^[3,58] Meshgi evaluated the prevalence of *D. immitis* in jackals and foxes in three areas of Iran. The infection rate in the first zone consisting of Gilan, Mazandaran, and Golestan was 3.8%. That of the second one (Zone 2, West Azerbaijan, East Azerbaijan, Ardebil, Markazi, and Esfahan) was 2.5% and the last one (Zone 3, Khuzestan and Hormozgan) was 5%.^[59]

Infection of foxes with *D. immitis* has been recorded from East Azerbaijan, Ardabil, and Khuzestan Provinces by different researchers with an abundance of 5.7%–50% [Table 4], but in 2003, Meshgi *et al.* reported the rate of infection in six

provinces as 9% in total so that two out of a total of 22 foxes caught in East Azerbaijan and Khuzestan Provinces were infected. They also mentioned an 8.9% infection of the total number of caught wild carnivores, including foxes, jackals, and wolves to *D. immitis*. Furthermore, Meshgi reported a rate of 8.1% in West Azerbaijan, East Azerbaijan, Ardebil, Markazi, and Esfahan for foxes infected to *D. immitis*. In the country, the species *D. repens* has not been isolated from foxes so far.^[3,58]

Dirofilaria infection in Iran

Dissemination of dirofilariasis in Iran: In total, human and animal *Dirofilaria* infection is reported from eighteen provinces of Iran. *D. immitis* species has been observed in all of the provinces of the country. In West Azerbaijan, Semnan, Khorasan Razavi, Kermanshah, Hamedan, Qazvin, and Chaharmahal-Bakhtiari Provinces, only animal infection has been reported. In Ardabil, Golestan, Gilan, Kerman, Khuzestan, East Azerbaijan, Fars, Hormozgan, Sistan and Balochistan, Mazandaran, and Tehran, both human and animal infections of this species have been reported. *D. repens* species was reported in five provinces. While in Khorasan Razavi Province, only animal infection was documented, in Tehran, Mazandaran, Khuzestan, Fars, Ardebil, and Gilan Provinces, both human and animal infections have been found [Table 1].

Table 4: Infection rate of *Dirofilaria* among foxes in Iran.

Province	Infection rate%	Reference
East Azerbaijan	5.7–11.1 13.3	[3,49,58,67] [77]
Khuzestan	50	[3,58,102]
6 Provinces*	9	[3,58]
Zone 2**	8.1	[59]

*Infected cases were in East Azerbaijan and Khuzestan. **West Azerbaijan, East Azerbaijan, Ardebil, Markazi, and Esfahan

According to [Table 1], in the seven provinces of Tehran, Gilan, Khuzestan, Fars, Ardebil, Khorasan Razavi, and Mazandaran, human or animal infection to both species of *D. immitis* and *D. repens* has been reported. Although in two other independent studies, neither of these two species were found in carnivores of Mazandaran Province.^[3,60,61] Given that Ardabil (Meshginshahr)^[3,37,52,55,62] and East Azerbaijan (Tabriz)^[3,15,16,63] were introduced as two zoonotic centers of dirofilariasis (*D. immitis*), human cases were presented from both and but no cases of *D. repens* species were found in East Azerbaijan. None of the provinces reported human infection alone with *D. immitis*. It is worth mentioning that none of the two species of *Dirofilaria* were previously found in carnivores of Gilan Province.^[3,60]

DISCUSSION

Due to the increase in human cases and also the higher prevalence of this disease in the northern regions of the country, human coexistence with animals is an important factor. In this regard, periodic attention to parasite testing and the use of antiparasitic drugs prescribed to animals should be taken seriously. The results indicate an increase in the incidence of *D. repens*, as well as an increase in conflict areas in more recent studies, which is more pronounced, especially in areas where health is not pursued more seriously. Furthermore, the number of cases of wild carnivores indicates the spread of this disease in this species of animals throughout the country, which is an important factor in the transmission in companion and domestic animals. Thus, attention to ecological measures in this regard is very important. It seems that in some parts of Iran which have been cleared of malaria or it has been controlled, dirofilariasis is one of the most important diseases transmitted by mosquitoes. However, there is no codified surveillance program for this disease, in the health and veterinary networks of the country. Due to the increasing trend of human reported cases of dirofilariasis in recent years, more attention from physicians and laboratory scientists to clinical symptoms of this disease is needed, especially in the centers of the disease or areas with significant animal infection. Most of the reports related to dirofilariasis in Iran were in terms of parasitology and isolation of parasites from animal reservoirs. Therefore, it is

