

Received: 19.06.2018  
Accepted: 10.12.2018  
Published: 07.03.2019

## Dirofilariosis in humans and animals: Two faces of one disease

### Dirofilarioza u ludzi i zwierząt – dwa oblicza jednej choroby

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#### Summary

Today, when animals have become family members, thus bringing a whole spectrum of positive effects on both the mental and physical health of people, the more we must bear in mind the potential hazards arising from such a relationship in order to make possessing companion animals both pleasant and safe. One such threat is undoubtedly dirofilariosis. Dirofilariosis is a parasitic zoonosis caused by the invasion of mosquito-borne nematodes of the genus *Dirofilaria*. Man is an accidental host of the parasite. Although dirofilariosis is considered to be an endemic disease of Mediterranean and US origin, which rarely affects humans, the increasing number of diagnosed cases in animals in Poland may in the near future result in frequent invasion of the parasite also in humans in our country. Frequent animal movements as well as the presence in Poland of mosquitoes capable, as a result of climate change, of carrying the pathogen seem to confirm this thesis. Clinical displays of human parasite invasion are mostly pulmonary, subcutaneous and ocular forms, as well as some others, which occur less frequently. Appropriate prophylaxis in animals, as well as the complex treatment of existing invasion, provides both animals and humans with security and comfort of life.

**Keywords:** dirofilaria • parasitic infections • zoonotic infectious diseases • humans • animals

**GICID:** 01.3001.0013.0842  
**DOI:** 10.5604/01.3001.0013.0842  
**Word count:** 4572  
**Tables:** –  
**Figures:** –  
**References:** 62

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**Abbreviations:** CT – computed tomography, ELISA – enzyme-linked immunosorbent assay, MRI – magnetic resonance, PCR – polymerase chain reaction, PLA2 – A2 phospholipase.

Animals have been companions for humans since time immemorial. Having a companion animals carries both benefits and risks. Today, when the animals have been become family members, thus bringing a whole spectrum of positive effects on both mental and physical health to the man, we must bear in mind the potential hazards arising from such a relationship in order to make possessing companion animals both pleasant and safe. One such threat of recently increasing importance in our geographical area (Central and Eastern Europe) is undoubtedly dirofilariosis. This parasitic disease, caused mainly by *Dirofilaria immitis* and *Dirofilaria repens*, as a zoonotic disease constitutes a real threat to the health of us and our animals. Good knowledge of its symptoms as well as proper diagnosis and treatment seem to be essential in the practice of medical and veterinary physicians.

Dirofilariosis is a parasitic disease resulting from the invasion of mosquito-born larvae of the genus *Dirofilaria*. Among all parasites of filaria, *Dirofilaria immitis* and *Dirofilaria repens* are the most important in Europe for their invasiveness and prevalence. *D. immitis* causes cardio-pulmonary dirofilariosis in dogs and cats, whereas *D. repens* causes a skin form. In addition, both parasites cause pulmonary and dermal/ocular inflammation in humans, who are accidental hosts of the parasite. The parasite can reach maturity within the human body. However, the presence of microfilariae in the blood is rarely observed [49], which is due to the fact that the parasites are usually present individually. Polish veterinary physicians have observed an increase in the frequency of invasive parasites (both species) in dogs and cats, as well as in carnivorous wildlife in our country, which is linked to climate change (which contributes to the survival and development in the vectors of these nematodes). This must result, in the near future, in the increase in the incidence of dirofilariosis also in humans.

Despite the fact that dirofilariosis is a common zoonotic disease, considered to be endemic in southern Europe, the United States, Canada, Mexico, Brazil, Australia, it rarely affects humans. Where there are animal forms of the disease there is a risk of human infection. Individual human cases have been reported in the Czech Republic, Slovakia and Hungary, as well as in Ukraine [19, 26, 42, 44, 48]. According to Simon et al. almost 5,000 cases of *D. repens* infection and over 500 *D. immitis* infections were found in people all over the world. They are above all subcutaneous or ocular forms [55]. Bearing in mind the above, dirofilariosis can be a problem for all people traveling around the world [15].

