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Epidemiology and clinical management of *Leishmania infantum*, *Dirofilaria immitis*, and *Dirofilaria repens* infections in dogs in Ticino, Switzerland: A combined questionnaire-based and multicentric retrospective study

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ABSTRACT

Climate change and increasing dog importation and travel may facilitate the emergence of canine vector-borne diseases in previously non-endemic regions. Competent vectors of *Dirofilaria* spp. are widespread in Switzerland, and phlebotomine sand flies have been repeatedly documented in Ticino, adjacent to highly endemic areas of canine leishmaniosis and dirofilariosis in Italy. This study provided insights into the epidemiology of *Leishmania infantum* and *Dirofilaria* spp. infections in dogs in Ticino, and evaluated current diagnostic, management, and prevention practices. A multi-stakeholder approach was applied, combining structured interviews with animal shelter representatives, standardized online questionnaires for veterinarians and dog owners, along with a 25-year retrospective review of clinical records. Data comprised responses from 3/4 public shelters, 44/56 veterinarians, 8 dog owners, and 106 clinical records (91 *L. infantum*, 15 *D. immitis*). *Leishmania infantum* infections were reported by 2/3 shelters and 36/44 (81.8%) veterinarians within the year preceding data collection. *Dirofilaria immitis* infections were less frequent (1/3 shelters; 8/44 (18.2%) veterinarians); *Dirofilaria repens* was not reported. Most infected dogs originated from Italy; one *D. immitis* positive dog had no history of travel abroad. Veterinarians frequently reported asymptomatic *L. infantum* infections. Preventive recommendations were generally appropriate, but owner compliance was inconsistent. Retrospective analysis revealed incomplete diagnostic staging of dogs with *L. infantum* infection (retrospective LeishVet classification achievable in one-third of cases, primarily due to omitted urinalysis). The high number of – often asymptomatic – infected dogs and gaps

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in testing and vector prophylaxis, indicates a risk of endemic establishment of *L. infantum* and sustained transmission of *Dirofilaria* spp. in southern Switzerland.

1. Introduction

Canine leishmaniosis and dirofilariosis are vector-borne zoonotic diseases of major veterinary and public health importance (Gramiccia and Gradoni, 2005; Simón et al., 2012). Both are widespread across Europe, with highest endemicity in Mediterranean regions (Genchi and Kramer, 2020; Maia et al., 2023).

The clinical outcome after infection with *Leishmania infantum*, transmitted by phlebotomine sand flies, is largely determined by the host immune response (Solano-Gallego et al., 2009). A large proportion of infected dogs are asymptomatic carriers and, like clinically affected animals, can serve as a source of infection for female phlebotomine sandflies (Deplazes et al., 2012). Clinically affected dogs may exhibit a variety of signs, from mild dermatological lesions to severe manifestations, including polyarthritis, severe hematologic changes, and renal failure (Solano-Gallego et al., 2011). Accurate laboratory diagnostics, based on international guidelines such as those of the LeishVet (Solano-Gallego et al., 2011) or Canine Leishmaniasis Working group (CLWG) (Castagnaro et al., 2007), are essential for early diagnosis and appropriate staging of the disease. Although treatment can improve clinical signs and quality of life, complete parasitological cure is rarely achieved. Consequently, infected dogs require lifelong monitoring and management (Solano-Gallego et al., 2009).

Dirofilaria immitis, the causative agent of canine heartworm disease, is transmitted by mosquitoes of the family Culicidae including the genera *Aedes, Culex,* and *Anopheles* (Fuehrer et al., 2021). Rising temperatures accelerate their life cycle (from egg to mosquito) and the development of the parasitic stages within the vector, enabling geographic spread (Fuehrer et al., 2021). Infected dogs may remain subclinical for prolonged periods or develop clinical signs that progress gradually, often beginning with exercise intolerance or coughing. Advanced disease is commonly fatal due to right-sided heart failure or, acutely, caval syndrome (Knight, 1987; Deplazes et al., 2012; Bendas et al., 2022). Appropriate therapy aims to reduce the reservoir potential of infected dogs and to improve the clinical outcome, following guidelines such as the ones of the American Heartworm Society (American Heartworm Society (AHS), 2020) or the European Scientific Counsel Companion Animal Parasites (Reference ESCAPP). In contrast, *Dirofilaria repens* infection is often subclinical, or may present with subcutaneous nodules and dermatological lesions (Tarello, 2002).

Switzerland is currently considered non-endemic for *L. infantum* and generally for *Dirofilaria* spp.; reported cases are frequently described in imported dogs or dogs that have travelled in endemic areas (Fuehrer et al., 2021; Rohrer Kaiser et al., 2023; Schaffner et al., 2024). The canton of Ticino, in southern Switzerland, provides favourable climatic conditions for parasite development within vectors and, importantly, borders endemic areas of northern Italy. In fact, phlebotomine sand flies competent for the transmission of *L. infantum* have repeatedly been detected in Ticino and other parts of Switzerland, although in low numbers (Schaffner et al., 2024; Ravasi et al., 2024); however, the identified infected canine hosts regularly had a travel history from endemic countries (Mettler et al., 2005; Ravasi et al., 2024). In contrast, single suspected autochthonous canine cases of *Dirofilaria* spp. infection have been reported in Ticino (Petruschke et al., 2001). Temperature is the most relevant factor determining the number of *D. immitis* generations in suitable Culicidae vectors. These are also present in high numbers north of the Alps: accordingly, a maximum of two generations is expected to develop in the vectors in case of the contemporaneous presence of infected hosts in regions north of the Alps (Genchi et al., 2009), therefore impeding currently the establishment of *D. immitis*. However, rising temperatures may not only further facilitate the northward spread of invasive species such as *Aedes albopictus* or *A. koreicus*, (Suter et al., 2015), both known vectors of *Dirofilaria* spp., but also increase the potential number of *Dirofilaria* generations in Culicidae vectors.

In addition, Switzerland records substantial numbers of imported dogs (Reference Amicus) – e.g., through the organized importation of dogs from shelters in the Mediterranean region, primarily conducted by animal welfare organizations. A major challenge associated with the importation of dogs from Southern Europe is the presence of latently infected, asymptomatic animals, which often remain seronegative for months to years and therefore cannot be reliably detected initially using serological methods. Moreover, travelling of resident dogs to endemic areas is common - often without proper vector prophylaxis (Maia and Cardoso, 2015; Ravasi et al., 2024). These factors may contribute to a growing reservoir of infected dogs, and raise concerns regarding the potential establishment of autochthonous transmission cycles (Maroli et al., 2010; Maia and Cardoso, 2015; Ravasi et al., 2024).

Nevertheless, comprehensive data on the current epidemiological situation, case numbers, and preventive strategies are lacking. Such data are essential to assess the concrete risk of pathogen establishment and to inform veterinary and public health measures, including raising disease awareness among veterinarians and owners of potentially infected dogs.

This study aimed to (i) provide insights into the current epidemiological situation of *L. infantum* and *Dirofilaria* spp. in a Swiss region suitable for autochthonous transmission and (ii) evaluate current diagnostic approaches, clinical management, and prevention practices.

2. Material and methods

2.1. Study area and study design

This study was conducted as part of the LeisCH project, a collaboration between the Clinic for Small Animal Internal Medicine and the Institute of Parasitology at the Vetsuisse Faculty, University of Zurich, Zurich, Switzerland, launched in April 2025. The study focused on the canton of Ticino, southern Switzerland, bordering endemic regions of northern Italy (Fig. 1). To comprehensively assess the epidemiological situation, multiple stakeholder groups were included: animal shelter representatives (n = 3, from four officially registered public shelters), private veterinary practitioners (n = 56, at least one veterinarian from each veterinary practice in Ticino), and owners of infected dogs (exact number unknown, as they were directly contacted by the participating veterinary practitioners). Structured interviews were conducted with shelters representatives, while standardized online questionnaires were distributed to veterinary practitioners and dog owners. Additionally, medical records of infected dogs from areas with reported cases (as defined in Section 2.4) were retrospectively reviewed to enable detailed analysis of diagnostic procedures, clinical management, prevention strategies, and outcomes. Informed consent for data collection, analysis, and anonymized scientific publication was obtained from all participants.

2.2. Interviews with shelter representatives

A questionnaire for animal shelter representatives was initially developed using «LimeSurvey» (https://www.limesurvey.org/de/, LimeSurvey GmbH, Hamburg, Germany) (Supplementary file 1). As on-site recruitment became feasible, it was adapted into a structured interview format (McGrath et al., 2019) using Microsoft Office Word (Microsoft Corporation, Redmond, WA, USA). The final interview comprised 29 questions covering professional background, shelter capacity, and weekly numbers of housed and infected dogs, followed by specific questions on dogs infected with *L. infantum* and/or *Dirofilaria* spp., including country of origin, travel history, procedures at importation, clinical signs, diagnostics, and preventive measures. On May 16, 2025, two investigators (J.G. and M.S.) conducted approximately 10-minute interviews with the directors of three of the four officially registered animal shelters in Ticino.

2.3. Online questionnaires for veterinary practitioners and dog owners

Two online questionnaires — for veterinary practitioners and dog owners — were developed using «LimeSurvey» (https://www.limesurvey.org/de/, LimeSurvey GmbH, Hamburg, Germany). The questionnaires are provided in Supplementary Materials (Supplementary files 2 and 3). Questionnaire design followed published methodological recommendations for survey research (Ranganathan and Caduff, 2023; Ranganathan et al., 2024) and was based on previously published questionnaire-based studies (Ruiz De Ybáñez et al., 2009; Lladró et al., 2017; Pereira et al., 2022). Additional questions relevant to the present epidemiological investigation were incorporated.