necessary to study this disease in other parts of the country that has not been researched. The presence of stray dogs and other carnivores as reservoirs, the increasing phenomenon of keeping dogs and cats as pets in cities in recent years, the use of dogs in police forces to detect crimes and in Red Crescent organizations for the occurrence of emergencies, and the role of herding dogs in the agricultural economy of rural areas, demand more attention from health and veterinary authorities in the country to dogs and their common diseases with humans, especially dirofilariasis. There is no entomological information available about the carriers of this disease in Iran.

CONCLUSION

Statistical reports indicate the incidence of this infection in animal and human in 11 provinces of Iran. Conflict with *D. immitis* were in dogs ranged from 0.95 to 62.8%, jackals (2.5–57.4%), foxes (5.7–50%), wolves (20–50%), and cats (0.8%) in different researches. These reports have been reported for *D. repens* in dogs and jackals (1.4–60.8%) and (10%) in different regions, respectively. Reports of dirofilaria in Iran are scattered and with different pathogenic characteristics, which highlights the importance of further studies on dirofilariasis in Iran, especially in areas where there is no research history.

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Declaration of patient consent

Patient’s consent not required as patients identity is not disclosed or compromised.

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Conflicts of interest

There are no conflicts of interest.

REFERENCES

- Ashford RW. Current usage of nomenclature for parasitic diseases, with special reference to those involving arthropods. *Med Vet Entomol* 2001;15:121-5.
- Anderson RC. *Nematode Parasites of Vertebrates: Their Development and Transmission*. Wallingford, United Kingdom: CABI; 2000.

