ESTONIAN UNIVERSITY OF LIFE SCIENCES
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KNOWLEDGE OF THE CANINE NASAL MITE (*Pneumonyssoides caninum*) AMONG VETERINARIANS IN FINLAND

SOOME LOOMAARSTIDE TEADLIKKUS KOERTE NINALESTAST (*Pneumonyssoides caninum*)

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Pneumonyssoides caninum is a canine nasal mite with worldwide distribution that inhabits the caudal nasal passages and paranasal sinuses of dogs. The aim of this descriptive study was to obtain an overview of the knowledge of nasal mites, their distribution, transmission, clinical signs, diagnostics, and treatment among veterinarians in Finland with a licence to practice the profession.

The data for this study was collected through a questionnaire provided in English and Finnish on a social media group for veterinarians in Finland. A total of 154 questionnaires that were filled out during a 26-day period were used in this study. Results should be interpreted with caution due to the limited sample size.

The results of the study showed that most veterinarians (n = 100, 65%) had a moderate amount of knowledge about *P. caninum*. However, only two veterinarians (1%) achieved a high level of knowledge in this study. Around one third of participants (n = 51, 33%) had a low level of knowledge. Almost all veterinarians (n = 153, 99%) had at least heard of *P. caninum* before. As *P. caninum* is considered endemic in Scandinavia, knowledge among veterinarians in Finland could be further improved, especially regarding clinical signs of *P. caninum*.

Keywords: *Pneumonyssoides caninum,* dog, knowledge, questionnaire

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Pneumonyssoides caninum on ülemaailmselt levinud koerte ninalest, mis elutseb koerte kaudaalsetes ninakäikudes ja paranasaalsetes siinustes. Selle kirjeldava uuringu eesmärk oli saada ülevaade Soomes kutsetegevuse loaga loomaarstide teadlikkusest ninalestadest, nende levikust, edasikandumisest, kliinilistest tunnustest, diagnostikast ja ravist.

Uuringu andmed koguti Soome loomaarstide sotsiaalmeedia grupis inglise ja soomekeelse küsimustiku abil. Uuringus kasutati kokku 154 küsimustiku andmeid, millele vastati 26-päeva jooksul. Valimi piiratud suuruse tõttu tuleks tulemusi tõlgendada ettevaatusega.

Uuringu tulemused näitasid, et enamikul loomaarstidel (n = 100, 65%) olid *P. caninum*'i kohta mõõdukad teadmised. Ainult kaks loomaarsti (1%) saavutas selles uuringus kõrge teadmiste taseme. Umbes kolmandikul osalejatest (n = 51, 33%) olid madalad teadmised. Peaaegu kõik loomaarstid (n = 153, 99%) olid *P. caninum*'ist varem vähemalt kuulnud. Kuna *P. caninum*'i peetakse Skandinaavias endeemseks, tuleks Soome veterinaararstide teadmisi veelgi täiendada, eriti seoses *P. caninum*'i poolt põhjustatud kliiniliste tunnustega.

Märksõnad: *Pneumonyssoides caninum*, koer, teadlikkus, küsimustik

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LIST OF ABBREVIATIONS

ELISA	enzyme linked immunosorbent assay
OD	optical density
P. caninum	*Pneumonyssoides caninum*
WB	western blot

INTRODUCTION

Pneumonyssoides caninum (P. caninum) is a nasal mite of canines that inhabits the nasal passages and paranasal sinuses. It is perhaps one of the lesser known of the common ectoparasites of dogs (Jokinen, 2002). The body shape of adult mites is oval and pale yellow in colour. They are roughly 1.0 mm to 1.5 mm in length and 0.6 to 0.9 mm in width (Wallace and Ruhe, 1940). Little is known about the life cycle, as only adult and larval stages have been identified. Transmission is thought to be through direct or indirect transmission between dogs (Wills et. al., 2008).

Infected dogs are often asymptomatic but moderate to severe symptoms can occur (Papazolglou et al., 2000). Clinical signs associated with *P. caninum* include sneezing, reverse sneezing, nasal pruritus, serous nasal discharge, epistaxis and hyposmia (Wills et al., 2008). Clinical diagnosis is based on visual observation of mites on the external nares, rhinoscopy, or microscopic examination of nasal flushing (Papazoglou et al., 2000). Diagnosis can be challenging due to poor access to the caudal nasal cavity and frontal sinuses (Bredal, 1998a) and is therefore often diagnosed based on response to treatment (Bredal and Vollset, 1998).

P. caninum was first reported by Chandler and Ruhe in 1940 and has been found sporadically in dogs worldwide since then. The most recent studies of necropsied dogs in Scandinavia show a 7% prevalence in Norway (Bredal, 1998a) and 20% prevalence in Sweden (Gunnarsson et.al., 2001). The high prevalence in Sweden is causing an increase in concern among veterinarians and dog owners in Sweden (Gunnarsson et al., 1999). While *P. caninum* is thought to be uncommon in most countries (Bredal, 1998a), it is considered to be endemic in Scandinavia (Gunnarsson et al., 2004), therefore knowledge and awareness of *P. caninum* among veterinarians in Finland is pertinent.

This final thesis delivers an overview of *P. caninum* and the current veterinary knowledge of *P. caninum* in Finland. The literature review provides information of the main aspects related

to the pathogen, distribution, transmission, clinical disease in dogs, diagnostic methods, and treatment of *P. caninum*. Through a questionnaire, this descriptive study aimed to gain insight to the level of knowledge of *P. caninum* in veterinarians with a licence to practice the profession in Finland.