The veterinary questionnaire comprised 70 main questions, including a subset of questions presented exclusively to respondents having managed infected dogs during the year preceding the questionnaire completion (24.07.2024 – 24.07.2025). "Partially" and "other" responses triggered a follow-up prompt requiring participants to specify their answer. Data collected included workplace characteristics, professional experience, weekly caseload (dogs), and frequency of *L. infantum, D. immitis,* and *D. repens* infection diagnoses. For dogs infected with *L. infantum* and/or *Dirofilaria* spp., additional questions covered origin and travel history, testing procedures at importation, follow-up testing and further diagnostic approaches, clinical signs and history, treatment protocols, preventive measures, and awareness and application of published international guidelines. Dog origin was classified as abroad or within Switzerland, based on the source from which the current owner acquired the dog, including shelters, welfare organizations, or breeding facilities. Treatment of *L. infantum* infection was assessed according to LeishVet staging system (Solano-Gallego et al., 2011), distinguishing between i) seropositive asymptomatic dogs; ii) clinically affected dogs without renal impairment; iii) clinically affected dogs with renal dysfunction corresponding to stages 1–2 chronic kidney disease (CKD), as defined by the International Renal Interest Society (IRIS); and iv) clinically affected dogs with renal impairment corresponding to IRIS stages 3–4 CKD (International Renal Interest Society, 2023). Veterinarians were identified via professional association websites ('Veterinary Medical Association of the Canon of Ticino' (https://www.veterinariticino.ch) and the 'Swiss Veterinary Medical Association' (https://www.gstsvs.ch/de/), and a list of veterinarians regularly referring cases to the Clinic for Small Animal Internal Medicine, Vetsuisse Faculty, University of Zurich, Zurich, Switzerland, to ensure canton-wide coverage. At least one veterinarian from each veterinary practice in Ticino was contacted. The survey was distributed by email over 2.5 months, with biweekly reminders sent to non-respondents. Veterinarians who had not participated after seven weeks were contacted individually by one investigator (M.S.) and invited to participate.

The dog owner questionnaire (46 questions per infection) was distributed via participating veterinary practices using QR-coded flyers. It captured signalment, origin, living conditions, travel history, age at diagnosis of infection with the specific pathogen, awareness of infection status at adoption, awareness of zoonotic potential, sources of information about the diseases, clinical signs, diagnostic procedures (including costs), medical treatment, and preventive measures.

Both online surveys were available in the three national languages (German, Italian and French), as well as in English. Prior to distribution, the questionnaires were internally pilot tested by veterinarians at the Clinic for Small Animal Internal Medicine, Vetsuisse Faculty, University of Zurich, Zurich, Switzerland, to assess comprehensibility, clarity and feasibility; based on this feedback, minor modifications were applied.

2.4. Retrospective analysis of medical records

Based on responses to the veterinary questionnaire, areas with reported *L. infantum* and *Dirofilaria* spp. infections in dogs were identified using cases diagnosed during the year preceding the questionnaire completion and stratified according to postal code. Veterinary practices in these areas were asked for access to medical records. Among seven collaborating practices, one is a multi-site clinic and operates at four locations. Medical records were reviewed retrospectively on site or transmitted electronically. To complete the dataset, medical records of dogs residing in the canton of Ticino and treated at the Clinic for Small Animal Internal Medicine, Vetsuisse Faculty, University of Zurich, Zurich, Switzerland, were included.

Inclusion criteria for *L. infantum* infection comprised confirmation of infection by serology (antibody detection) or direct methods (cytology,

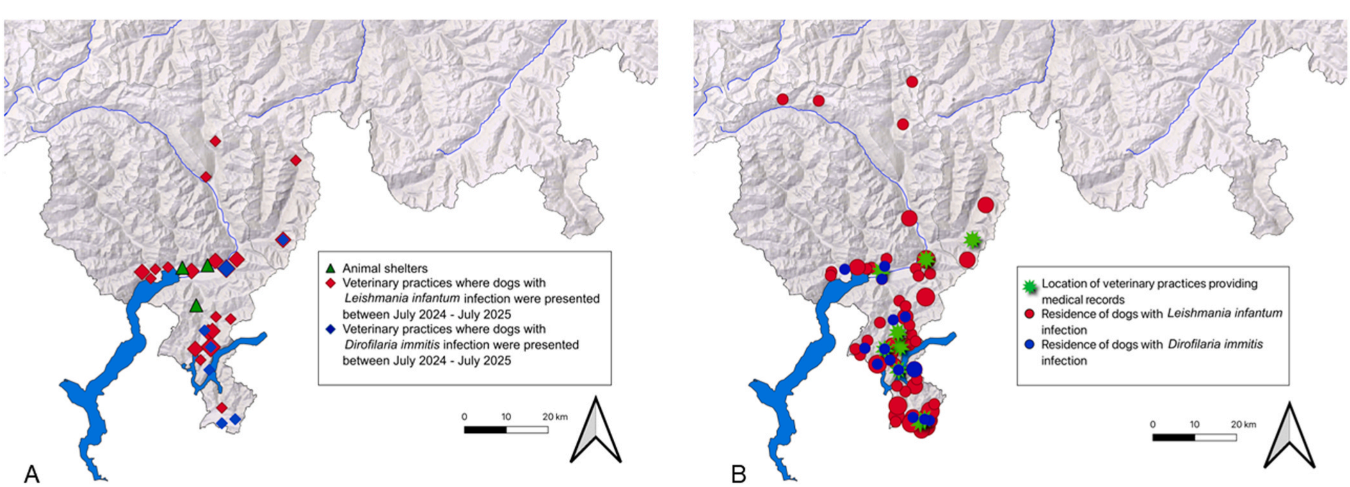

Fig. 1. Distribution of reported *Leishmania infantum* and *Dirofilaria immitis* infections among dogs in the canton of Ticino, southern Switzerland. A) Locations of the animal shelters where the interviews took place and geographic distribution of veterinary practices where dogs with *Leishmania infantum* or *Dirofilaria immitis* infection were presented between mid−2024 and mid−2025 based on a survey among veterinarians. Larger icon size indicates a higher number of veterinary practices. B) Residential locations of dogs infected with *Leishmania infantum* or *Dirofilaria immitis* over the past 25 years based on retrospectively analysed medical records of dogs living in the canton of Ticino from 7 veterinary practices and the Clinic for Small Animal Internal Medicine, Vetsuisse Faculty, University of Zurich, Zurich, Switzerland. Larger icon size indicates a higher number of dogs.

histology, or polymerase chain reaction (PCR)); false-positive rapid antibody tests with negative confirmatory assays such as enzyme-linked immunosorbent assay (ELISA) or immunofluorescent antibody test (IFAT) were excluded. When sufficient diagnostic data were available (i.e., haematology, serum biochemistry, and urinalysis results including urine protein-to-creatinine ratio (UPCR)), cases were retrospectively staged according to LeishVet guidelines (Solano-Gallego et al., 2011).

Dirofilaria immitis cases required confirmation by antigen testing, or detection of microfilariae in blood smears confirmed by PCR.

Each medical record was systematically reviewed from initial presentation to the date of data extraction, and variables collected included signalment, country of origin, importation date, age or estimated age at diagnosis, clinical history, travel history, clinical signs, diagnostic procedures performed and results, treatment, nutritional management, preventive measures, and current vital status. Globulin concentration was retrospectively calculated as the difference between total protein and albumin. The albumin-to-globulin (A:G) ratio was subsequently determined and considered decreased if < 0.89 (Willard and Tvedten, 2012).

Anaemia, hypergammaglobulinemia, thrombocytopenia, hypoalbuminemia, leukopenia, leukocytosis, eosinophilia, azotaemia, and increased C-reactive protein were defined based on the respective reference intervals of the in-house or external laboratory performing the analyses. Pathological renal proteinuria was defined as a UPCR > 0.5 in the absence of an active sediment (International Renal Interest Society, 2023). Data were recorded in Microsoft Excel (Microsoft Corporation, Redmond Washington, USA).

2.5. Data analysis and mapping

All results were subjected to descriptive analysis, with cases/answers presented as absolute numbers and percentages. Graphical evaluation was performed using GraphPrism (version 10.6.1, GraphPad Software, LLC, Boston, Massachusetts, USA) and the maps were created using the software QGIS (QGIS Association, online/open source, qgis.org).

3. Results

3.1. Interviews with shelter representatives

Data comprised responses from 3/4 public shelters. Between mid−2024 and mid−2025, two shelter representatives reported *L. infantum* infections among their residents, while *D. immitis* infection was identified in dogs of one shelter (Fig. 1A). No cases of *D. repens* were reported.

In all three shelters, dogs were primarily imported from Italy, with additional dogs coming from Romania. Prior or subsequent travel abroad could not be determined. Dogs from endemic areas were consistently tested for *L. infantum* and *D. immitis* infections. Testing was generally performed abroad prior to border crossing, although one shelter representative reported that timing may vary. Seronegative dogs without clinical signs were retested at one and four months post-importation in one shelter, whereas the others retested only if clinical signs developed.

In dogs positive for *L. infantum,* dermatological lesions, polyuria/polydipsia, and diarrhoea were often observed; onychogryphosis was occasionally documented. No clinical signs were reported in dogs infected with *D. immitis.*

Diagnostic testing for *L. infantum* primarily relied on antibody detection using ELISA or IFAT. In some cases, serological testing was supplemented with a complete blood count and serum chemistry, followed by serum protein electrophoresis. Urinalysis and PCR testing from blood, skin, lymph nodes, or bone marrow were performed in only a few instances. Testing for *D. immitis* was primarily based on antigen detection.