In Poland, the first case of *D. repens* infection in humans was detected in the Department of General and Parasitology Biology and the Department of Pathological Anatomy of the Medical Academy in Warsaw in 2007. In a histopathological examination of a tumor in the abdominal area of a 25-year-old male, a female *D. repens* nymph was detected [11]. Cielecka et al. reports that in

Poland in 2012 a total of 18 cases of *D. repens* infection in humans were diagnosed [12]. The first indigenous case of *D. immitis* invasion in dogs in Poland was detected in 2012, which was, at the same time, an example of the spread of the parasite endemic areas outside its occurrence [57]. Among the more than 40 species of *Dirofilaria* there are 6 opposite to cause disease to humans these are: *D. immitis*, *D. repens*, *D. striata*, *D. tenuis*, *D. ursi*, and *D. spectans* [27].

## LIFE CYCLE

In the life cycle of *Dirofilaria* spp., mosquitoes are intermediate hosts and vectors, and the vertebrates are the definitive hosts. Both *Dirofilaria immitis* and *Dirofilaria repens* have low specificity for the final host and may, therefore, invade a variety of mammal species. They best adapt to domestic and wild dogs that can become their definitive hosts.

Humans and cats are less suitable hosts for the parasite. There is a significant modification in the development of parasites compared to infection in dogs. Parasites vectors are female of over 60 Culicidae mosquitoes species that produce eggs by feeding on blood [21]. In one mosquito, up to 3 larvae may be present, a greater number results in the death of the intermediate host [7].

While feeding on blood, mosquitoes transmit to the wound hemolymph containing infective larvae L3; these larvae have the ability to penetrate the skin of the host. Transformation from L3 to L4 occurs shortly after infection with *D. immitis*, between 3 and 12 days after invasion, while the next transformation, which forms L5, takes place between 50 and 70 days after the infection. The first immature forms reach the pulmonary artery and the right ventricle of the dog between 70 and 85 days, and reaches full maturity in about 120 days [32].

Adult forms take the form of filaments - a female form reaches a length of 1-1.3 mm and 250-300 mm in diameter, while a male form is 120-200 mm long and 0.7-0.9 mm wide. Females begin to produce the first larvae (microfilariae) between 6 to 9 months after the infection. Mosquitoes become infected with microfilariae L1 from the blood of infected dogs or cats. Larvae remain in the gastrointestinal tract of the mosquito for a short time only and then migrate to the Malpighi coils within 24 to 36 hours [45]. The larvae are then twice lined from L1 to L2 and then from L2 to L3, which lasts about 14-16 days [61]. The total time from transformation from L1 to swallowed L3 is about 2-3 weeks.

*D. repens* larvae, similar to *D. immitis*, enter the final host in the L3 stage, as the mosquito takes blood. In the final host, the larvae undergo two molts and, consequently, as L5 larvae they settle in the subcutaneous tissue, where they develop, mature, and finally, the female begins to produce microfilariae. The length of the development cycle is largely influenced by ambient temper-

ature. The prepatent period is 6-9 months, and adult nematodes survive in typical host tissues up to 4 years. Adults reach a length of 17 cm and a thickness of about 0.5 mm (female are slightly larger than males). It is clear from the evidence that dogs have significant annual and daily differences in the severity of microfilariae (the number of microfilaria in peripheral blood) with the highest peak in August and September, and the highest number of parasite larvae recorded in the evening [14]. The relationship between the intensity of microfilaria and the seasonal appearance of clinical symptoms such as itching, alopecia, and erythema have also been observed [59].

Due to the fact that only the mosquito of the *Culex pipiens* species collects the blood of the cat (and thus may contribute to its infection), it is up to 80% more resistant to dirofilariosis than dogs [38]. In order to infect a cat, more larvae in stage L3 are needed. Significantly fewer larvae develop to adults, which means that the length of the prepatent period is increased by 1-2 months [17].

Humans are not a suitable host for the parasite. We observed deviations in the developmental cycle compared to other host species. Larvae can enter the pulmonary artery, but the resulting inflammatory reaction causes them to die. *D. repens* can be located in the subcutaneous tissue, but it can also cause an ocular form of the disease. Both parasites can attack other anatomical regions, but this is an incidental phenomenon. Although parasites can reach maturity, the presence of microfilariae in the blood is very rare, which is due to the individual presence of the parasite [49].

### Transmission

The infection of the vertebrate host, being at the same time the definitive host, occurs as a result of mosquito bites. Transmission directly from dogs, cats or humans is not possible.

### Symptoms of dirofilariosis in humans

The most common clinical manifestations of infections in humans are the following: pulmonary, subcutaneous and ocular. The parasite can also establish itself in other organs such as the liver, intestines, mesenteric adipose tissues, lymph nodes, muscles, and testicles, and breast in women invariably leading to an erroneous diagnosis of malignancy [18, 46].