1. LITERATURE REVIEW

1.1 *Pneumonyssoides caninum*

Pneumonyssoides caninum is a nasal mite that inhabits the caudal nasal passages and paranasal sinuses of dogs (Wallace and Ruhe, 1940). *P. caninum* belongs to the order of mesosigmata (Saari et al., 2019) and is only known to infect dogs and foxes (Saari et al., 2019) Nasal mites have not been identified to carry or transmit diseases and being limited to affecting the family Canidae they therefore do not present a zoonotic threat (Movassaghi and Mohri, 1998).

The adult mite is oval in shape and pale yellow in colour. The adult mite is 1.0 to 1.5 mm in length and 0.6 to 0.9 mm in width. The exoskeleton is smooth and relatively tough. They have palps consisting of five segments and four pairs of legs that are all located on the anterior part of the body. The legs are of walking type (Wallace and Ruhe, 1940). The anterior legs are the most developed. Strong, curved, claw-like structures are found at the tips of the front legs. Long stemmed, pad-like pulvillus are attached to the tips of the second, third, and fourth pair of legs. Two claw structures are attached to the pulvillus. These legs are weaker than the front legs (Saari et al., 2019). The larvae generally have the same anatomy as adult mites but have a more octagonal body shape with three sets of legs and measure roughly 0.7 mm in length (Wallace and Ruhe, 1940). *P. caninum* can be seen in figure 1.

There was thought to be no breed, sex, or age predilection between infected dogs (Bredal, 1998a), but a more recent study by Gunnarsson et al. (2001) discovered an age predisposition in their results. Dogs younger than three years old were less commonly infected than older dogs (Gunnarsson et al., 2001).

Figure 1. Female nasal mite on the left and male nasal mite on the right (Saari et al., 2019).

1.2 Distribution and prevalence

Nasal mites have been found worldwide including the mainland United States of America, Hawaii, Canada, Australia, the Republic of South Africa, Spain, Norway, Sweden, and Finland (Movassaghi and Mohri, 1998) with higher incidence in Scandinavia (Wills et al., 2008). Cases of *P. caninum* have also been reported in the UK (Wills et al., 2008), Iran (Movassaghi and Mohri, 1998), and France (Dedenback and Bergeaud, 2001). *P. caninum* is considered uncommon in most countries. However, due to the difficulty of clinical diagnosis and that they are often overlooked or not carefully looked for during necropsy the statement that nasal mites are uncommon may not be true (Bredal, 1998a).

In Norway between January and December of 1993 a total of 250 dogs were submitted for autopsy to investigate the presence of nasal mites. These dogs were mainly from south-eastern Norway and consisted of different breeds, sexes, and ages with no previous suspicion of nasal mite infection in these dogs. Eighteen dogs (7%) were found positive for nasal mites (Bredal, 1998a).

A study from 1971 in Sweden reported a 2% prevalence of nasal mites out of four hundred twenty-four necropsied dogs (Gunnarsson et al., 2001). However, a more recent four-year study was conducted in Sweden from June 1992 to August 1996 where four hundred and seventy-two dogs were submitted for necropsy and examined for the presence of nasal mites. The results showed that nasal mites were found in 95 (20%) of the dogs. The prevalence also appeared to be similar in the southern, middle, and northern parts of Sweden (Gunnarsson et al., 2001). However, this study may have had some selection bias as dogs suspected of being infected with *P. caninum* were collected for autopsy (Bredal, 1998a). With Norway reporting a prevalence of 7% and Sweden 20%, it seems *P. caninum* is a common parasite in these countries (Gunnarsson et al., 2001). This makes *P. caninum* is the most commonly occurring mite in Norway (Bredal, 1998c).

1.3 Transmission and pathogenesis

The life cycle of *P. caninum* is not yet clearly understood (Wills et al., 2008). The developmental stages that have been identified are the adult and larval stages. Female and male adult mites had been identified with females much more commonly observed and males very rarely seen. The eggs are large and carried in the abdominal cavity of the female where they also hatch. A nymphal stage has not been identified thus it is believed to be either a very short stage or non-existent (Saari et al., 2019).

Transmission is considered to be through direct contact between dogs as nasal mites have been seen on the muzzle of dogs (Wills et al., 2008). *P. caninum* are motile and can move one centimetre per second (Baneth and Bornstein, 2021). Most often the mites observed on the dog's nose or environment are larvae which move actively. It is believed that infestation occurs

as the larval stages move from one dog to another (Saari et al., 2019). This mode of transmission is explained in figure 2.