All shelter representatives reported implementing defined prophylactic protocols: oral macrocyclic lactones (milbemycin oxime, complemented with praziquantel) in two of them (one consistently at admission, on day 10, and then monthly; the other monthly); monthly isooxazoline-based products (sarolaner or afoxolaner) for tick and flea control in two shelters, and deltamethrin-containing collars as mosquito repellent in the remaining one.

3.2. Online questionnaires for veterinary practitioners and dog owners

By October 2025, 44/56 (78.5%) questionnaires for veterinary practitioners were fully completed and included in the analysis (Table 1, Supplementary file 4). Of these respondents, 33/44 (75.0%), 10/44 (22.7%) and 1/44 (2.3%) reported enquiring about a dog's origin "always", "often", and "sometimes", respectively; 21/44 (47.7%), 16/44 (36.4%) and 7/44 (15.9%) reported asking "always", "often", and "sometimes" about travels abroad, respectively. Approximately half (55.5%) of the 44 respondents assessed the incidence of both infections as stable over the past 10 years (Table 2).

Between July 2024 and 2025, 36/44 (81.8%) veterinarians reported having diagnosed at least one dog infected with *L. infantum*, while 8/44 (18.2%) reported consulting at least one dog infected with *D. immitis* (Fig. 1A, Table 1). Infections were primarily seen in practices located in central and southern Ticino (Fig. 1A). None of the respondents reported managing cases of *D. repens* infection or observed clinical signs suggestive of such infection.

All dogs infected with *L. infantum* had reportedly been imported from endemic countries (predominantly from Italy), either directly by their current owners or through welfare organizations (Table 2). Four (11.1%) of the 36 veterinarians having managed *L. infantum*-infected dogs stated diagnosing concurrent infections, mainly with *Ehrlichia canis* (Table 2). Dermatological manifestations were the most frequently reported clinical signs, although one third to three quarters of the participants rarely or never observed clinical signs (Fig. 2A). Among the 36 veterinarians, 27/36 (75.0%) reported following international clinical guidelines. The LeishVet guidelines were most frequently cited (20/27 (74.1%)) (Solano-Gallego et al., 2011), followed by the IRIS guidelines for CKD (15/27 (55.6%)) (International Renal Interest Society, 2023), and the CLWG guidelines (7/27 (25.9%)) (Castagnaro et al., 2007) (multiple answers were allowed). Three participants explained relying on the clinical experience from veterinarians in southern Italy, without following specific guidelines. According to the respondents, monotherapy with allopurinol was the first treatment option for seropositive

Table 1
Professional background of veterinarians and their *Leishmania infantum* and *Dirofilaria immitis caseloads,* based on a survey among 44 veterinarians in the canton of Ticino, southern Switzerland.

	n	%
Work experience in the current practice (years)		
0–2	2	4.6
> 2–5	15	34.1
> 5–10	9	20.4
> 10	18	40.9
Dogs examined/week		
1–5	4	9.1
6–10	0	0
11–50	31	70.5
> 50	9	20.4
Involvement in animal shelter or welfare organization care		
Yes	14	31.8
No	30	68.2
No. of practitioners treating ≥ 1 infected dog with		
Leishmania infantum	36	81.8
Dirofilaria immitis	8	18.2
Dirofilaria repens	0	0

n = number, % = percentage.

Table 2
Epidemiological and clinical features of canine *Leishmania infantum* and *Dirofilaria immitis* infections, based on a survey among 44 veterinarians in the canton of Ticino, southern Switzerland (*: multiple responses were allowed).

	***L. infantum* (n = 36)**		***D. immitis* (n = 8)**	
	n	%	n	%
Dogs with compatible clinical signs				
1–5	31	86.1	8	100
6–10	4	11.1	0	0
> 10	1	2.8	0	0
Newly diagnosed cases				
1–5	26	72.2	8	100
6–10	9	25	0	0
> 10	1	2.8	0	0
Subjective evolution of the incidence in the past 10 years				
Increase	15	41.7	1	12.5
Static	20	55.5	4	50
Decrease	0	0	3	37.5
Unknown	1	2.8	0	0
Co-infections*	4	11.1	0	0
Ehrlichia canis	4	11.1		
Babesia spp.	1	2.8		
Anaplasma phagocytophilum	2	5.6		
Anaplasma platys	0	0		
Origin of the infected dogs*				
Abroad	35	97.2	6	75.0
Switzerland	16	44.4	4	50.0
Origin from[a]/Travel to[b]*	a/b	a/b	a/b	a/b
Italy	36/35	100/97.2	6/7	75.0/87.5
Spain	33/34	91.7/94.4	4/7	50.0/87.5
Portugal	6/26	16.7/72.2	1/5	12.5/62.5
France	2/25	5.5/69.4	1/5	12.5/62.5
Greece	5/17	13.9/47.2	1/2	12.5/25.0
Croatia	2/20	5.5/55.6	1/5	12.5/62.5
Romania	3/5	8.3/13.9	1/1	12.5/12.5
Bulgaria	1/1	2.8/2.8	0/1	0/12.5
Other	2/2	5.5/5.5	2/0	25.0/0
Unknown	0/1	0/2.8	0/1	0/12.5

n = number, % = percentage.

asymptomatic dogs, whereas combination therapy with allopurinol and miltefosine was preferred in subsequent disease stages (Table 3). Nearly all (43/44 (97.7%)) veterinarians indicated recommending prophylaxis against *L. infantum,* with deltamethrin-containing collars and spot-on treatments containing imidacloprid and permethrin as the first-line preventive measures. Overall, 24/44 (54.5%) veterinarians stated recommending year-round use of repellents for infected dogs living in Ticino, especially deltamethrin-containing collars.

All eight veterinarians having managed dogs with *D. immitis* infection over a one-year period from July 2024 to July 2025 reported enquiring about the origin from endemic countries, and seven about the time since importation. Most (6/8) respondents stated that positive dogs were directly imported from abroad. All but one dog had a history of residence in or travel to an endemic area, predominantly Italy or Spain (Table 2). Co-infections were not reported. Dyspnoea and chronic cough were the most frequently reported signs (Fig. 2B). Four of the participants reported performing further examinations themselves in case of a clinical suspicion, following established international guidelines (3 the ones from AHS, 2 from ESCAPP and 1 from the European Society of Dirofilariosis and Angiostrongylosis (multiple responses allowed)). Macrocyclic lactones were the most frequently reported treatment: milbemycin oxime (5/8), moxidectin (1/8), and selamectin (1/8). Surgical removal of adult worms was performed by 2/8 respondents, and 2/8 reported the use of melarsomine. Additionally, 2/8 indicated doxycycline treatment (multiple responses allowed). All 44 participating veterinarians explained recommending macrocyclic lactones as prophylactic treatment against *Dirofilaria* spp. Most participating veterinarians (33/44 (75.0%)) reported informing dog owners about the zoonotic potential, primarily via verbal communication.

Eight fully completed owner questionnaires (corresponding to 8 *L. infantum*-infected dogs) were included in the analysis (Supplementary file 5). All dogs had been adopted from southern Italy, and five households reported owning at least one additional dog. One owner was aware that the dog was infected at the time of adoption and had been informed about the potentially lifelong therapy and required follow-ups. For the remaining seven dogs, infection had not been diagnosed upon adoption in four, and it was unclear if infection had been already diagnosed in three (the new owners did not receive any information). All eight owners reported having been sufficiently informed by their veterinarian following diagnosis, including the zoonotic risk of *L. infantum* infection, and six sought additional information independently. Diagnostic testing costs were < 500 Swiss francs in three cases and 500–1000 Swiss francs in four cases, while annual treatment and monitoring expenses were < 500 Swiss francs in two cases and 500–1000 Swiss francs in six cases. Regarding prophylactic measures, owners reported implementing avoidance of walks at dusk (3/8), the use of mosquito nets (2/8), collars containing imidacloprid and flumethrin (2/8), and topical spot-on formulations containing imidacloprid and permethrin (3/8) (multiple answers allowed).

3.3. Retrospective analysis of medical records

A total of 106 medical records from the past 25 years were collected, comprising 91 cases of *L. infantum* and 15 cases of *D. immitis* infection. No cases of *D. repens* were identified. Two (2/106 (1.9%)) dogs were co-infected with both *L. infantum* and *D. immitis*. Infected dogs resided predominantly in regions bordering Italy, with additional cases of *L. infantum* identified in northern Ticino (Fig. 1B).