3. Azari-Hamidian SH, Yaghoobi-Ershadi MR, Javadian E, Mobedi I, Abai MR. Review of dirofilariasis in Iran. *J Med Fac Guilan Univ Med Sci* 2006;15:102-13.
4. Howell PG. The encyclopedia of arthropod-transmitted infections. *J S Afr Vet Assoc* 2003;74:143-50.
5. Venco K. Heartworm Disease in Dogs and Cats. IX Eur Multicolloquium Parasitol Val Spain; 2004. p. 398.
6. Muller R. Worms and Human Disease. 2nd ed. Wallingford: CABI Publishing; 2002.
7. Konishi E. Susceptibility of aedes albopictus and culex tritaeniorhynchus (Diptera: Culicidae) collected in Miki city, Japan, to *Dirofilaria immitis* (Spirurida: Filariidae). *J Med Entomol* 1989;26:420-4.
8. Maslov AV, Ward RA, Rao PM. Blood-Sucking Mosquitoes of the Subtribe Culisetina (Diptera, Culicidae) in World Fauna. United States: Citeseer; 1989.
9. Varodi E, Kuzmin Y, Vasylyk N, Kononko G, Kuz L, Yu M, et al. Experimental infection of mosquitoes with *Dirofilaria repens* (Nematoda, Filarioidea) larvae. *Vestn Zool* 2005;132:595-771.
10. Simon F, Lopez-Belmonte J. Human Dirofilariasis: Past Studies, Current Approches. IX European Multicolloquium of Parasitology, Valencia, Spain; 2004. p. 399.
11. Sadighian A. Helminth parasites of stray dogs and jackals in Shahrivar area, caspian region, Iran. *J Parasitol* 1969;55:372-4.
12. Parsa R, Sedighi A, Sharifi I, Bamorovat M, Nasibi S. Molecular characterization of ocular dirofilariasis: A case report of *Dirofilaria immitis* in South-Eastern Iran. *BMC Infect Dis* 2020;20:520.
13. Eslami A, Meshgi B. Periodicity of *Dirofilaria immitis* in a dog from around in Tehran. In: Abstracts of the Fourth National Congress of Animal-Human Transmissible Diseases; 2000. p. 170.
14. Eslami A, Meshgi B. Periodicity of *Dirofilaria immitis* in a dog from around in Tehran. *J Vet Res* 2000;2:15-8.
15. Meshgi B, Eslami A, Ashrafi Halan J. Periodicity of microfilar *Dirofilaria immitis* in Tabriz dogs. *J Vet Res* 2001;56:115-7.
16. Meshgi B, Eslami A, Ashrafi Halan J. Periodicity of microfilar *Dirofilaria immitis* in dog bloodstream in Tabriz. In: Abstracts of the 3rd National Congress of Medical Parasitology of Iran; 2000. p. 64.
17. Bahadori SR, Eslami A. Comparison of modified knott and ELISA methods for diagnosis of dirofilariasis in dogs in Golestan province and determining of its periodicity. In: The 20th International Conference of the World Association for the Advancement of Veterinary Parasitology, Christchurch, New Zealand; 2005. p. 249.
18. CDC. Life Cycle of *D. immitis*. United States: CDC; 2012.
19. CDC. Life Cycle of *D. repens*. United States: CDC; 2012.
20. Farzaneh N. Evaluation of Dirofilariasis in Dogs. Iran: Tehran University; 1991.
21. Rafii Sm. The first clinical report of *Dirofilaria immitis* heartworm in dogs from Iran. In: Abstracts of the Third National Congress of Human-Animal Transmissible Diseases Mashhad; 1996. p. 253.
22. Tabrizi BA. Evaluation of calcium, phosphorus and alkaline phosphatase in *Dirofilaria immitis* infection in dogs. *World J Zool* 2012;7:79-82.
23. Mahdizadeatar MA. Heartworm disease (*Dirofilaria immitis*). *Sel Knowl Vet Res* 1991;4:41-7.
24. Mahdizadeatar MA. Heartworm disease (*Dirofilaria immitis*). *Sel Knowl Vet Res* 1992;4:1-62.