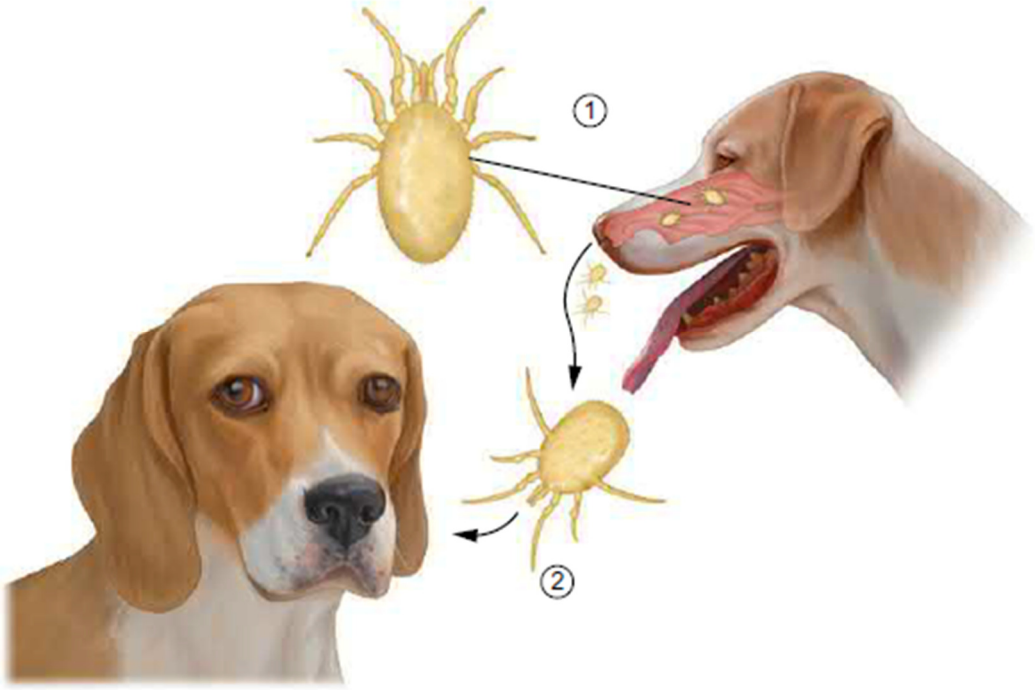

Figure 2. Transmission of *Pneumonyssoides caninum* (Saari et al., 2019).

Indirect transmission may also be possible because nasal mites are able to survive for up to nineteen days in a cool and humid environment (Wills et al., 2008), with temperatures between +4-8 °C. In humid environments with temperatures of +18-20 °C survival time may be three weeks. In dry environments the survival time is up to twenty-four hours (Baneth and Bornstein, 2021). Under laboratory conditions, it has been observed that nasal mites are attracted to expired air more than being influenced by light (Saari et al., 2019). There has been a case reported of a nasal mite infection in a silver fox, but it is unknown whether foxes are transient or reservoir hosts and their part in spreading nasal mite infections in dogs is unclear (Bredal et al., 1997).

In a study by Gunnarsson et al. (1998), four dogs were experimentally inoculated with nasal mites and then necropsied and examined for nasal mites. Each dog was inoculated with fourteen female mites, three males, and three larvae. The mites were placed at the edge of the dog's nostril. After fourteen weeks the dogs were necropsied. The experiment was successful as nasal mites were found in all four dogs. The highest number of mites found in a dog was twelve.

None of the dogs had more mites than the amount they were originally inoculated with, therefore it is not clear if the mites were able to reproduce in these dogs. How long nasal mites live in the nasal cavity is also not known. Nasal mites were only found in the upper respiratory tract (Gunnarsson et al., 1998).

Indirect evidence that *P. caninum* can spread between dogs in the same household was seen in a study by Bredal and Vollset (1998). Two dogs within the same household presented with similar clinic signs and both responded successfully to treatment. In two other cases, dogs presented with clinical signs who shared a household with a dog infected with nasal mites (Bredal and Vollset, 1998).

Gunnarsson et al. (2003) investigated if *P. caninum* could be transferred from inoculated bitches to puppies. The bitches were housed with their offspring until the puppies were eight weeks old. While nasal mites were found in the bitches at necropsy, no mites were discovered in the puppies (Gunnarsson et al., 2003).

1.4 Clinical disease in dogs

P. caninum is typically not considered to be a dangerous mite (Saari et al., 2019). Infection with *P. caninum* is often asymptomatic, but moderate to severe clinical signs can occur in some dogs. The symptoms of *P. caninum* are often nonspecific and imitate upper respiratory tract disease. Foreign body rhinitis, neoplasia and fungal disease are some of the most common nasal diseases that should be considered in the differential diagnoses of *P. caninum* (Papazoglou et al., 2000). There was thought to be no breed, sex, or age predilection between infected dogs (Bredal, 1998a), but a more recent study by Gunnarsson et al. (2001) discovered an age predisposition in their results. Dogs younger than three years old were less commonly infected than older dogs (Gunnarsson et al., 2001).

Clinical signs include chronic nasal discharge, epistaxis, sneezing and reverse sneezing, lacrimation, coughing, facial pruritus, dyspnoea, head shaking, stertorous breathing, restlessness, and hyposmia (Papazoglou et al., 2000). In Sweden, hyposmia is a commonly

recognized sign (Gunnarsson et al., 1998). The lack of scenting ability is noticed in hunting and working dogs (Bredal and Vollset, 1998). This may be due to inflammation of the olfactory mucosa (Gunnarsson et al., 1998). Reverse sneezing was the most commonly reported clinical sign in a study by Gunnarsson et al. (1999). All seventy dogs had signs of reverse sneezing in a study where twenty-five were confirmed to be infected with *P. caninum* and forty-five were suspected of being infected as they had one or more clinical signs associated with *P. caninum* (Gunnarsson et al., 1999).

In histopathology, inflammatory lesions are observed in the olfactory mucosa, respiratory mucosa, and tonsils. These inflammatory lesions may be the cause of the clinical signs associated with *P. caninum* (Gunnarsson et al., 1998). A common pathological finding is sinusitis (Papazoglou et al., 2000). Bredal (1998) reported that sixty percent of dogs with a moderate to severe infection had sinusitis, which was consistent with similar findings previously reported (Bredal, 1998a). Pulmonary and hepatic lesions are an uncommon pathological finding. Some other clinical signs not commonly observed are orbital cellulitis and central nervous system disturbances (Papazoglou et al., 2000). Central nervous system disorders are caused by sinusitis (Movassaghi and Mohri, 1998).

Eosinophilia is a nonspecific finding that can be seen in parasitic infections. In a study by Gunnarsson et al. (1998), three out of four experimentally inoculated dogs showed mild, transient eosinophilia. There was a minor increase in eosinophils observed after the first week of inoculation, but levels returned back to normal after two weeks (Gunnarsson et al., 1998).

Interestingly, a study by Bredal (1998) suggested *P. caninum* may be a risk factor for gastric dilation-volvulus in dogs. This is because reverse sneezing that is associated with nasal mite infections may cause aerophagia (Bredal, 1998b).