Among the 91 dogs with *L. infantum* infection, 30/91 (33.0%) had died and 2/91 (2.2%) were lost to follow-up (Table 4). Most dogs had been directly imported from Italy (61/91 (67.0%)), followed by Spain (11/91 (12.1%)) (Table 4). Travel history after diagnosis was unavailable for 71/91 (78.0%) dogs. Of the 20 dogs with documented travel history, three had not travelled after their diagnosis, while the remaining ones had primarily travelled to Italy, but also to Spain, Sri Lanka, southern France, and Croatia. Approximately a quarter (24/91 (26.4%)) lived with at least another dog. Co-infections were documented in 24/91 (26.4%) dogs, primarily *Ehrlichia canis* (Table 4). Serological antibody testing was the most frequently used diagnostic method (86/91 (94.5%)). In addition, a substantial proportion of veterinarians conducted haematological and serum biochemical analyses, both at the initial assessment (65/91 (71.4%) and 65/91 (71.4%), respectively) and during follow-ups (45/91 (49.5%) and 39/91 (42.9%), respectively) (Table 5). Almost half (42/91 (46.2%)) of the dogs presented with dermatological lesions associated with *L. infantum* infection (Table 6). The most frequent serum biochemistry and haematology abnormalities were decreased A:G (46/63 (73.0%)) and anaemia (19/65 (29.2%)), respectively (Table 6). Pathological renal proteinuria was observed in 13/38 (34.2%) dogs (Table 6). Based on available diagnostics, fewer than half of the dogs could be clearly staged according to LeishVet guidelines, with stages IIa and III reported at similar frequencies (Table 6). A total of 84/91 (92.3%) dogs received allopurinol, of which

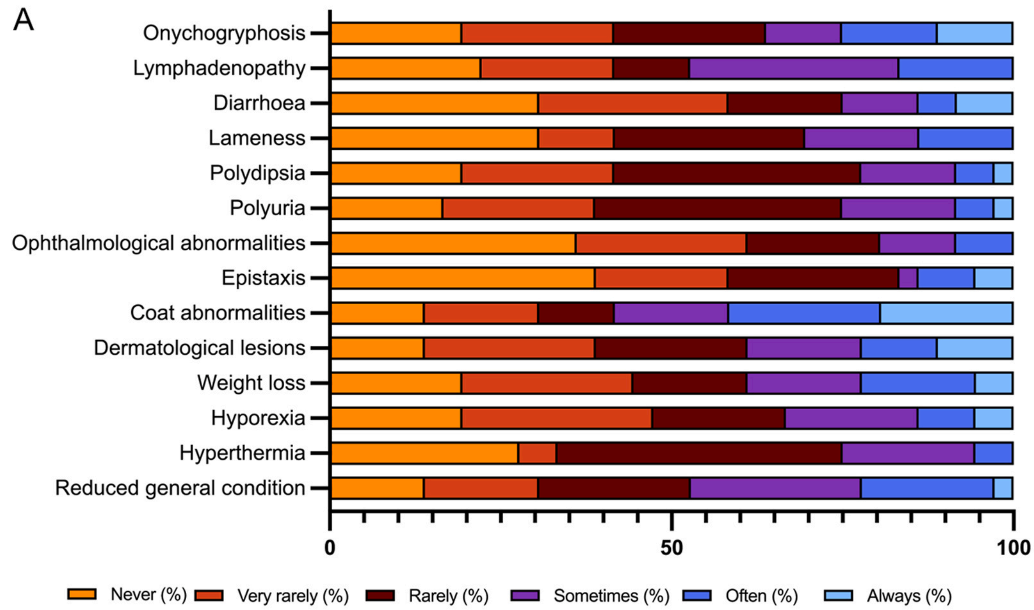

Fig. 2. Clinical signs observed in dogs with A) *Leishmania infantum* or B) *Dirofilaria immitis* infection based on a survey among 44 veterinarians in the canton of Ticino, southern Switzerland.

Table 3
Compounds used by 36 veterinarians in relation to leishmaniosis stages based on a survey in the canton of Ticino, southern Switzerland. Percentages were rounded to one decimal place; consequently, their sum may not equal exactly 100%.

	Asymptomatic n (%)	Clinically ill without impairment of kidney function n (%)	Clinically ill with impaired kidney function, IRIS stage 1–2 CKD n (%)	Clinically ill with impaired kidney function, IRIS stage 3–4 CKD n (%)
Monotherapy	21 (58.3%)	8 (22.2%)	13 (36.1%)	14 (38.8%)
Allopurinol	19 (52.7%)	8 (22.2%)	8 (22.2%)	10 (27.7%)
Domperidone	2 (5.6%)	0 (0%)	2 (5.6%)	1 (2.8%)
Miltefosine	0 (0%)	0 (0%)	3 (8.3%)	3 (8.3%)
Combination therapy	6 (16.7%)	27 (75%)	22 (61.1%)	20 (55.6%)
Allopurinol + Meglumine antimoniate	0 (0%)	2 (5.6%)	1 (2.8%)	0 (0%)
Allopurinol + Miltefosine	3 (8.3%)	17 (47.2%)	13 (36.1%)	11 (30.6%)
Allopurinol + Domperidone	3 (8.3%)	2 (5.6%)	1 (2.8%)	4 (11.1%)
Miltefosine + Domperidone	0 (0%)	0 (0%)	0 (0%)	2 (5.6%)
Allopurinol + Miltefosine + Domperidone	0 (0%)	4 (11.1%)	6 (16.6%)	3 (8.3%)
Allopurinol + Meglumine antimoniate + Domperidone	0 (0%)	1 (2.8%)	1 (2.8%)	0 (0%)
Allopurinol + Miltefosin + Meglumine antimoniate	0 (0%)	1 (2.8%)	0 (0%)	0 (0%)
No treatment	9 (25.0%)	1 (2.8%)	1 (2.8%)	2 (5.6%)
Total	36 (100%)	36 (100%)	36 (100%)	36 (100%)

CKD= chronic kidney disease, IRIS= International Renal Interest Society, n = number, % = percentage.

Table 4
Signalment and epidemiological characteristics of dogs infected with *Leishmania infantum* (n = 91) or *Dirofilaria immitis* (n = 15) living in the canton of Ticino, southern Switzerland, based on retrospectively analysed medical records over the last 25 years from seven veterinary practices and the Clinic for Small Animal Internal Medicine, Vetsuisse Faculty, University of Zurich, Zurich, Switzerland. Age groups in years defined according to Creevy et al. (2019). (*: multiple responses were allowed). Percentages were rounded to one decimal place; consequently, their sum may not equal exactly 100%.

	L. infantum		*D. immitis*	
	n	%	n	%
Vital status				
Dead	30	33.0	3	20
Lost to follow-up	2	2.2	2	13.3
Alive	59	64.8	10	66.7
Age (dogs alive)				
Puppy (< 2 years)	0	0	0	0
Young adult (2–4 years)	4	6.8	0	0
Mature adult (5–8 years)	24	40.7	4	40.0
Senior (≥ 9 years)	31	52.5	6	60.0
Sex				
Female	49	53.8	7	46.7
Male	42	46.2	8	53.3
Castration status				
Yes	60	65.9	11	73.3
No	19	20.9	4	26.7
Chemical	1	1.1	0	0
Unknown	11	12.1	0	0
Breed				
Crossbred	61	67.0	9	60.0
Purebred	30	33.0	6	40.0
Size				
Small (< 10 kg)	12	13.2	1	6.7
Medium (10–30 kg)	57	62.6	8	53.3
Large(> 30 kg)	20	22.0	2	13.3
Unknown	2	2.2	4	26.7
Coat				
Short	41	45.0	7	46.7
Medium length	21	23.1	3	20.0
Long	3	3.3	0	0
Unknown	26	28.6	5	33.3
Age at diagnosis				
Puppy (< 2 years)	12	13.2	1	6.7
Young adult (2–4 years)	27	29.6	7	46.6
Mature adult (5–8 years)	16	17.6	3	20.0
Senior (≥ 9 years)	6	6.6	0	0
Unknown	30	33.0	4	26.7
Time between importation and seropositivity/clinical signs				
< 2 years	25	27.5	8	53.3
2–4 years	12	13.2	0	0
5–8 years	1	1.1	0	0
≥ 9 years	0	0	0	0
Unknown	25	27.5	3	20.0
Already positive at import	28	30.7	4	26.7
Living with other dogs				
Yes	24	26.4	1	6.7
No	24	26.4	8	53.3
Unknown	43	47.2	6	40.0
Country of origin				
Italy	61	67.0	12	80.0
Spain	11	12.1	0	0
France	1	1.1	0	0
Greece	1	1.1	0	0
Bosnia	1	1.1	1	6.7
Ukraine	0	0	1	6.7
Morocco	1	1.1	0	0
Switzerland	7	7.7	0	0
Unknown	8	8.8	1	6.7
Co-infections*	24	26.4	3	20.0
Anaplasma phagocytophilum	2	2.2	0	0
Babesia spp.	8	8.8	1	6.7
Ehrlichia canis	10	11.0	0	0
Anaplasma platys	0	0	0	0
Rickettsia spp.	3	3.3	1	6.7
Thelazia spp.	5	5.5	2	13.3
Borrelia burgdorferi sensu lato	1	1.1	0	0
Use of repellents against mosquitoes				
Yes	52	57.1	5	33.3
No	34	37.4	8	53.4
Unknown	5	5.5	2	13.3
Prevention against *D. immitis*				
Yes	71	78.0	12	80.0
No	15	16.5	1	6.7
Unknown	5	5.5	2	13.3

n = number, % = percentage.

14/84 (16.7%) experienced adverse effects, primarily xanthine crystals or stone formation. A minority of dogs (8/91 (8.8%)) were fed a low-purine diet. Twelve (12/91 (13.2%)) dogs received allopurinol combined with meglumine antimoniate, including three dogs that were already on this combination prior to importation from Italy. Combination therapy with allopurinol and miltefosine was administered to 49/91 (53.8%) dogs, including three previously treated with meglumine antimoniate. Additional treatments included domperidone (7/91 (7.7%)) and prednisolone (6/91 (6.6%)). Repellent protection against mosquitoes was used in 52/91 (57.4%) dogs. Of the 30 deceased dogs, 10/30 (33.3%) were assumed to have died from canine leishmaniosis, primarily due to deteriorating general condition, end-stage kidney disease, or owner-initiated euthanasia.