25. Vahedi A. A review of diagnostic methods for *Dirofilaria immitis* in humans and animals. *Brought Vet Med* 1997;15:18-23.
26. Elsami A, Ashrafi J, Meshghi B. Canine heartworm, clinical presentation and treatment. In: World Small Animal Veterinary Association World Congress Proceedings; 2003.
27. Sharifdini M, et al. *Dirofilaria immitis* and its relationship with gender and age of infected dogs in Meshkinshahr, Ardebil Province, Iran. In: 1st International and 8th National Congress of Parasitology and Parasiticide Disease in Iran; 2012. p. 28.
28. Jalali MH, Ghorbanpoor M, Mosalanezhad B, Avizeh R, Alborzi AR, Rahrowani M. Dignosis OF *Dirofilaria immitis* infection in urban and rural dogs in Ahvaz city by counterimmunoelectrophoresis. *J Vet Res* 2012;69:319-26.
29. Zarei Z, Kia EB, Heidari Z, Mikaeili F, Mohebbali M, Sharifdini M. Age and sex distribution of *Dirofilaria immitis* among dogs in Meshkin-Shahr, Northwest Iran and molecular analysis of the isolates based on COX1 gene. *Vet Res Forum* 2016;7:325-30.
30. Ranjbar-Bahadori S, Eslami A, Bokaic S. Evaluation of different methods for diagnosis of *Dirofilaria immitis*. *Pak J Biol Sci* 2007;10:1938-40.
31. Panarese R, Iatta R, Mendoza-Roldan JA, Szlosek D, Braff J, Liu J, et al. Comparison of diagnostic tools for the detection of *Dirofilaria immitis* infection in dogs. *Pathogens* 2020;9:1-8.
32. Rouhani S, Athari A. Ocular dirofilariasis in Iran: A case report. *Med J Islam Repub Iran* 2003;17:85-6.
33. Siavashi M, Massoud J. Human Cutaneous dirofilariasis in Iran: A report of two cases. *Iran J Med Sci* 1995;20:85-6.
34. Athari A. Zoonotic subcutaneous dirofilariasis in Iran. *Arch Iran Med* 2003;6:63-5.
35. Salahimoghdam A, Mobedi I, Banhashemi S. A case report of *Dirofilaria* in the hydrocele of a 5-year-old child. In: Abstracts of the 3rd National Congress of Medical Parasitology of Iran Sari; 2000. p. 319.
36. Degardin P, Simonart JM. Dirofilariasis, a rare, usually imported dermatosis. *Dermatology* 1996;192:398-9.
37. Mobedi I, Javadian E, Ebaii M. Introducing the zoonotic center of dog heartworm (Nematoda, Filarioidea *Dirofilaria immitis*) in Meshginshahr region (East Azerbaijan province) and its importance in Iran. In: Abstracts of the First National Congress of Parasitic Diseases in Iran Rasht; 1990. p. 78.
38. Maraghi S, Rahdar M, Akbari H, Radmanesh M, Saberi AA. Human dirofilariasis due to *Dirofilaria repens* in Ahvaz-Iran: A report of three cases. *Pak J Med Sci* 2006;22:211-3.
39. Tavakolizadeh S, Mobedi I. Orbital dirofilariasis in Iran: A case report. *Korean J Parasitol* 2009;47:397.
40. Ashrafi K, Golchai JG. Human subcutaneous dirofilariasis due to *Dirofilaria* (Nochtiella) repens: Clinically suspected as cutaneous fascioliasis. *Iran J Public Health* 2010;39:105-6.
41. Radmanesh M, Saberi A, Maraghi S, Emad-Mostowfi N. *Dirofilaria repens*: A dog parasite presenting as a paranasal subcutaneous nodule. *Int J Dermatol* 2006;45:477-8.
42. Tabatabaei SA, Soleimani M, Nikmanesh B, Mahmoudzadeh R, Vahedian Z, Salabati M, et al. Human subconjunctival dirofilariasis presenting as the daytime photophobia: A case report. *Iran J Public Health* 2017;46:1430-4.
43. Maraghi S, Sameri A, Jeddi Y. Human *Dirofilaria repens* infection of the breast: A case report. *Arch Med Lab Sci*