1.5 Diagnostic methods

Diagnosis is difficult due to poor access to the caudal nasal cavity and frontal sinuses (Bredal, 1998a) and the lack of laboratory tests available for detecting nasal mites (Gunnarsson et al, 2000). At present, the only way to make a diagnosis is by direct observation of nasal mites. No detection of nasal mites during an examination does not rule out infection (Gunnarsson et al., 2000). The detection of only one mite is adequate for a diagnosis of nasal ascariasis. A veterinary parasitologist should be consulted for the identification of *P. caninum* (Papazaglou et al., 2000).

Several clinical methods can be performed to identify *P. caninum*. These include nasal flushing with saline and inspecting the nasal cavity with endoscopy (Gunnarsson and Zakrisson., 2000). These methods are performed under general anaesthesia and therefore are time consuming and high-cost procedures. Careful inspection of the nasal cavity during necropsy is the only method for reliably confirming or ruling out the presence of *P. caninum*. Therefore, dogs are frequently treated based on clinical signs without a confirmed diagnosis (Gunnarsson and Zakrisson., 2000).

Nasal radiography has been performed but the results did not reveal nasal mites in two case reports with confirmed *P. caninum* infection in dogs (Papazoglou et al., 2000). In a case report by Papazaglou et al. (2000) infection with *P. caninum* in a dog was confirmed with rhinoscopic examination with endoscopy and flushing of the nasal cavity with normal saline. An arthropod was seen crawling in the nasal passage and microscopic examination of a nasal flush showed a larvae of the mite *P. caninum.* Bilateral hyperemia of the nasal mucosa was observed during rhinoscopy (Papazaglou et al., 2000).

The technique most often used in Scandinavia is nasal flushing (Bredal and Vollset, 1998). Performing a nasal flush or taking a swab directly from the nose may be helpful in identifying nasal mites. Nasal mites can be more clearly seen in nasal flush fluid (Wills et al., 2008). Retrograde nasal flushing may be more effective than anterograde flushing (Wills et al., 2008). With retrograde flushing the probability of collecting mites inhabiting the frontal sinuses and

nasal choanae increases (Papazaglou et al., 2000). The possibility of missing mites is higher when using anterograde flushing (Bredal and Vollset, 1998).

Flushing the nasal cavity with a mixture of halothane and oxygen has also been suggested. The aim of this procedure is to cause the mites to migrate caudally to the nasopharynx. In this location the nasal mites are then more easily seen using pharyngoscopy (Papazaglou et al., 2000).

1.5.1 Eosinophilia

Laboratory abnormalities in dogs with *P. caninum* include an increase in eosinophil numbers and antibodies in sera (Gunnarsson and Zakrisson, 2000; Lilliehöök et al., 2000). Eosinophils are involved in inflammatory processes of many types. Eosinophils are secretory cells that contain cytotoxic and neurotoxic proteins which are used to defend against parasites (Boyce, 1997). The parasites most commonly causing eosinophilia are *Dirofilaria immitis* (heartworm) and fleas in cases of flea allergy dermatitis. However, due to the climate, heartworm and fleas do not normally occur in dogs in Norway with the exception of imported animals (Bredal and Vollset, 1998). A similar situation is seen in Sweden where due to the colder climate as well as a low density of dog populations, low numbers of large kennels, and an absence of stray dogs, parasites are less common. Like Norway, in Sweden heartworm does not occur and in the central and northern parts of Sweden fleas are very uncommon (Lilliehöök et al., 2000).

A study by Lilliehöök et al. (2000) showed a median eosinophil count of 0.7 x 10^9 /l (range 0.1 to 4.4 x 10^9/l) out of fifty-one dogs with nasal mite infestation. Fourteen dogs (28%) had an eosinophil count above the reference range while most of the dogs had only a mild increase in eosinophils (Lilliehöök et al., 2000). In a case report by Wills et al. (2008), cytological analysis of nasal flush fluid and brush cytology samples showed a marked eosinophilic inflammatory reaction in two dogs with *P. caninum* infection. Likewise, in a study by Gunnarsson et al. (1997) dogs inoculated with *P. caninum* showed a mild and temporary increase in the number of eosinophils. The number of eosinophils may depend on the dog's individual reaction as well in what phase of infection the samples were taken (Lilliehöök et al., 2000). Because eosinophilia

is not seen in all dogs with a *P. caninum* infection, and it is also seen in other unrelated condition, it is not of diagnostic value (Wills et al., 2008).

1.5.2 Detection of antibodies

Antibodies to *P. caninum* have been demonstrated to occur in naturally and experimentally infected dogs. In a study by Gunnarsson and Zakrisson (2000), serum samples from four experimentally infected dogs and seventy-seven naturally infected dogs were analysed by ELISA for *P. caninum* antibodies. In the four naturally infected dogs, antibodies were first detected on day eleven post-inoculation. Two significant protein bands were detected on day eleven post-inoculation by western blot (WB) and three more protein bands were detected on day fourteen. The protein bands stayed constant until the end of the experiment. In all seventy-seven naturally infected dogs antibody reactions to *P. caninum* were demonstrated by ELISA. Sera from four of the seventy-seven naturally infected dogs showed a corresponding protein pattern with that of the four experimentally infected dogs on day twenty-five post-inoculation. The average optical density (OD) value was 0.56. In five dogs that were not infected with *P. caninum,* no antibodies to *P. caninum* were detected by WB and the OD values in sera did not surpass >0.15 in the *P. caninum* ELISA at any point in the experiment. This study suggests that the proteins may have diagnostic value (Gunnarsson and Zakrisson, 2000). However, ELISA for *P. caninum* has not yet been evaluated as a diagnostic method and is not currently commercially available (Baneth and Bornstein, 2021).