### OCULAR FORM

In the case of the ocular form caused by *D. repens*, various ocular tissues and periocular tissues are invaded. The parasite may be placed subconjunctivally or in the Tenon's capsule [39] as well as in periocular tissues (eyelids, eye socket) [60] and intraocularly (anterior chamber) [10], the vitreous body [24]. Eye symptoms, including local pain, bulging of the eye, double vision, edema of

the eyelids and the conjunctiva, redness, foreign body sensation and visual impairment were observed in the course of ocular manifestations [27, 58]. The only effective method of treatment is the surgical removal of the entire parasite [28].

### PULMONARY FORM

Most patients with pulmonary disease are asymptomatic patients. It is estimated that only about 30% of the infected have symptoms [5] such as the following: cough, chest pain, fever, and hemoptysis, and eosinophilia in blood morphology [8].

The most common lesion found in the lung image in the course of dirofilariosis are granulomas. In differential diagnosis, other lung diseases, such as primary lung cancer, metastatic changes, tuberculosis and hamartoma, should be considered in addition to dirofilariosis [20, 26, 56].

### SYMPTOMS OF DIROFILARIOSIS IN ANIMALS

Clinical manifestations of the disease occur only in animals that have reached the age of 6 months, which is related to the life cycle of the parasite. In the case of invasions at a young age, the first clinical symptoms appear only after one year. It is because of this fact that a properly conducted clinical interview, taking into account the age of the patient and its environment, is very important in the case of dirofilariosis. Information concerning if the sick animal had travelled within the known endemic areas is important, especially in southern Europe and the USA - in particular its southern part. However, it is important to take into consideration with regards to young females the fact that the animals could have been hatched in the Mediterranean countries.

Clinical symptoms include the following: accelerated breathing and dyspnoea, the appearance of cough reflex (usually the effect of sudden pulmonary embolism due to severe parasite invasion), fever, weight loss, sometimes cardiac murmurs, heart failure symptoms, widening of the jugular veins, positive venous pulse rate, ascites, as well as effort intolerance. In the majority of dogs a second tone of the heart is observed, which is related to pulmonary arterial hypertension. The diagnosis requires a veterinary physician experienced in auscultation. In this case, a phonocardiographic study is needed to show the moment of the tone S4. In the advanced stage of the disease, the murmur associated with tricuspid insufficiency can occur. Occasionally, neurological symptoms associated with larval migration to the central nervous system may occur as well [29].

In addition, cardiac arrest, collapse, gastrointestinal symptoms (vomiting, diarrhea, excessive salivation), as well as neurological symptoms (convulsions) can occur in cats. Some cats manifest symptoms resembling asthma and sometimes cough [3]. Such reactions usually

occur 3-4 months after the infection. The observation in cats a triad of symptoms, such as vomiting, eosinophilia and hyperglobulinaemia, should result in a reasonable suspicion of dirofilariasis poisoning [9].

The cutaneous form of the disease in most dogs does not indicate any abnormality. However, some changes may occur in the skin and subcutaneous tissue, resulting from mechanical damage and being a consequence of the presence of both adult and larval forms of the parasite, such as the formation of skin blood vessel congestion, the toxic effects exerted by its metabolites, and the immunological mechanisms [59].

Two types of cutaneous forms can be observed. The first type is nodular and is located in the subcutaneous tissue in which the adult parasite or parasites are located. The second type involves cases of multifocal dermatitis. In 85% of the caudal part of the body: the lumbar region, the pelvic limb and the perianal area. This is most often accompanied by pruritus and erythema (in one study these symptoms were seen in about 100% and 79% of cases). Follicular, focal and multifocal alopecia lesions may also occur, rarely hyperkeratosis, scleroderma and nodular lesions [1, 23, 59]. A case of allergic dermatitis, characterized by multiple papillary lesions, alopecia with lichenification and hyperpigmentation, and the appearance of erythematous lesions that have progressed without pruritus are also described [51].

Microfilaremia has also been reported in dogs with a lethal syndrome. These individuals have been found to have numerous microfilariae in the peripheral blood, especially in the small capillaries [13].

Cases of sudden death caused by hepatitis of unknown origin in dogs with *D. repens* microfilaremia kept in a kennel in central Poland have been described recently [6].

*D. immitis* can also cause subcutaneous dirofilariasis in dogs. Few cases in which stray adults of this species resulted in the formation changes as nodules containing purulent material, mainly located in the subcutaneous tissue of the limb have been reported. Another clinical form of dermatitis associated with *D. immitis* is the manifestation of hypersensitivity, in which we do not observe the presence of parasites in the skin. Clinically, they are characterized by itchy, nodular, papillary and pustular lesions [59].