- 2019;1:42-4.
44. Mirahmadi H, Maleki A, Hasanzadeh R, Ahoo MB, Mobedi I, Rostami A. Ocular dirofilariasis by *Dirofilaria immitis* in a child in Iran: A case report and review of the literature. *Parasitol Int* 2017;66:978-81.
 45. Negahban S, Daneshbod Y, Atefi S, Daneshbod K, Sadjjadi SM, Hosseini SV, et al. *Dirofilaria repens* diagnosed by the presence of microfilariae in fine needle aspirates: A case report. *Acta Cytol* 2007;51:567-70.
 46. Tafti MR, Hajilary A, Siatiri H, Rokni MB, Mobedi I, Mowlavi G. Ocular dirofilariasis, a case report. *Iran J Parasitol* 2010;5:64-8.
 47. Anvari D, Narouei E, Daryani A, Sarvi S, Moosazadeh M, Hezarjaribi HZ, et al. The global status of *Dirofilaria immitis* in dogs: A systematic review and meta-analysis based on published articles. *Res Vet Sci* 2020;131:104-16.
 48. Ashrafi Halan J, Eslami A, Meshgi B, Shirani D, Mostoufi S. A study on the prevalence, clinical findings and treatment of feline heartworm disease in Iran. *J Vet Res* 2001;56:21-3.
 49. Razmaraii N, Ebrahimi M, Amaghi A. Report of *Dirofilaria immitis* in wild carnivores in the northern region of East Azerbaijan province. In: Abstracts of the Fourth National Congress of Animal-Human Transmissible Diseases Tehran; 2000. p. 220-1.
 50. Sanjar M, Niak A, Khatibi S. Dirofilariasis in the dog in Iran. *Vet Rec* 1969;85:204.
 51. Darijani N, Akhtardanesh B, Jafari H. Serum prevalence of dirofilariasis in domestic dogs in Kerman. In: First National Congress of Veterinary Laboratory Sciences; 2009.
 52. Ebaii M. Determination of Fauna, Seasonal Activity of Sandflies and Visceral Reservoirs of Visceral Leishmaniasis in Meshginshahr Region. Iran: Tehran University of Medical Sciences and Health Services; 1990.
 53. Alborzi A, Mosallanejad B, Najafabadi MG, Nikpour Z. Report of a case of cat infection with heartworm in Ahvaz city. *J Vet Res* 2010;65:255-7.
 54. Jalali MH, Alborzi AR, Avizeh R, Mosalanezhad B. Survey of prevalence of dirofilariosis in rural dogs in Ahvaz. *Sci Iran Vet J* 2009;5:81-8.
 55. Molavi G. Histopathological Study of Parasitic Worms in Humans and Animals with Emphasis on their Microanatomy. Iran: Medical University Tehran; 2004.
 56. Lee G, Wong M. A new subcutaneous dirofilariid in a dog. In: The 20th International Conference of the World Association for the Advancement of Veterinary Parasitology, Christchurch, New Zealand; 2005. p. 189.
 57. Javadian E, Macdonald WW. The effect of infection with *Brugia pahangi* and *Dirofilaria repens* on the egg-production of *Aedes aegypti*. *Ann Trop Med Parasitol* 1974;68:477-81.
 58. Meshgi B, Eslami A, Kharazianmoghadam M. Prevalence of *Dirofilaria immitis* in wild carnivores in Iran. In: Abstracts of the 13th Iranian Veterinary Congress Tehran; 2003. p. 199.
 59. Meshgi B, Eslami A, Bahonar AR, Kharrazian-Moghadam M, Gerami-Sadeghian A. Prevalence of parasitic infections in the red fox (*Vulpes vulpes*) and golden Jackal (*Canis aureus*) in Iran. *Iran J Vet Res* 2009;10:387-91.
 60. Dalimi A, Mobedi I. Helminth parasites of carnivores in Northern Iran. *Ann Trop Med Parasitol* 1992;86:395-7.
 61. Sadighian A. Helminths of wildcats in the Shahsavari area, Caspian region, Iran. *J Parasitol* 1970;56:270.
 62. Mobedi I, Javadian E, Ebaii M. Introducing the zoonotic center of dog heartworm (Nematode, Filariidae, *Dirofilaria immitis*) in Meshginshahr region. In: Abstracts of the Iranian National Veterinary Student Congress; 1990. p. 65-6.
 63. Meshgi B. Epidemiology of Dirofilariasis Caused by *Dirofilaria immitis* in Tabriz Dogs. Iran: University of Tehran; 2001.
 64. Schrey CF, Trautvetter E. Canine and feline heartworm disease-diagnosis and therapy. *Waltham Focus* 1998;8:23-30.
 65. Khanmohammadi M, Falak R, Meamar AR, Arshadi M, Akhlaghi L, Razmjou E. Molecular detection and phylogenetic analysis of endosymbiont *Wolbachia pipiensis* (Rickettsiales: Anaplasmataceae) isolated from *Dirofilaria immitis* in Northwest of Iran. *J Arthropod Borne Dis* 2019;13:83.
 66. Khodabakhsh M, Malmasi A, Mohebbali M, Zarei Z, Kia EB, Azarm A. Feline dirofilariosis Due to *Dirofilaria immitis* in Meshkin Shahr district, Northwestern Iran. *Iran J Parasitol* 2016;11:269-73.
 67. zarif fard M. Evaluation of Worm Parasites in Carnivores of East Azerbaijan Province with Emphasis on *Echinococcus multilocularis* and their Importance in Public Health. Iran: Medical University of Tehran; 1994.
 68. Jameie F, Dalimi A, Mohammadiha A. Detection of *Dirofilaria immitis* and *Dirofilaria repens* in dogs of Meshkinshahr, Northwest of Iran. In: 9th International Congress of Laboratories and Clinics; 2016. p. 480.
 69. Namjo A, Dehkordi EV, Dehkordi MJ. Prevalence of *Dirofilaria immitis* infection in autopsy stray dogs in Shahrekord city. In: First National Congress of Veterinary Laboratory Sciences; 2009.
 70. Varjoy MH, Helan JA, Salehi N, Bazmani A, Nematollahi A, Baran AI, et al. Molecular detection and epidemiological aspects of *Dirofilaria immitis* in dogs in Tabriz and Suburbs. *J Mazandaran Univ Med Sci* 2015;26:20-31.
 71. Razmaraii N, Eteghad SS, Babaii H, Paykari H, Esmaeilnia K, Frogly L. Molecular survey of canine microfilariae species in East-Azerbaijan province of Iran. *Arch Razi Inst* 2013;68:125-9.
 72. Khanmohammadi M. Seroprevalence of canine *Dirofilaria immitis* in Sarab district. *J Vet Clin Res* 2012;3:109-16.
 73. Khanmohammadi M. *Dirofilaria immitis* occult infection and seroprevalence in sheepdogs in Sarab (East-Azerbaijan province). *J Comp Pathobiol* 2012;8:657-64.
 74. Nematollahi A, Barazandeh MA. A survey on *Dirofilaria immitis* occurrence in stray dogs of Tabriz (Iran). *Acta Vet Brno* 2010;79:449-51.
 75. Farhang HH, Bahavarnia SR, Esmailzadeh MJ, Kamalabad NM. Survey on zoonotic importance and prevalence of *Dirofilaria immitis* infection in dogs of Tabriz, Iran. *Int J Med Parasitol Epidemiol Sci* 2020;1:11-3.
 76. Raouf P, Garedaghi Y. Investigation of infection with *Dirofilaria immitis* parasite in stray dogs in Tabriz city of Iran. *J Livest Sci* 2017;8:38-42.
 77. Razmaraii N, Roodsari AA, Ebrahimi M, Karimi GH. *Dirofilaria immitis* in wild carnivores in East-Azerbaijan province in Iran. *Pajouhesh Va Sazandegi* 2008;21:23-6.
 78. Sadjjadi S, Mehrabani D, Oryan A. Dirofilariosis of stray dogs in Shiraz, Iran. *J Vet Parasitol* 2004;18:181-2.
 79. Mehrabani D, Sadjjadi SM, Oryan A. Prevalence of