1.6 Anthelmintics used in treatment

Due to the high prevalence, *P. caninum* is becoming an increasing concern among veterinarians and dog owners in Sweden (Gunnarsson et al., 1999) and therefore effective treatments are needed. Currently there are no drugs approved for the treatment of canine nasal mites, but ivermectin, milbemycin oxime, and selamectin have been suggested for use (Tonozzi, 2022). Ivermectin, milbemycin oxime, and selamectin are macrocyclic lactones. Ivermectin and selamectin belong to the product group of avermectins and milbemycin oxime belongs to the

product group of milbemycins. Macrocyclic lactones have a broad antiparasitic spectrum and are commonly used in dogs for prevention of heartworm and for the control of gastrointestinal roundworms (Vercruysse and Claerebout, 2014).

A commonly used method for diagnosis is response to treatment (Bredal and Vollset, 1998). If treatment is based on suspicion of infection and clinical signs do not resolve then it is likely that the signs are from a concurrent upper airway disease (Tonozzi, 2022). The treatment period should be continued for several weeks, and symptomatic dogs should be kept separated from healthy dogs (Saari et al., 2019). A survey by Bredal (1998) reported that there were twenty-seven different treatment regimens using ivermectin and milbemycin oxime used by small animal practitioners in Norway.

1.6.1 Ivermectin

Ivermectin is one of the most important drugs used in veterinary medicine. The mode of action of ivermectin in parasitic species is still unclear but it used to treat a broad spectrum of parasitic infections. However, widespread resistance to ivermectin in veterinary medicine has become an increasing issue in the treatment of parasitic infections (Laing et al., 2017).

Brandt (1988) was the first to publish a report on the use of ivermectin for the treatment of nasal mites in dogs (Bredal and Vollset, 1998). Variable dosages of ivermectin have proven to be an effective treatment against *P. caninum* in dogs (Gunnarsson et al., 1999). While ivermectin is effective, it is not licensed to be used for the treatment of *P. caninum* and may pose a danger in certain canine breeds (Gunnarsson et al., 1999). Herding dogs, such as Collies, can be sensitive to ivermectin and react adversely. Adverse signs in case of ivermectin toxicity are ataxia, disorientation, bradycardia, mydriasis, lethargy, hypersalivation. In severe cases coma or death may occur (Hopper et al., 2002). Normally, an adverse reaction develops within five hours of receiving the drug (Bredal, 1997).

Ivermectin is approved for the use as a heartworm prevention in dogs, but it is commonly used off-label for other ectoparasites and endoparasites. Ivermectin can be given per oral or as a

subcutaneous injection. Currently, the dosage recommendation in *Plumb's veterinary drug handbook* (Plumb, 2018, p. 648) for the treatment of nasal mites is 0.3 mg/kg (300 μg/kg) given as subcutaneous injections every one to two weeks for a total of two to three times. In sensitive Collies a safe dose was found to be 50-60μg/kg (Hopper et al., 2002). It should not be used in animals less than six weeks of age (Papich 2002, p. 277). It is suspected that some breeds may have genetic defects allowing ivermectin to penetrate the blood-brain barrier more readily than normal resulting in adverse reactions. For that reason, the use of ivermectin should also be avoided in dogs with conditions affecting the blood-brain barrier such as inflammation and old age (Bredal, 1997).

1.6.2 Milbemycin oxime

Milbemycin family of drugs have broad anthelmintic and ascaridal activity. It is the active ingredient found in Interceptor tablets which are used in dogs to prevent heartworm disease and control hookworm infections using a dosage of 0.5 to 1.0 mg/kg given orally monthly (Bredal and Vollset, 1998). *Pharmaca Fennica Veterinaria* suggests giving Interceptor tablets at a regimen of once weekly for three consecutive weeks for the treatment of canine nasal mites (*Pharmaca Fennica Veterinaria,* 2022, p. 816-818). Studies have revealed that milbemycin oxime is safe to use in recommended dosages in dogs, puppies, breeding animals and collie breeds. Side effects can develop the dose used is around twenty times that of the recommended dose (Bredal and Vollset, 1998). Adverse effects include depression, lethargy, and coma as milbemycin oxime may cross the blood-brain barrier producing central nervous system toxicosis is some susceptible dog breeds like collie breeds (Papich 2002, p. 348)

A study to assess the efficacy of milbemycin oxime for the treatment of nasal mites in dogs was performed by Bredal and Vollset (1998). A dose of 1.0 mg/kg was used, given orally three times at ten-day intervals. This regimen was used in this study as it is a common regimen in Scandinavia when using ivermectin to treat infection with *P. caninum* (Bredal and Vollset, 1998). The results showed that clinical signs resolved in 85% of the dogs after treatment with milbemycin oxime within fourteen days. Clinical signs resolved within ten days in all four dogs that had a confirmed infection. This result may indicate that one dose of milbemycin oxime (1.0

mg/kg) may be enough to treat dogs with a nasal mite infection. Some clinical signs remained after treatment in three of the dogs with suspected infection, but the signs were noticeably less severe than before treatment. No serious side effects were reported. In addition, feedback from owners stated that milbemycin oxime tablets were easy to administer and that home treatment with tablets was preferred over visits to a veterinarian for three separate ivermectin injections. Unfortunately, because the life cycle of *P. caninum* is not well known it is difficult to determine what the best dosage intervals to target the crucial life stages of the mite would be (Bredal and Vollset, 1998).