Among the 15 dogs with *D. immitis* infection, 3/15 (20.0%) had died and 2/15 (13.3%) were lost to follow-up (Table 4). Twelve dogs (12/15 (80%)) had been imported from Italy (Table 4). Travel history was not documented in any of the cases. One dog (1/15 (6.7%)) lived with another dog in the same household. Co-infections were reported in three dogs (2/15 (13.3%) *Thelazia* sp., 1/15 (6.7%) *Babesia* sp. and *Rickettsia* sp.) (Table 4). Typical clinical signs were observed in 2/15 (13.3%) dogs, including chronic cough and reduced general condition with vomiting. Diagnosis was primarily based on blood analyses (Table 5), which revealed eosinophilia (3/10 (30.0%)) and hypergammaglobulinemia (3/10 (30.0%)). Microfilariae detection was performed mainly using the Knott test (6/15 (40.0%)). Surgical removal of adult heartworms was performed in 2/15 (13.3%) dogs, and adulticide therapy with melarsomine was administered to 8/15 (53.3%) dogs. Microfilaremia treatment included milbemycin oxime (5/15 (33.3%)) and moxidectin (1/15 (6.7%)); treatment regimens were unknown in three cases (3/15 (20%)). Overall, 12/15 (80.0%) dogs received anthelminthic prophylaxis against *D. immitis*.

4. Discussion

This study aimed to provide insights into the current epidemiological situation and clinical management of *L. infantum* and *Dirofilaria* spp. infections in dogs in the canton of Ticino, southern Switzerland, as an example of region at risk for endemic establishment. The combination of questionnaires among all stakeholders and a retrospective analysis of 106 clinical cases spanning the past 25 years represents a major strength of this study. While survey-based research allows for the efficient inclusion of a large number of participants within a short time period

Table 5
Diagnostic tests performed upon first assessment and follow-ups in dogs with *Leishmania infantum* or *Dirofilaria immitis* infection residing in the canton of Ticino, southern Switzerland, based on retrospectively analysed medical records over the last 25 years from seven veterinary practices and the Clinic for Small Animal Internal Medicine, Vetsuisse Faculty, University of Zurich, Zurich, Switzerland. *: multiple responses were allowed.

	First assessment		Follow-ups	
Diagnostics *Leishmania infantum**	n	%	n	%
Blood analysis				
Haematology	65	71.4	45	49.5
Only leukocyte count	1	1.1	0	0
Serum biochemistry	65	71.4	39	42.9
Only kidney values	5	5.5	9	9.9
Only proteins	0	0	2	2.2
Only kidney values and proteins	5	5.5	6	6.6
Only electrolytes	1	1.1	0	0
CRP	3	3.3	1	1.1
Urinalysis				
Urinalysis with dipstick	50	54.9	21	23.1
UPCR	38	41.8	20	22.0
Pathogen detection				
Serology (antibody titre: IFAT, ELISA)	86	94.5	41	45.1
Rapid test antibody	12	13.2	0	0
PCR blood	1	1.1	1	1.1
Cytology of lymph nodes	8	8.8	1	1.1
Cytology of bone marrow	1	1.1	0	0
Serum protein electrophoresis	23	25.3	18	19.8
Histology of skin biopsy	1	1.1	1	1.1
PCR conjunctival swab	1	1.1	0	0
Arthrocentesis for synovial fluid analysis	3	3.3	0	0
Testing for co-infections	44	48.4	0	0
Diagnostics *Dirofilaria immitis**	n	%	n	%
Laboratory blood examination				
Haematology	10	66.7	2	13.3
Serum biochemistry	10	66.7	4	26.7
Urinalysis				
Urinalysis with dipstick	6	40.0	2	13.3
UPCR	6	40.0	1	6.7
Pathogen detection				
Rapid test antigen	9	60.0	0	0
Blood smear	3	20.0	0	0
Difil test	5	33.3	1	6.7
Knott test	6	40.0	2	13.3
PCR blood	1	6.7	0	0
Ultrasound of the heart	5	33.3	0	0
Testing for co-infections	8	53.3	0	0

CRP= C-reactive protein, PCR= polymerase chain reaction, UPCR= urine protein-to-creatinine ratio, IFAT= immunofluorescence antibody test, ELISA= enzyme-linked immunosorbent assay, n = number, % = percentage.

(Hennink and Kaiser, 2022; Goodfellow, 2023), it is inherently limited by recall bias. The retrospective evaluation of over 100 cases from areas with frequent reports further strengthens the findings by confirming patterns identified in the questionnaires and providing insight into real-world clinical management.

Previous epidemiological studies have mainly focused on regions with established endemicity (Lopes et al., 2024; Lladró et al., 2017). For Ticino, the presence of competent vectors of *L. infantum* has been reported, indicating a potential risk for autochthonous infections and the endemic establishment of canine leishmaniosis, despite lower abundance compared to known endemic areas (Ravasi et al., 2024; Schaffner et al., 2024). Given climate change-driven temperature increases and rising imports of dogs from endemic regions into Switzerland (Mettler et al., 2005; Ravasi et al., 2024; Reference Amicus), continuous epidemiological surveillance, veterinary awareness, and national prevention strategies are essential to prevent local establishment of these vector-borne zoonoses. In this study, most infected dogs resided in central and southern Ticino, which corresponds to the regions with a higher human population density, while northern alpine regions are less densely inhabited (Brinkhoff, 2025). Overall, the predominance of *L. infantum* infections over *D. immitis* infections is consistent with the endemic distribution and prevalence of these pathogens in the dogs' countries of origin, particularly Italy and Spain (Mendoza-Roldan et al., 2020; Díaz-Regañón et al., 2020). Notably, all but one dog had a history abroad, with this single exception for one dog infected with *D. immitis,* potentially representing a local infection, although inaccurate reporting cannot be fully excluded.

Veterinary practitioners demonstrated awareness of infection risks, routinely inquiring about the dog's origin, duration since import into Switzerland, and travel abroad. Medical records generally included country of origin and import dates; however, post-import travel history was often incomplete, highlighting an area for improvement. Schäfer et al. (2019) demonstrated that even short trips to endemic areas pose a significant risk of infection, emphasizing the importance of including this information in the medical history. Dogs were routinely tested for vector-borne infections abroad prior to import, which represents an important preventative measure (Menn et al., 2010). However, repeated testing of initially seronegative dogs was reported in one single shelter (with analyses conducted up to four months post-importation). Given that the incubation period of *L. infantum* may extend from several months to years (Slappendel, 1988; Mettler et al., 2005), follow-up testing is warranted, ideally at six-month intervals (Solano-Gallego et al., 2011), and also reliable detection of *D. immitis* through diagnostic tests is possible earliest 5–6 months post-infection (American Heartworm Society (AHS), 2020; Deplazes et al., 2012). Mettler et al. (2005) reported that most of the dogs with *L. infantum* infection imported into Germany developed clinical signs within a time frame of one month to three years after importation or travel exposure. However, one dog developed the disease as late as eight years after import from Italy. Such long incubation periods must be taken into account when obtaining the clinical history and performing diagnostic tests, particularly in dogs originating from shelters. Nevertheless, autochthonous transmission should be considered if any history of travel abroad — even in the distant past — can be reliably excluded. Despite a broad spectrum of observed clinical signs, many infected dogs remained clinically unremarkable, consistent with previous studies from German speaking countries (Mettler et al., 2005). Similarly, in a study performed in Portugal 64% of *D. immitis* infected dogs were asymptomatic (Vieira et al., 2014). Such infected but asymptomatic dogs represent a significant risk of further transmission (Solano-Gallego et al., 2001), as it requires higher commitment to test them regularly despite absence of suggestive clinical signs. ELISA and IFAT performed at external laboratories were the primary diagnostic tools for *L. infantum* infection, providing higher sensitivity than point-of-care tests and enabling accurate infection status determination (Solano-Gallego et al., 2014).

Our results suggest that prophylactic measures could be optimized: although all shelters implemented preventive medications, they did not consistently cover all relevant parasites. Ideally, topical repellents should be applied upon arrival and the application repeated depending on the recommended frequency of use for the respective active ingredient for the duration of the vector season, comparable to macrocyclic lactones that should be administered monthly in potentially endemic areas such as southern Switzerland. Resistance of *D. immitis* to macrocyclic lactones is widely spread in the United States of America (Pulaski et al., 2014), but in Europe this has been reported in a single dog imported from the United States of America to Italy (Traversa et al., 2024). While the survey among veterinarians reported high repellent coverage, retrospective data showed that only half of the dogs were adequately protected. This discrepancy may reflect limited owner awareness regarding the importance of consistent prophylaxis, as corroborated by the owner survey. However, the low number of survey responses from dog owners limits the generalization of this finding.

Overall, survey and retrospective data indicate that the clinical management of infected dogs is generally appropriate and that

Table 6

Clinical signs, laboratory abnormalities, urinalysis findings, and LeishVet stage at first presentation in 91 dogs with *Leishmania infantum* infection residing in the canton of Ticino, southern Switzerland, based on retrospectively analysed medical records over the last 25 years from seven veterinary practices and the Clinic for Small Animal Internal Medicine, Vetsuisse Faculty, University of Zurich, Zurich, Switzerland. *: multiple responses were allowed.