- gastrointestinal nematode parasites in stray dogs in Shiraz, Southern Iran. *J Appl Anim Res* 2002;22:157-60.
80. Jafari S, Gaur SN, Khaksar Z. Prevalence of *Dirofilaria immitis* in dogs of Fars province of Iran. *J Appl Anim Res* 1996;9:27-31.
 81. Malmasi A, Hosseini SH, Aramoon M, Bahonar A, Seifi HA. Survey of canine *Dirofilaria immitis* infection in caspian provinces of Iran. *Iran J Vet Res* 2011;12:340-4.
 82. Hosseini S, Malmasi A, Aramon M. Comparison of two diagnostic methods for *Dirofilaria immitis*: Modified Knott test and ELISA. *J Vet Lab Res* 2010;2:87-96.
 83. Ranjbar-Bahadori S, Veshgini A, Shirani D, Eslami A, Mohieddin H, Shemshadi B, et al. Epidemiological aspects of canine dirofilariasis in the North of Iran. *Iran J Parasitol* 2011;6:73-80.
 84. Bagher AM, Hosseini S, Jalousian F, Chegani ZJ, Bakhshiani A. Parasitic infection of stray dogs in Qazvin, Guilan and Mazandaran provinces, Iran. In: 2nd International and 9th National Congress of Parasitology and Parasitic Diseases of Iran (NICOPA); 2015.
 85. Ranjbar-Bahadori S, Eslami A. Prevalence of blood fillers in dogs in Golestan province using the modified Knut method and determining its frequency. *J Vet Res* 2007;62:11-4.
 86. Hoseini M, Jalousian F, Hoseini SH, Sadeghian AG. A cross sectional study on *Dirofilaria immitis* and acanthocheilonema reconditum in sheepdogs in a Western region in Iran. *Vet Res Forum* 2020;11:185-90.
 87. Jamshidi A, Jamshidi M, Mobedi I, Khosroara M. Periocular dirofilariasis in a young woman: A case report. *Korean J Parasitol* 2008;46:265-7.
 88. Ghasemi E, Shamsinia S, Taghipour A, Anvari D, Bahadory S, Shariatzadeh SA, et al. Filarial worms: A systematic review and meta-analysis of diversity in animals from Iran with emphasis on human cases. *Parasitology* 2020;147:909-21.
 89. Salahi-Moghaddam A, Mobedi I, Banihashemi H. Unusual location of *Dirofilaria immitis* in a 5-year-old boy's hydrocele: A case report. *Bimon J Hormozgan Univ Med Sci* 2016;20:231-4.
 90. Bamorovat M, Sharifi I, Harandi MF, Nasibi S, Sadeghi B, Khedri J, et al. Parasitological, serological and molecular study of *Dirofilaria immitis* in domestic dogs, Southeastern Iran. *Iran J Parasitol* 2017;12:260-6.
 91. Khedri J, Radfar MH, Borji H, Azizzadeh M, Akhtardanesh B, Parasitol IJ, et al. Canine heartworm in Southeastern of Iran with review of disease distribution. *Iran J Parasitol* 1970;9:560-7.
 92. Akhtardanesh B, Radfar MH, Voosough D, Darijani N. Seroprevalence of canine heartworm disease in Kerman, Southeastern Iran. *Comp Clin Pathol* 2012;20:573-7.
 93. Bohloli Oskoi S, Sadeghi E, Hashemian AH, Khaligh SG. Study on shepherd dog dirofilariasis in Kermanshah province in 2011-2012. *J Vet Lab Res* 2013;5:47-54.
 94. Heidarifard H. A case report of dirofilariasis in a dog for the first time in Khorasan province, Neishabour city. In: Abstracts of the 3rd National Congress of Veterinary Students of Urmia; 2000. p. 108.
 95. Razmi G. Evaluation of infection of Mashhad dogs with two species of *Dirofilaria immitis* and *Dirofilaria repens*. In: Abstracts of the Fourth National Congress of Animal-Human Transmissible Diseases Tehran; 2000. p. 188.