## DIAGNOSTICS IN HUMANS

### Serology

It should be stated that *D. immitis* and *D. repens* cannot be differentiated serologically.

Serological tests are a useful tool in the diagnosis of dirofilariasis in areas of its endemic appearance, but they are not widely used in the wider population

because of their low specificity and limited availability. Complement fixation, indirect hemagglutination and the ELISA (enzyme-linked immunosorbent assay) should be considered in serological diagnostics. With the ELISA, positive results have been obtained in 75% of patients suffering from the pulmonary form of the disease. Unfortunately, the results may be false-positive in about 30% of patients due to cross-reactions with other parasitic nematodes such as *Toxocara canis*. Therefore, when selecting antigens for the above-mentioned tests in humans, one should bear in mind that they do not cross-react with *T. canis*, *Strongyloides stercoralis*, *Ancylostoma duodenale*, *Ascaris lumbricoides* or *Necator americanus*. These nematodes have migratory pathways by which the antibody responds to antigen [62]. The use of 22 kD protein (Di22) derived from adult *D. immitis* as well as recombinant antigens (eg, 35 kD, P22U fusion protein, A2 phospholipase [PLA2]), which are not recognized in Western Blot tests in patients with other parasitic and non-parasitic lung diseases, improves the effectiveness of ELISA in detecting the invasion. P22U and PLA2 are the secretory or excretory proteins of *D. immitis* larvae. P22U is probably in some way connected with Di22. The cutaneous form of disease PLA2 is in no way related to the Di22, but reacts specifically with serum obtained from patients. Regardless of the ELISA, each positive result must be confirmed by a radiological examination as well as a careful analysis of the patient's history [52].

## POLYMERASE CHAIN REACTION (PCR)

Duplex Real-time PCR is used in the differentiation of *D. immitis* and *D. repens* in blood samples from patients as well as in the body of mosquitoes [33]. Multiplex PCR based their action on mitochondrial gene amplification circulating in the blood. *D. immitis* and *D. repens* microfilariae proved to be useful in the identification of the molecular structure of the parasite and differentiation of both pathogens in cytology is not specific [34]. PCR using paraffin blocks is applicable to a case in which parasite identification is not feasible in morphological studies because of its low maintenance [50]. It should be noted that biopsy material as well as parasites intended for PCR should not be stored in formalin due to its destructive effect on fragments of genomic DNA and the polymerase.

## RADIOLOGICAL EXAMINATION

Abnormalities detected in chest X-ray are often observed in the course of the pulmonary form of human dirofilariasis.

These are oval, well-defined shadows (coin-shaped). In up to 90% of cases, only one nodule with a diameter of less than 30 mm, often subpleural, located on the right (76%), indicating a preference for the right lower lobe (46% of all cases) is observed [30, 43]. Coin-shaped damage is the result of the parasite's death in the lung vascular bed, leading to pneumonia and granuloma. This

stage is often unnoticeable in a radiological examination, as a result of its exposure nodule lesions associated with pneumonia [62]. The shortest period of time observed between the normal image of the lung fields and the appearance of damage resulting from infection *D. immitis* was 5 months. In 13% of patients with evidence of pulmonary dirofilariosis, concomitant pleural effusion was observed [4, 43]. Changes observed in pulmonary tissue are often transient.

Changes visible on the chest X-ray due to dirofilariosis in children are often misinterpreted as a Ghon focus, which appears in the lung form of tuberculosis, resulting in misdiagnosis and thus improper treatment of the patient [30].

CT scan is an ancillary examination that allows for more accurate visualization of lesions in the lungs and abdomen, as well as the evaluation of mediastinal lymph nodes. Depending on the form of the disease and the lesions observed, a fine needle biopsy should be considered using CT lesions in lung tissue, abdominal cavity or under ultrasound (abdominal changes, skin lesions). MRI is used in the differentiation of dirofilariosis with changes of another origin, e.g., neuroblastoma [30]. The final stage of the diagnosis is the collection of material (e.g., fine needle biopsy, surgical procedure) to perform a histopathological examination, the result of which is the basis for a final diagnosis.

## DIAGNOSTICS IN ANIMALS

### Complete Blood Test

The blood of an infected individual in the case of an invasion of this parasite is non-specific. Eosinophilia is observed (affects approximately 50% of infected animals). Symptoms of anemia, basophilia and monocytosis may occur. Sometimes, when lung embolism is present, leukocytosis with the white-blood cell shift to the left may occur. Hyperglobulinaemia occurs in biochemical studies [29].