An epidemiological survey by Bredal (1998), about the treatments and diagnostic methods used by small animal practitioners in Norway for *P. caninum* infections in dogs showed that fifty-three percent of practitioners said they solely used ivermectin for treatment. Ten percent only used milbemycin oxime and thirty-seven percent used both drugs. Only these drugs were used. For diagnosis of *P. caninum,* fifty-nine percent of practitioners used at least a case history and a clinical examination before starting treatment. Less than ten percent used more specific procedures for diagnosis routinely. Only 1.8% of the diagnoses were confirmed before starting treatment. Effectiveness of treatment was based on the resolution of clinical signs (Bredal, 1998c).

Moxidectin is another endectocide belonging to the group of milbemycins that has been used in combination with imidaclopride to treat *P. caninum* infections in dogs. In concentrations of imidaclopride (40 mg/kg) and moxidectin (2.5-10 mg/kg) in a spot-on formulation used twice at four-week intervals showed a resolution of clinical signs in seventy-three percent of dogs (Ritter, 2009).

1.6.3 Selamectin

Selamectin is offered in the form of a topical “spot on” application making it easy to administer. It has a wide margin of safety. No adverse effects were seen when it was administered to avermectin-sensitive dogs at a dose five times higher than the recommended dosage (Gunnarsson et al., 2004). A study by Gunnarsson et al. (2004) showed that selamectin is

effective for the treatment of canine nasal mites. Out of twelve experimentally infected dogs, six dogs were treated with selamectin. Two dogs were treated with a dosage of 6 mg/kg and four dogs were treated with a dosage of 24 mg/kg applied topically every two weeks for a total of three times. No nasal mites were observed in the treated dogs at necropsy. In five out of the six dogs that were left untreated active nasal mites were discovered at necropsy. Mild alopecia at the site of application was observed in two dogs that received a dosage of 24 mg/kg. No other adverse effects were reported. In this study, selamectin effectively treated dogs infected with *P. caninum,* however additional studies would be needed to find the ideal dosage of selamectin needed (Gunnarsson et al., 2004).

Two Pekingese dogs with confirmed *P. caninum* infection in the UK were treated with 50 mg selamectin (Stronghold) topically once every two weeks for a total of three times. Both dogs had reduced clinical signs, particularly a reduction in sneezing, within twenty-four hours after the first treatment. One dog showed an increase in sneezing frequency after two weeks, but signs resolved again after the second course of selamectin. Complete resolution of clinical signs was seen two weeks after the third treatment (Wills et al., 2008).

2. AIMS OF THE STUDY

The aim of this descriptive study was to gain an overview of the knowledge of veterinarians in Finland regarding the canine nasal mite (*P. caninum*) including the mite's distribution, morphology, transmission, clinical signs, diagnostic methods, and treatment.

The data was collected through a questionnaire that was answered by veterinarians who were members of a social media group for veterinarians in Finland over a 26-day period.

3. MATERIALS AND METHODS

3.1 Questionnaire

For this study an online questionnaire was made using Google Forms. The questionnaire was available in both English and Finnish. The link to the questionnaire (Appendix 1 and 2) was shared on a social media forum for veterinarians in Finland. Members of this private Facebook group consisted of 2,244 veterinarians in Finland with a license to practice the profession. The number of members represented a large portion of the veterinarians in Finland and were the target group for this study. Answers were collected between the 8th of March 2022 and the 2nd of April 2022.

Filling the questionnaire was voluntary and was done anonymously. No personal information was asked from the participants. The questionnaire was provided in English and Finnish. An introduction of the aim of the study and the topics covered in the questionnaire were given at the beginning of the questionnaire. The questionnaire consisted of 22 questions in total. Three questions had yes/no answers. One question had yes/no, or I do not know answers. There were seventeen multiple choice answers of which six had options of selecting more than one correct answer.

The participants were required to answer yes or no to the first two questions, “Do you give consent to take part in this study?” and “Are you licensed to work as a veterinarian in Finland?”. If participants answered no to either of these questions their answers were omitted from the study.

3.2 Data handling

Data from 154 questionnaires was included in this study. Most questionnaires were filled completely, however four respondents left one question unanswered each. This was taken into account during calculations for these questions.

Out of 22 questions, the questionnaire contained 17 questions that aimed to assess the participants knowledge of *P. caninum*. The questions evaluated the veterinarian's knowledge regarding the distribution, anatomy, and transmission of *P. caninum* as well as the clinical signs, diagnostic methods, and treatment of infection with *P. caninum.* The correct answers were chosen based on literature from peer reviewed scientific articles and textbooks.

The questionnaire consisted of 11 questions that had one correct answer and six multiple choice questions with more than one correct answer. Participants were awarded one point for every correct answer selected. Incorrect answers were not awarded points. In multiple choice questions, if participants selected at least one correct answer and "I do not know", their answer was regarded as correct and received one point for each correct answer. It was assumed that they knew at least one correct answer but did not know the other correct answers. Points were not deducted for selecting incorrect answers. The highest number of points that a participant could receive was 31 points. Participants were divided in four groups of knowledge based on their total points. The four groups of knowledge were poor level of knowledge if a participant received between 0-7 points, low level of knowledge if a participant received 8-14 points, moderate level of knowledge if a participant received 15-21 points, and high level of knowledge if a participant received 22-31 points.

In addition to the first two required questions, the questionnaire contained three questions that did not measure knowledge with points. The questions asked if the participants have heard of *P. caninum* before, what the participants assume is the prevalence of *P. caninum* in Finland, and if the participants have treated dogs for *P. caninum* before. All participants except for one had heard of *P. caninum* before and all but one who selected "I do not know" had treated dogs for *P. caninum*. As there is no data available on the prevalence of *P. caninum* in Finland, only the participants' opinion was asked.

The results of the questionnaire are described in rounded percentages. Therefore, they may not equal to 100%.