 96. Razmi G. Investigation of the infection of dogs in Mashhad city with different types of fillers. *J Vet Res* 1999;1:5-7.
 97. Jalali R, Jalali MH, Alborzi A, Avizeh R, Jalali H, Jalali R. A study on *Dirofilaria immitis* in healthy urban dogs from Ahvaz, Iran. *Iran J Vet Res* 2010;11:357-62.
 98. Nikpour Z. Prevalence of *Dirofilaria immitis* in domestic cats in Ahvaz. Iran: Shahid Chamran University; 2010.
 99. RaziJalali MH, Najafabadi MG, Mosallanejad B, Avizeh R, Alborzi A, Rahrovani M. Diagnosis of *Dirofilaria immitis* infection in urban and rural dogs in Ahvaz city by counterimmunoelectrophoresis. *J Vet Res* 2013;68:319-26.
 100. Ranjbar-Bahadori S, Eidi Delvarzadeh M, Shemshadi B. *Dirofilaria immitis* infection in stray dogs of Khuzestan, a province in South-Western Iran. *Int J Vet Res* 2009;3:133-6.
 101. Maraghi S, Naini-Kashani M, Masroupour M, Sameri A, Jeddi Y. Case report ophthalmic dirofilariasis acknowledgment. *Arch Med Lab Sci* 2016;2:36-8.
 102. Farahnak A, Mobedi I, Mohamadi F. Study of zoonotic helminths of carnivores in Khuzestan, Iran. *Iran J Public Health* 1970;27:15-20.
 103. Farahnak A, Mobedi I, Mohammadi F. Investigation of worm parasites of wild carnivores in Khuzestan and their zoonotic role. In: Abstracts of the Third National Congress of Human-Animal Transmissible Diseases Mashhad; 1996. p. 201.
 104. Alborzi A, Mosallanejad B, Najafabadi MG, Nikpoor Z. Infestation of heartworm (*Dirofilaria immitis*) in a cat in Ahvaz city: A case report. *J Vet Res* 2010;65:255-7, 271.
 105. Gholami S, Daryani A, Sharif M, Amouei A, Iraj M. Seroepidemiological survey of helminthic parasites of stray dogs in Sari city, Northern Iran. *Pak J Biol Sci* 2011;14:133-7.
 106. Bahadori SH, Mohtasham RM, Eslami AL, Meshgi B. Study on blood filariasis of dog in Tonekabon. *J Vet Res* 2005;60:353-6.
 107. Bahadori SH, Khah AH. A study on filariasis of stray dogs in Garmsar. *J Vet Res* 2007;62:73-6.
 108. Moazezi H. Evaluation of Infection of Some Blood Parasites In Dogs Referred to the Veterinary Clinic of Semnan University. Iran: Semnan University; 2018.
 109. Mohebi M. Evaluation of *Dirofilaria immitis* Infection in Dogs in Zabol City. Iran: Zabol University-School of Veterinary Medicine; 2016.
 110. Anvari D, Saadati D, Siyadatpanah A, Gholami S. Prevalence of dirofilariasis in shepherd and stray dogs in Iranshahr, Southeast of Iran. *J Parasit Dis* 2019;43:319-23.
 111. Pedram N, Tabrizi AS, Hosseinzadeh S, Pourmontaseri M, Rakhshandehroo E. Prevalence of *Dirofilaria immitis* and *Dirofilaria repens* in outdoor dogs in Tehran province, Iran. *Comp Clin Pathol* 2019;28:1165-9.
 112. Mirzayans A, Zakarian B. The occurrence of *Dirofilaria repens* in dogs in Iran. *Vet Rec* 1970;87:422.
 113. Mirzayans A, Eslami AH, Anwar M, Sanjar M. Gastrointestinal parasites of dogs in Iran. *Trop Anim Health Prod* 1972;4:58-60.
 114. Tafti MR, Hajilary A, Siatiri H, Rokni MB, Mobedi I, Mowlavi G, et al. Ocular dirofilariasis, a case report. *Iran J Parasitol* 2010;5:64-8.
 115. Naghipour M, Javadi S, Tavassoli M, Shamsi S. Serological study of *Dirofilaria immitis* in urban dogs of Urmia using modified knot and rapid antigen tests. *J Zoonotic Dis*