Clinical signs*			Laboratory abnormalities			Urinalysis findings			LeishVet stage		
	n	%		n	%		n	%		n	%
Cutaneous lesions	42/91	46.2	Increased CRP	3/3	100	**USG**			I	3/91	3.3
			Reduced A:G Ratio	46/63	73.0						
Coat changes	23/91	25.3	Hypergammaglobulinemia	14/23	60.9	> 1030	23/50	46.0	IIa	15/91	16.5
Lymphadenopathy	21/91	23.1	Anaemia	19/65	29.2	1013–1029	22/50	44.0	IIb	3/91	3.3
			Thrombocytopenia	12/65	18.5						
Ophthalmological changes	16/91	17.6	Hypoalbuminemia	11/70	15.7	1008–1012	3/50	6.0	III	15/91	16.5
Lameness	16/91	17.6	Leukopenia	9/66	13.6	< 1008	2/50	4.0	IV	1/91	1.1
Reduced general condition	15/91	16.5	Leucocytosis	8/66	12.1	**UPCR**			n.d.	54/91	59.3
Weight loss	13/91	14.3	Eosinophilia	6/66	9.1	< 0.2	15/38	39.5			
Hyporexia	9/91	9.9	Azotaemia	6/70	8.6	0.2–0.5	10/38	26.3			
Diarrhoea	9/91	9.9				> 0.5	13/38	34.2			
Onychogryphosis	6/91	6.6									
Polydipsia	6/91	6.6									
Polyuria	5/91	5.5									
Fever	3/91	3.3									
Epistaxis	3/91	3.3									
Neurological changes	1/91	1.1									

Anaemia, hypergammaglobulinemia, thrombocytopenia, hypoalbuminemia, leukopenia, leukocytosis, eosinophilia, azotaemia, and increased C-reactive protein were defined based on the respective reference intervals of the in-house or external laboratory performing the analyses. Globulin concentration was retrospectively calculated as the difference between total protein and albumin. The albumin-to-globulin (A:G) ratio was subsequently determined and considered decreased if < 0.89 (Willard and Tvedten, 2012). CRP=c-reactive protein, USG= urine specific gravity, UPCR= urine protein-to-creatinine ratio, A:G= albumin: globulin, n.d.= not defined, n = number of dogs, % = percentage.

practitioners are familiar with current guidelines. Nevertheless, in the retrospective evaluation, more than half (54/91 (59.3%)) of dogs with *L. infantum* infection could not be assigned to a LeishVet stage due to incomplete diagnostics, particularly the absence of UPCR measurements. This contrasts with the findings of a recent questionnaire-based survey among 149 veterinarians in Switzerland, in which 84.6% of respondents reported performing urinalysis (Gämperli et al., 2026). One possible explanation is that some of the retrieved medical records were relatively old and originated from periods when the clinical consequences of pathological renal proteinuria were less well recognized and diagnostic workups were less comprehensive, partly because of financial limitations or lower owner willingness to pursue further diagnostics and treatments. Comprehensive assessment at the initial consultation, including clinical signs, blood work (haematology, total protein, albumin, creatinine and urea concentration, and antibody titre), and urinalysis with UPCR would facilitate accurate staging and a more targeted prognostic and therapeutic management (Solano-Gallego et al., 2011). Determination of the UPCR is crucial, as pathological renal proteinuria is commonly observed in canine leishmaniosis (affecting one-third of dogs in this study). It also enables the timely initiation of antiproteinuric treatment, thereby helping to delay the progression of kidney disease (Brown et al., 2013; Gämperli et al., 2026).

In line with the current recommendations, the first-line treatment for canine leishmaniosis typically includes the parasitostatic compound allopurinol (Cavaliero et al., 1999; Koutinas et al., 2001; Pennisi et al., 2005), administered for at least six months to control parasite burden and reduce relapse risk (Baneth and Shaw, 2002; Plevraki et al., 2006). According to previous studies, allopurinol therapy may provide adequate therapeutic efficacy in early, non-azotemic stages of the disease, particularly in non-endemic regions (Helm et al., 2013). Allopurinol can be combined with a leishmanicidal agent, such as meglumine antimoniate or miltefosine (Manna et al., 2015), chosen based on disease stage, degree of renal involvement, and comorbidities (Kaempfle et al., 2025). Only a minority of veterinarians in Ticino prescribed a low-purine diet in combination with allopurinol therapy. This measure is important to reduce the risk of xanthine crystal/urolith formation and associated urinary complications (Torres et al., 2011; Roura et al., 2021; Jesus et al., 2022). A possible explanation is that some veterinarians were not familiar with these studies, or they recommend the diet, but pet owners may be reluctant to change their dogs' food.

For the diagnosis of *D. immitis* infection, routine blood analysis may already provide an initial indication of infection. The most commonly reported haematological findings in affected dogs include non-regenerative anaemia, thrombocytopenia, leucocytosis with neutrophilia, eosinophilia and basophilia (Bendas et al., 2022). Eosinophilia, which was the predominant bloodwork abnormality in this study, is typically associated with chronic infection and is particularly pronounced in cases with pulmonary involvement as a reaction to the presence of worms (Lilliehöök et al., 2000). In this study, the Knott test was frequently employed to detect microfilariae during the diagnostic evaluation of *D. immitis* cases. All dogs living in or returning from potential endemic areas should be tested for blood microfilariae (followed by PCR analyses) or for circulating antigens. Not all *D. immitis*-infected dogs received a therapy targeting both adult worms and microfilariae, as recommended by current guidelines (American Heartworm Society (AHS), 2020; Reference ESCAPP). The elimination of microfilariae using macrocyclic lactones is particularly important, as untreated microfilariae may persist in the bloodstream for years, serving as a source of infection for mosquitoes and posing a potential risk for the establishment of local transmission cycles (American Heartworm Society (AHS), 2020; Reference ESCAPP).

The monitoring and treatment of both infections, *D. immitis* and *L. infantum*, may entail high costs for the animal owners: even though the here mentioned amounts were less than 1000 Swiss francs (approx. 1085 euros), previous studies from 2005 indicated that for instance the follow-up of *Leishmania*-infected dogs may cost up to 5800 euros (Mettler et al., 2005).

Some limitations must be acknowledged. The questionnaire-based component may be subject to selection bias and recall bias; however, broad participation and consistency of responses across multiple stakeholder groups support the representativeness and validity of the data. At least one person from each veterinary practice in Ticino was contacted, ensuring broad coverage across the surveyed practices. In the interview component, interviewer-related factors such as wording, facial expressions, and gestures of the interviewer may introduce bias (Bonaccio et al., 2016; Roberts, 2020). Conducting all interviews by the same two investigators minimized interviewer-related bias. In the retrospective analyses, laboratory parameters were analysed; however, different laboratories were used across practices and, in some cases, even for individual patients. This resulted in varying reference ranges, which did not allow direct comparison of the laboratory values. To reduce this limitation, the analysis focused on abnormal findings, defined according to the reference values of the respective laboratories.

5. Conclusion

Our results indicate a potential risk of the endemic establishment of important vector-borne zoonotic pathogens in Ticino (i.e. *L. infantum* and *D. immitis*). Fortunately, veterinarians have demonstrated a high level of risk awareness: many dogs without clinical signs were identified, monitored, or treated. Timely diagnostic testing and preventive measures—particularly the consistent use of repellents—should be further promoted, as they are the primary and most accessible interventions for effective disease prevention.

Dirofilaria repens infection was not detected in the present study, likely reflecting its low prevalence (or current absence). However, because infected dogs are frequently subclinical, underdiagnosis cannot be excluded. Continued awareness of this parasite should therefore be maintained, particularly in dogs with relevant risk factors, also taking into account the zoonotic potential.

CRediT authorship contribution statement

Jasmin Gämperli: Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation. **João Crisóstomo:** Writing – review & editing, Visualization, Methodology. **Stefania Cazzin:** Writing – review & editing, Resources. **Valeria Guidi:** Writing – review & editing, Resources. **Curzio Bernasconi:** Writing – review & editing, Resources. **Luca Galeandro:** Writing – review & editing, Resources. **Miriam Galeandro:** Writing – review & editing, Resources. **Rosita Neri:** Writing – review & editing, Resources. **Laura Olgiati:** Writing – review & editing, Resources. **Paola Juri:** Writing – review & editing, Resources. **Ulli Scheu:** Writing – review & editing, Resources. **Julia Birnberger Mazzoleni:** Writing – review & editing, Resources. **Cristina Volonté:** Writing – review & editing, Resources. **Marilisa Novacco:** Writing – review & editing, Methodology, Formal analysis. **Sandra Felten:** Writing – review & editing, Formal analysis. **Manuela Schnyder:** Writing – review & editing, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Solène M. Meunier:** Writing – review & editing, Visualization, Supervision, Methodology, Funding acquisition, Formal analysis, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.vetpar.2026.110852.

References

American Heartworm Society (AHS). 2020. (Holly Springs, NC), Current Canine Guidelines for the Prevention, Diagnosis, and Management of Heartworm (*Dirofilaria immitis*) Infection in Dogs. https://www.heartwormsociety.org/veterinary-resources/american-heartworm-society-guidelines.

Baneth, G., Shaw, S.E., 2002. Chemotherapy of canine leishmaniosis. Vet. Parasitol. 106 (4), 315–324. https://doi.org/10.1016/S0304-4017(02)00115-2.

Bendas, A.J.R., Alberigi, B., Galardo, S., Labarthe, N., Mendes De Almeida, F., 2022. Clinical and blood count findings in dogs naturally infected with *Dirofilaria Immitis*. . Braz. J. Vet. Med. 44, e001922. https://doi.org/10.29374/2527-2179.bjvm001922.