3.3 Statistical analysis

Data from the questionnaires was moved to Microsoft Office Excel (Version 2102). Data from the answers from the questionnaire in Finnish was combined with the data from the questionnaire in English to make one data set. Microsoft Office Excel (Version 2102) was used to render descriptive statistics as well as create figures and tables.

Data used in the study was collected anonymously, and no personal information was collected from the participants. Only data from participants who consented to being included in this study was used. There is no conflict of interest.

4. RESULTS

There was a total of 155 questionnaires submitted. Fifty-two questionnaires were answered in English and 103 questionnaires were answered in Finnish. One questionnaire was excluded from the study as the participant marked that they did not have a valid license to work as a veterinarian in Finland making the final sample size 154. The results of English and Finnish questionnaires are presented together.

4.1 Knowledge about infection in species

All participants knew that *P. caninum* is not considered a zoonosis. One hundred and fifty-three participants (99%) correctly selected that *P. caninum* infects canines and 54 participants (35%) knew that it can also infect foxes. Nineteen (12%) selected that it can infect felines. Three participants additionally selected “I do not know”.

4.2 Knowledge of distribution and prevalence

The majority of participants (n = 89, 58%) knew that *P. caninum* is found worldwide (Movassaghi and Mohri, 1998). The second most chosen answer was “I do not know” selected by 38 (25%) of participants. Sixteen participants (10%) selected “Northern Hemisphere”, eight participants (5%) selected “Only Norway, Sweden and Finland” and three participants (2%) selected “Europe”. Answers are presented in Figure 3.

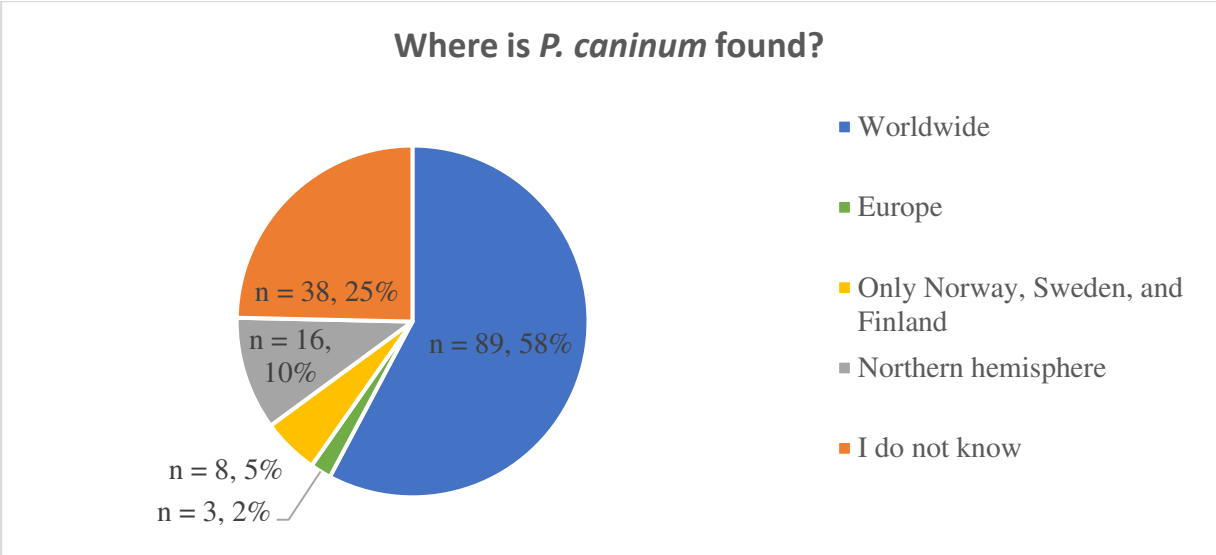

Figure 3. Responses to the question about the distribution of *Pneumonyssoides caninum*. The correct answer is "Worldwide" (Movassaghi and Mohri, 1998).

Norway has reported a prevalence of 7% in canines studied in 1993 and Sweden has reported a prevalence of 20% in canines examined between 1992-1996 (Gunnarsson et al., 2001). Because to our knowledge there have not been any studies published concerning the prevalence of *P. caninum* in Finland, the participants were asked what they assume the prevalence of *P. caninum* in Finland is. This question was not awarded points. Most participants (n = 68, 44%) selected that the prevalence was less than 10%. Forty-two participants (27%) selected 20%. Fourteen participants (9%) selected 40% and three participants (2%) thought the prevalence was more than 50%. Twenty-seven (18%) said they did not know. The results are described in Figure 4 shown below.