- 2018;3:42-7.
116. Javadi S, Hanifeh M, Tavassoli M, Dalir-Naghadeh B, Khezri A, Hadian M. *Dirrofilariasis* in shepherd dogs of high altitudes areas in West Azerbaijan-Iran. *Vet Res Forum* 2011;2:53-7.
117. Ariamanesh M. Study of infection of stray dogs with *Dirofilaria immitis* in Urmia City. In: Abstracts of the 4th National Congress of Animal and Human Transmissible Diseases in Tehran; 2000. p. 189-90.
118. Fallah E, Onishi A, Nasrin M. Prevalence of dirofilariasis in one of the areas of Meshginshahr and its health importance. In: Abstracts of the 5th National Conference on Parasitic Diseases of Iran; 2005. p. 15.
119. Bokaii S, Mohebal M, Mobedi I, Hosseini S. Investigation of the status of infection of dogs owned by Meshginshahr city to *Dirofilaria immitis*. In: Abstracts of the Third National Congress of Human-Animal Transmissible Diseases Mashhad. 1991. p. 177.
120. Bokaii H, Mobedi I, Mohebal M, Hoseini S, Nadim A. Prevalence of dirofilariasis in dogs in Meshkinshahr, Northwestern Iran. *J Vet Res* 1998;53:23-8.
121. Razmaraii N, Roudsari AA, Khalili I, Hashemzade E. Evaluation of *Dirofilaria immitis* microfiliars in the blood of shepherd dogs in Tabriz and Marand regions using the modified Knott method. In: First National Congress of Veterinary Laboratory Sciences; 2009.
122. Jamali R, Farhang HH. Investigation of infection in stray dogs in Tabriz with *Dirofilaria immitis*. In: Abstracts of the Third National Congress of Human-Animal Transmissible Diseases Mashhad; 1996. p. 179.
123. Meshgi B, Eslami A, Halan JA. Epidemiological study of blood fillers in rural and urban dogs in Tabriz. *J Fac Vet Med Univ Tehran* 2002;57:59-93.
124. Meshgi B, Eslami A. Investigation of filariasis of herding dogs around Tehran. *J Vet Res* 2000;55:53-6.
125. Heidari Z, Kia EB, Arzamani K, Sharifdini M, Mobedi I, Zarei Z, et al. Morphological and molecular identification of *Dirofilaria immitis* from Jackal (*Canis aureus*) in North Khorasan, Northeast Iran. *J Vector Borne Dis* 2015;52:329-33.

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