No advanced diagnostics methods are needed to differentiate between *D. repens* and *D. immitis*. It has been proven that such differentiation is possible by evaluating the morphological and morphometric larvae in peripheral blood smears stained with a routine method (Giemsa staining reagent). The differentiation between microfilariae of different species of the genus *Dirofilaria* is significant due to the cases of *D. repens* and *D. immitis* co-invasion described in the literature [35].

### Serological tests

Diagnosis of nematode invasion is based on the ELISA test, allowing for the detection of antibodies or antigens of the parasite (glycoprotein derived from the female reproductive system). The undeniable advantage of commercially available ELISA antibody-detect-

ing tests is also the possibility of using them in cats. Unfortunately, a significant percentage of false positive results decreases the reliability of the test [41]. The ELISA test used to detect the antigen are much more specific (their specificity is nearly 100%) and much more reliable (their sensitivity exceeds 85%); however, they are not recommended for the diagnosis of disease in cats. Serological tests detecting antigens of adult parasites are more sensitive than those detecting microfilariae; therefore, these commercial tests are recommended in the diagnosis of dirofilariosis by the American Heartworm Society. These are IMC, HA and ELISA tests. Female antigens detected by these tests are highly specific (100% efficiency), but they do not detect antigens released by males, which may result in false negative results in cases where only invasive male parasites are involved in the invasion. McTier in his diagnostic tests on dogs (which were implanted with 24 male parasites) received false-negative results [37]. In the presence of at least 1-2 female, positive results are obtained in 90% of cases, and when there are more than three females, positive results reach 100%. Another diagnostic problem has to do with young parasites (less than 5 months old), as they are only detected when they reach the age of about 8 months [36].

Immunochromatographic tests are able to explore the blood, serum and plasma. False positive results are mostly due to technical errors. False negative, however, are most often the result of the low number of parasites. In cats, immunochromatographic tests fail, giving false negative results, due to infection with a small number of parasites or invasion only by male subjects [41].

## HISTOPATHOLOGICAL EXAMINATION

In the case of subcutaneous dirofilariosis, the presence of microfilariae is more often stated accidentally during the study of biopsies taken for suspected cancer, or in the evaluation of peripheral blood smears taken as a result of other reasons than the suspicion of dirofilariosis.

The diagnosis is based on finding the above-mentioned dermatological lesions, as well as the presence of microfilariae in the peripheral blood, the detection of parasite antigens in peripheral blood, and (which is not always possible) the presence of adults in the subcutaneous tissue of the patient. Changes in the intensity of the microfilariae depending on the time of day and season, not in each case of adult *D. repens* in subcutaneous tissue, as well as the larvae of the parasite are detectable during microscopic examination of the peripheral blood smear. In one study, a microscopic examination of the peripheral blood smear detected microfilariosis in only about 30% of subcutaneous dirofilariosis cases [47].

## DIAGNOSTIC IMAGING

One of the most fundamental methods for the effective diagnosis of clinical disease in dogs is radiological diagnostics [29]. Routine activity in the case of suspicion of invasion involves a chest X-ray in three projections -AP, right- and left-sided.

Lesions described by veterinary radiologists in the interpretation of radiographs of patients with dirofilariosis are pulmonary widening and pulmonary edema in the lung parenchyma.

The first lesions usually occur in the posterior and middle lobes. As a result of the disease, the right atrium or the right ventricle of the heart (and sometimes the advanced forms to enlarge the whole heart) become enlarged. The sum of the measurements made in the right-angled projection for most dog breeds should not exceed 10.5 of the vertebra [40].

X-ray diagnostics is also an element that facilitates recognition in cats, but lesions observed in radiographs are different from those in dogs. Cats may develop chylothorax and, in advanced stage, enlargement of the caudal branches of the pulmonary artery [41].

In the diagnostic process, an angiography may be considered; however, there is a potential for severe life-threatening complications. An angiography is performed on the right side, the contrast is introduced intravenously, in a slow infusion into the external jugular vein. It is more often performed in cats than in dogs.

## ULTRASOUND EXAMINATION

An echocardiography is an extremely important study in the case of *D. immitis* invasion. The parasites seen on an ultrasound exam are parallel lines with a narrow hyper-echogenic agent.