Bonaccio, S., O'Reilly, J., O'Sullivan, S.L., Chiocchio, F., 2016. Nonverbal behavior and communication in the workplace: A review and an agenda for research. J. Manag. 42 (5), 1044–1074. https://doi.org/10.1177/0149206315621146.

"Amicus" 2026. Accessed on February 4, 2026. https://tierstatistik.identitas.ch/de/dogs-importExports.html.

Brinkhoff, T., 2025. Population statistics of Ticino districts. City Population Website. Accessed March 18, 2026. https://www.citypopulation.de/en/switzerland/ticino/.

Brown, S., Elliott, J., Francey, T., Polzin, D., Vaden, S., 2013. Consensus recommendations for standard therapy of glomerular disease in dogs. J. Vet. Int. Med. 27 (1), S27–S43. https://doi.org/10.1111/jvim.12230.

Castagnaro, M., Crotti, A., Fondati, A., Gradoni, L., Lubas, G., Maroli, M., Oliva, G., Paltrinieri, S., Solano-Gallego, L., Roura, X., Zatelli, A., Zini, E., 2007. Canine Leishmaniasis: Guidelines for Diagnosis, Staging, Therapy, Monitoring and Prevention. Part. I. 21 (3), 19–32. https://www.gruppoleishmania.org/files/veterinaria_2007_eng.pdf.

Cavaliero, T., Arnold, P., Mathis, A., Glaus, T., Hofmann-Lehmann, R., Deplazes, P., 1999. Clinical, serologic, and parasitologic follow-up after long-term allopurinol therapy of dogs naturally infected with *Leishmania infantum*. J. Vet. Int. Med. 13 (4), 330–334. https://doi.org/10.1892/0891-6640(1999)013<0330:csapfu>2.3.co;2.

Creevy, K.E., Grady, J., Little, S.E., Moore, G.E., Strickler, B.G., Thompson, S., Webb, J. A., 2019. 2019 AAHA Canine life stage guidelines. J. Am. Anim. Hosp. Assoc. 55 (6), 267–290. https://doi.org/10.5326/JAAHA-MS-6999.

Deplazes, P., Eckert, J., Von Samson-Himmelstjerna, G., Zahner, H., 2012. Lehrbuch der Parasitologie für die Tiermedizin (3. ed.), Enke Verlag, Stuttgart, Germany.

Díaz-Regañón, D., Xavier, R., Suárez, M.L., León, M., Sainz, A., 2020. Serological evaluation of selected vector-borne pathogens in owned dogs from Northern Spain based on a multicenter study using a commercial test. Paras. Vectors 13 (1), 301. https://doi.org/10.1186/s13071-020-04172-5.

European Scientific Counsel Companion Animal Parasites (ESCCAP). 2019. ESCCAP Guidelines for the Control of Vector-Borne Infections in Dogs: Dirofilaria spp. https://www.esccap.org/uploads/docs/32ir16g1_0775_ESCCAP_Guideline_GL5_20241203_1p.pdf.

Fuehrer, H., Morelli, S., Unterköfler, M.S., Bajer, A., Bakran-Lebl, K., Dwuznik-Szarek, D., Farkas, R., Grandi, G., Heddergott, M., Jokelainen, P., Knific, T., Leschnik, M., Miterpáková, M., Modrý, D., Petersen, H.H., Skírnisson, K., Vergles Rataj, A., Schnyder, M., Strube, C., 2021. *Dirofilaria* spp. and *Angiostrongylus vasorum*: Current risk of spreading in Central and Northern Europe. Pathogens 10 (10), 1268. https://doi.org/10.3390/pathogens10101268.

Gämperli, J., Major, A., Meunier, S.M., 2026. Wie gehen TierärztInnen in der Schweiz mit Leishmaniose um? Eine umfragebasierte Übersicht über unsere Behandlungsansätze mit Fokus auf das Management der Proteinurie. Schweiz. Arch. Thdk. 168 (4), 34–45. https://doi.org/10.17236/sat00473.

Genchi, C., Kramer, L.H., 2020. The prevalence of *Dirofilaria immitis* and *D. repens* in the Old World. Vet. Parasitol. 280 (April), 108995. https://doi.org/10.1016/j.vetpar.2019.108995.

Genchi, C., Rinaldi, L., Mortarino, M., Genchi, M., Cringoli, G., 2009. Climate and *Dirofilaria* infection in Europe. Vet. Parasitol. 163 (4), 286–292. https://doi.org/10.1016/j.vetpar.2019.108995.

Goodfellow, L.T., 2023. An overview of survey research. Resp. Care 68 (9), 1309–1313. https://doi.org/10.4187/respcare.11041.

Gramiccia, M., Gradoni, L., 2005. The current status of zoonotic leishmaniases and approaches to disease control. Int. J. Parasitol. 35 (11–12), 1169–1180. https://doi.org/10.1016/j.ijpara.2005.07.001.

Helm, M., Müller, W., Schaarschmidt, D., Grimm, F., Deplazes, P., 2013. Allopurinol-Therapie bei importierten Hunden mit Leishmaniose ausserhalb des Endemiegebietes. Schweiz. Arch. Thkd. 155 (10), 559–567. https://doi.org/10.1024/0036-7281/a000512.

Hennink, M., Kaiser, B.N., 2022. Sample sizes for saturation in qualitative research: A systematic review of empirical tests. Soc. Sci. Med. 292 (January), 114523. https://doi.org/10.1016/j.socscimed.2021.114523.

International Renal Interest Society, 2023. Treatment Recommendations for CKD in Dogs. https://static1.squarespace.com/static/666b9ecb4064a156963b4162/t/66a6dc0145e3de78f7b830f1/1722211329976/IRIS-DOG-Treatment_Recommendations_2023.pdf.

Jesus, L., Arenas, C., Domínguez-Ruiz, M., Silvestrini, P., Englar, R.E., Roura, X., Leal, R. O., 2022. Xanthinuria secondary to allopurinol treatment in dogs with leishmaniosis: Current perspectives of the Iberian veterinary community. Comp. Immunol.