An ultrasound scan performed by an experienced person guarantees the effectiveness of the diagnosis. Right ventricular dilatation is another lesion seen in the ultrasound in the course of the invasion of the parasite.

Using a doppler echocardiography tricuspid regurgitation with reverse flow and systolic pressure in the right ventricle and the pulmonary artery diastolic may be indicated.

An echocardiography is the method of choice in the diagnosis of the caval syndrome. In its course a large number of parasites (exceeding 100 individuals) can be located in the tricuspid region as well as in the vena cava posterior. However, electrocardiography does not allow for one hundred percent of the parasitic invasion to be diagnosed. In the mild form of the disease, we do not observe any changes, while the more serious cases the enlargement of the right atrium and right ventricle is sometimes observed [25, 29].

## TREATMENT IN HUMANS

A pharmacotherapy is not recommended in humans. The treatment of choice is surgical treatment. Treatment is often the result of suspicion of malignancy or diagnosis of ocular dirofilariosis, where the removal of the entire parasite during surgery is the only effective treatment [28]. While treatment to remove a subcutaneous nodule or parasite located in the conjunctiva is not particularly complex, in the case of parasites located in the lung, eyeball, periocular or other internal organs, surgical intervention is much more complex and involves incomparably greater risk [20, 31]. A surgical procedure to remove the parasite from the lung tissue should be preceded by a careful analysis of its location (in case of not every location the treatment is a must). The most important, however, is the proper diagnosis and thus the exclusion of other causes observed in the individual patient, including cancer, where potential surgical intervention might be necessary [54].

## TREATMENT IN ANIMALS

The treatment of dirofilariosis should be guided by three basic objectives: elimination of adult forms, killing of all microfilariae, and minimization of the toxic effects of applied drugs and symptoms of pulmonary embolism resulting from the disintegration of parasites. Due to the high toxicity of drugs used in therapy, a patient should be carefully prepared for it by performing morphological and biochemical studies of blood (creatinine, urea, liver function parameters). Dogs with the caval syndrome must first undergo the surgical removal of parasites and only then begin pharmacological treatment. The first-line drug in the process of the elimination of adult forms of the parasite is melarsomine, which is administered intramuscularly at the level of lumbar vertebrae L3-L5 (avoid subcutaneous administration due to severe irritant effects on the tissue). Melarsomine cannot be used in cats [29]. The long-term therapy used for tiacetarsamide is extremely toxic; therefore, constant monitoring of the patient for 48 hours after drug administration is recommended.

Three to four weeks after killing the adult forms using melarsomine or thiaceramide treatment, the treatment aimed at eliminating the circulating peripheral blood of microfilariae can be started by orally administering ivermectin or milbemycin. Animals should be monitored during the first 24 hours of drug administration because of possible adverse reactions resulting from parasite disintegration. The protocol for treating patients with cutaneous dirofilariosis has not been fully developed yet. The research, as well as casuistic reports, indicates high effectiveness of the combination of imidacloprid and moxidectin in the spot-on formulation [16, 51].

Selamectin (spot-on form) has been successfully used in the treatment of subcutaneous dirofilariosis therapy, as well as in the prevention of the disease.

Emphasis should be placed on prevention, which is safe and well tolerated, as both, parasitic infection and its treatment, can carry a large number of complications.

The fact that the treatment of dirofilariosis in animals is as dangerous as the disease itself may be another strong argument for prevention, which is not only effective, but also safe. This is especially important in cases of animals traveling with their owners to southern Europe and the United States. Macrocytic lactones, available in oral form, dermal solution and injectable solution, are used in the prevention.

The aforementioned spot-on formulation containing a combination of imidacloprid and moxidectin is effective in preventing the onset of subcutaneous dirofilariosis and microfilariosis with *D. repens*. Studies have shown that disposing of the specimen prior to experimental

infection with L3 stage larvae completely prevented the development of adult parasites. In contrast, in 8 dogs infected, but previously unprotected, sectional studies showed the presence of 3 to 21 adult *D. repens* forms in subcutaneous tissue [22].

## CONCLUSION

Dirofilariosis as a zoonotic disease is still underestimated in our country. Climate change leading to its warming is conducive to the development and survival of intermediate hosts (mosquitoes) and contributes to it becoming a real threat also to people. Dirofilariosis is detected in more and more animals by Polish veterinarians. It is important to raise awareness among both medical staff (doctors and veterinarians) and the public about the dangers both to humans and animals as well as about the various options for counteracting this disease.

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The authors have no potential conflicts of interest to declare.