Microbiol. Inf. Dis. 83 (April), 101783. https://doi.org/10.1016/j.cimid.2022.101783.
Kaempfle, M., Hartmann, K., Bergmann, M., 2025. Treatment of *Leishmania infantum* infections in dogs. Microorganisms 13 (5), 1018. https://doi.org/10.3390/microorganisms13051018.
Knight, D.H., 1987. Heartworm infection. Vet. Clin. North. Am. Small Anim. Pract. 17 (6), 1463–1518. https://doi.org/10.1016/S0195-5616(87)50012-2.
Koutinas, A.F., Saridomichelakis, M.N., Mylonakis, M.E., Leontides, L., Polizopoulou, Z., Billinis, C., Argyriadis, D., Diakou, N., Papadopoulos, O., 2001. A randomised, blinded, placebo-controlled clinical trial with allopurinol in canine leishmaniosis. Vet. Parasitol. 98 (4), 247–261. https://doi.org/10.1016/S0304-4017(01)00399-5.
Lilliehöök, I., Gunnarsson, L., Zakrisson, G., Tvedten, H., 2000. Diseases associated with pronounced eosinophilia: A study of 105 dogs in Sweden. J. Small Anim. Pract. 41 (6), 248–253. https://doi.org/10.1111/j.1748-5827.2000.tb03934.x.
Lladró, S., Picado, A., Ballart, C., Portús, M., Gállego, M., 2017. Management, prevention and treatment of canine leishmaniosis in North-eastern Spain: An online questionnaire-based survey in the province of Girona with special emphasis on new preventive methods (CaniLeish vaccine and domperidone). Vet. Rec. 180 (2), 47. https://doi.org/10.1136/vr.103653.
Lopes, R., Garcês, A., Silva, A., Brilhante-Simões, P., Martins, Â., Durate, E.D., Coelho, A. C., Cardoso, L., 2024. Distribution of and relationships between epidemiological and clinicopathological parameters in canine leishmaniosis: A retrospective study of 15 years (2009–2023). Pathogens 13 (8), 635. https://doi.org/10.3390/pathogens13080635.
Maia, C., Cardoso, L., 2015. Spread of *Leishmania infantum* in Europe with dog travelling. Vet. Parasitol. 213 (1–2), 2–11. https://doi.org/10.1016/j.vetpar.2015.05.003.
Maia, C., Conceição, C., Pereira, A., Rocha, R., Ortuño, M., Muñoz, C., Jumakanova, Z., Pérez-Cutillas, P., Özbel, Y., Töz, S., Baneth, G., Monge-Maillo, B., Gasimov, E., Van der Stede, Y., Torres, G., Gossner, C.M., Berriatua, E., 2023. The estimated distribution of autochthonous leishmaniasis by *Leishmania infantum* in Europe in 2005–2020. PLOS Negl. Trop. Dis. 17 (7), e0011497. https://doi.org/10.1371/journal.pntd.0011497.
Manna, L., Corso, R., Galiero, G., Cerrone, A., Muzj, P., Gravino, A.E., 2015. Long-term follow-up of dogs with leishmaniosis treated with meglumine antimoniate plus allopurinol versus miltefosine plus allopurinol. Paras. Vectors 8 (1), 289. https://doi.org/10.1186/s13071-015-0896-0.
Maroli, M., Gradoni, L., Oliva, G., Castagnaro, M., Crotti, A., Lubas, G., Paltriniert, S., Roura, X., Zini, E., Zatelli, A., 2010. Guidelines for prevention of leishmaniasis in dogs. J. Am. Vet. Med. Ass. 236 (11), 1200–1206. https://doi.org/10.2460/javma.236.11.1200.
McGrath, C., Palmgren, P.J., Liljedahl, M., 2019. Twelve tips for conducting qualitative research interviews. Med. Teach. 41 (9), 1002–1006. https://doi.org/10.1080/0142159X.2018.1497149.
Mendoza-Roldan, J., Benelli, G., Panarese, R., Iatta, R., Furlanello, T., Beugnet, F., Zatelli, A., Otranto, D., 2020. *Leishmania infantum* and *Dirofilaria immitis* infections in Italy, 2009–2019: Changing distribution patterns. Paras. Vectors 13 (1), 193. https://doi.org/10.1186/s13071-020-04063-9.
Menn, B., Lorentz, S., Naucke, T.J., 2010. Imported and travelling dogs as carriers of canine vector-borne pathogens in Germany. Paras. Vectors 3 (1), 34. https://doi.org/10.1186/1756-3305-3-34.
Mettler, M., Grimm, F., Nauke, T.J., Maasjost, C., Deplazes, P., 2005. Canine Leishmaniose in Mitteleuropa: retrospektive Umfrage und serologische Untersuchung importierter und reisebegleitender Hunde. Berl. Münch. Tierärztl. Wschr. 118 (1–2), 37–44.
Pennisi, M.G., Reale, S., Lo Giudice, S., Masucci, M., Caracappa, S., Vitale, M., Vitale, F., 2005. Real-Time PCR in dogs treated for leishmaniasis with allopurinol. Vet. Res. Comm. 29 (S2), 301–303. https://doi.org/10.1007/s11259-005-0067-4.
Pereira, M.A., Santos, R., Nóbrega, C., Mega, C., Cruz, R., Esteves, F., Santos, C., Coelho, C., Mesquita, J.R., Vala, H., Santos-Gomey, G., 2022. A questionnaire-based survey on the long-term management of canine leishmaniosis by veterinary practitioners. Animals 12 (6), 731. https://doi.org/10.3390/ani12060731.
Petruschke, G., Rossi, L., Genchi, C., Pollono, F., 2001. Dirofilariosi canine nel Canton Ticino e in aree confinanti del Nord Italia. Schweiz. Arch. Thkd. 143 (3), 141–147.
Plevraki, K., Koutinas, A.F., Kaldrymidou, H., Roumpies, N., Papazoglou, L.G., Saridomichelakis, M.N., Savvas, I., Leondides, L., 2006. Effects of allopurinol treatment on the progression of chronic nephritis in canine leishmaniosis (*Leishmania infantum*). J. Vet. Int. Med. J. 20 (2), 228–233. https://doi.org/10.1111/j.1939-1676.2006.tb02850.x.
Pulaski, C.N., Malone, J.B., Bourguinat, C., Prichard, R., Geary, T., Ward, D., Klei, T.R., Guidry, T., Smith, G., Delcambre, B., Bova, J., Pepping, J., Carmichael, J., Schenker, R., Pariaut, R., 2014. Establishment of macrocyclic lactone resistant *Dirofilaria immitis* isolates in experimentally infected laboratory dogs. Paras. Vectors 7, 494. https://doi.org/10.1186/s13071-014-0494-6.
Ranganathan, P., Caduff, C., 2023. Designing and validating a research questionnaire - Part 1. Persp. Clin. Res. 14 (3), 152–155. https://doi.org/10.4103/picr.picr_140_23.
Ranganathan, P., Caduff, C., Frampton, C.M.A., 2024. Designing and validating a research questionnaire - Part 2. Persp. Clin. Res. 15 (1), 42–45. https://doi.org/10.4103/picr.picr_318_23.
Ravasi, D., Schnyder, M., Guidi, V., Haye, T., Parrondo Monton, D., Flacio, E., 2024. Exploring emerging challenges: survey on phlebotomine sand flies and *Leishmania infantum* at the northern endemic border in Europe. Pathogens 13 (12), 1074. https://doi.org/10.3390/pathogens13121074.
Roberts, R.E., 2020. Qualitative interview questions: Guidance for novice researchers. Qual. Rep. 25 (9), 3185–3203. https://doi.org/10.46743/2160-3715/2020.4640.
Rohrer Kaiser, C., Müller, P., Zinsstag, J., 2023. Vorkommen des Hautwurms *Dirofilaria repens* bei Hunden in der Schweiz. Schweiz. Arch. Thkd. 165, 321–331. https://doi.org/10.17236/sat00 395.
Roura, X., Cortadellas, O., Day, M.J., Benali, S.L., Canine Leishmaniosis Working Group, Zatelli, A., 2021. Canine leishmaniosis and kidney disease: Q&A for an overall management in clinical practice. J. Small Anim. Pract. 62 (1), E1–E19. https://doi.org/10.1111/jsap.13237.
Ruiz De Ybáñez, R., Del Río, L., Martínez-Carrasco, C., Segovia, M., Cox, J., Davies, C., Berriatua, E., 2009. Questionnaire survey on canine leishmaniosis in Southeastern Spain. Vet. Parasitol. 164 (2–4), 124–133. https://doi.org/10.1016/j.vetpar.2009.06.013.
Schäfer, I., Volkmann, M., Beelitz, P., Merle, R., Müller, E., Kohn, B., 2019. Retrospective analysis of vector-borne infections in dogs after travelling to endemic areas (2007–2018). Vet. Parasitol. 276, 100015. https://doi.org/10.1016/j.vpoa.2019.100015.
Schaffner, F., Silaghi, C., Verhulst, N.O., Depaquit, J., Mathis, A., 2024. The Phlebotomine sand fly fauna of Switzerland revisited. Med. Vet. Entomol. 38 (1), 13–22. https://doi.org/10.1111/mve.12690.
Simón, F., Siles-Lucas, M., Morchón, R., González-Miguel, J., Mellado, I., Carretón, E., Montoya-Alonso, J.A., 2012. Human and animal dirofilariasis: The emergence of a zoonotic mosaic. Clin. Microbiol. Reviews. 25 (3), 507–544. https://doi.org/10.1128/CMR.00012-12.
Slappendel, R.J., 1988. Canine leishmaniasis: A review based on 95 cases in the Netherlands. Vet. Q. 10 (1), 1–16. https://doi.org/10.1080/01652176.1988.9694140.
Solano-Gallego, L., Koutinas, A., Miró, G., Cardoso, L., Pennisi, M.G., Ferrer, L., Bourdeau, P., Oliva, G., Baneth, G., 2009. Directions for the diagnosis, clinical staging, treatment and prevention of canine leishmaniosis. Vet. Parasitol. 165 (1–2), 1–18. https://doi.org/10.1016/j.vetpar.2009.05.022.
Solano-Gallego, L., Miró, G., Koutinas, A., Cardoso, L., Pennisi, M.G., Ferrer, L., Bourdeau, P., Oliva, G., Baneth, G., 2011. LeishVet Guidelines for the practical management of canine eishmaniosis. Paras. Vectors 4 (1), 86. https://doi.org/10.1186/1756-3305-4-86.
Solano-Gallego, L., Morell, P., Arboix, M., Alberola, J., Ferrer, L., 2001. Prevalence of *Leishmania infantum* infection in dogs living in an area of canine leishmaniasis endemicity using PCR on several tissues and serology. J. Clin. Microbiol. 39 (2), 560–563. https://doi.org/10.1128/JCM.39.2.560-563.2001.
Solano-Gallego, L., Villanueva-Saz, S., Carbonell, M., Trotta, M., Furlanello, T., Natale, A., 2014. Serological diagnosis of canine leishmaniosis: Comparison of three commercial ELISA tests (Leiscan®, ID Screen® and Leishmania 96®), a rapid test (Speed Leish K®) and an in-House IFAT. Paras. Vectors 7 (1), 111. https://doi.org/10.1186/1756-3305-7-111.
Suter, T., Flacio, E., Fariña, B.F., Engeler, L., Tonolla, M., Müller, P., 2015. First report of the invasive mosquito species *Aedes koreicus* in the Swiss-Italian border region. Paras. Vectors 8 (1), 402. https://doi.org/10.1186/s13071-015-1010-3.
Tarello, W., 2002. Dermatitis associated with *Dirofilaria* (*Nochtiella*) *repens* microfilariae in dogs from Central Italy. Acta Vet. Hung. 50 (1), 63–78. https://doi.org/10.1556/avet.50.2002.1.9.
Torres, M., Bardagí, M., Roura, X., Zanna, G., Ravera, I., Ferrer, L., 2011. Long term follow-up of dogs diagnosed with leishmaniosis (clinical stage II) and treated with meglumine antimoniate and allopurinol. Vet. J. 188 (3), 346–351. https://doi.org/10.1016/j.tvjl.2010.05.025.
Traversa, D., Diakou, A., Colombo, M., Kumar, S., Long, T., Chaintoutis, S.C., Venco, L., Betti Miller, G., Prichard, R., 2024. First case of macrocyclic lactone-resistant *Dirofilaria immitis* in Europe - Cause for concern. Int. J. Parasitol. Drugs Resist. 25, 100549. https://doi.org/10.1016/j.ijpddr.2024.100549.
Vieira, A.L., Vieira, M.J., Oliveira, J.M., Simões, A.R., Diez-Baños, P., Gestal, J., 2014. Prevalence of canine heartworm (*Dirofilaria immitis*) disease in dogs of Central Portugal. Parasite 21, 5. https://doi.org/10.1051/parasite/2014003.
Willard, M.D., Tvedten, H., 2012. Small animal clinical diagnosis by laboratory methods, 5th ed. Saunders Elsevier, St. Louis, MO, USA.