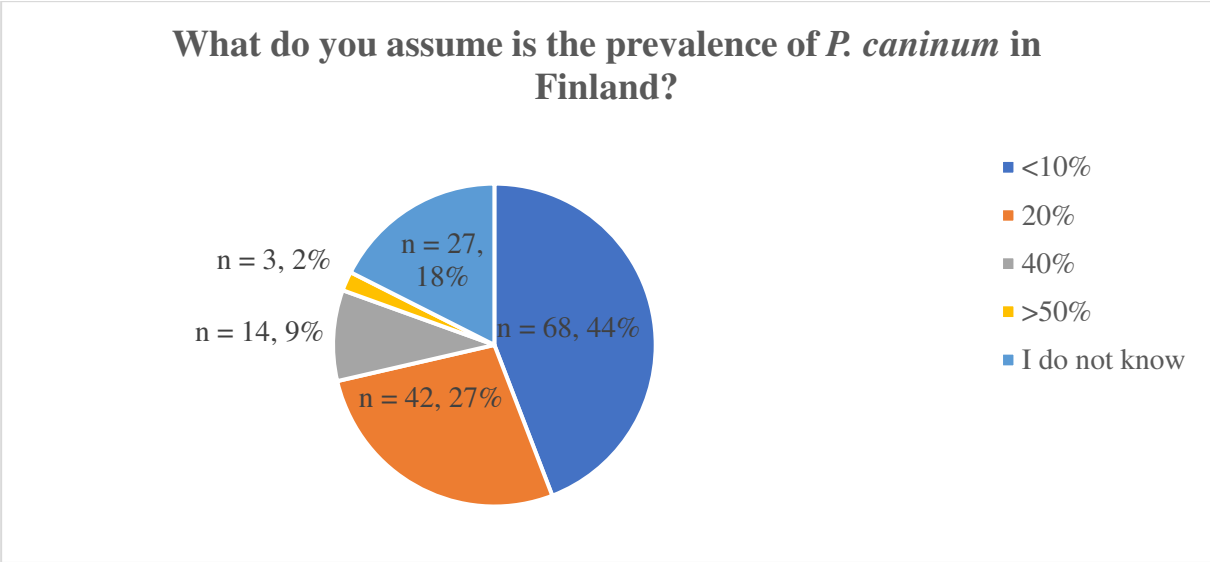

Figure 4. Answers to the fifth question about the prevalence of *Pneumonyssoides caninum* in Finland.

4.3 Knowledge of transmission and environmental survival

The seventh question asked if *P. caninum* is transmitted directly, indirectly, or through both modes of transmission. Only 85 participants (55%) selected the correct answer "Directly and indirectly" (Wills et al., 2008), 67 participants (44%) answered "Directly", and two participants (1%) answered "I do not know". No participant selected "Indirectly".

The eighth question asked what area in the body *P. caninum* inhabits. All participants selected at least one of the two correct answers; "Caudal nasal passages" (n = 121, 79%) and "Paranasal sinuses" (n = 105, 68%) and one participant additionally answered, "I do not know". Seventy-two participants (47%) selected both correct answers.

The thirteenth question was a multiple-choice question about the environmental conditions in which *P. caninum* can survive. The answer most often selected was "I do not know" by 64 participants (42%). The results are demonstrated in Table 1.

Table 1. The responses and proportions to the question regarding the environmental survival of *Pneumonyssoides caninum*

Answer options	**Answers** n from 154	**Percentage of answers**
P. caninum cannot survive in the environment	22	14%
P. caninum can survive for up to twenty-four hours in dry environments	35	23%
P. caninum can survive ten days in cool environments (+1-3°C)	22	14%
P. caninum can survive three weeks in warm and humid environments (+18-20°C)	15	10%
P. caninum can survive nineteen days in cool and humid environments (+4-8°C)	18	12%
I do not know	64	42%

Correct options: *P. caninum* can survive for up to twenty-four hours in dry environments (Baneth and Bornstein, 2021), *P. caninum* can survive three weeks in warm and humid environments (+18-20°C) (Baneth and Bornstein, 2021), *P. caninum* can survive nineteen days in cool and humid environments (+4-8°C) (Wills et al, 2008).
Incorrect options: *P. caninum* cannot survive in the environment, *P. caninum* can survive ten days in cool environments (+1-3°C).

4.4 Knowledge of morphology

The ninth question asked what colour *P. caninum* is. Only 6% (n = 10) selected the correct answer, "Yellow" (Wallace and Ruhe, 1940). The majority of participants (n = 124, 81%) selected "white". Answers "Brown" and "I do not know" were both selected by ten participants. The answer "Red" was not selected. Results can be seen in Figure 5.

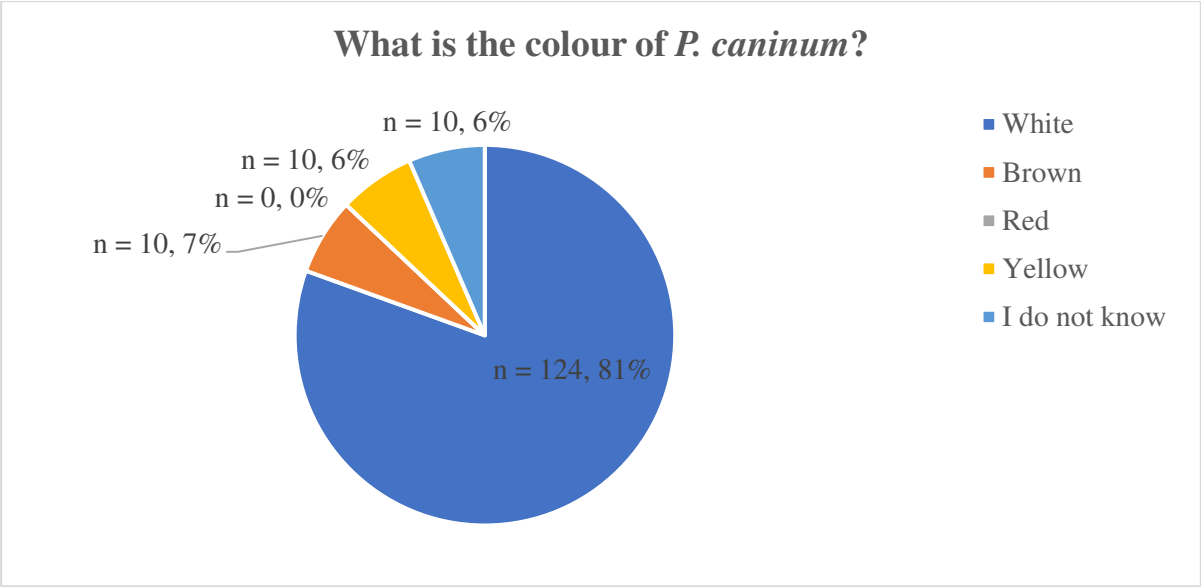

Figure 5. Answers to the ninth question about the colour of *Pneumonyssoides caninum.* The correct answer is "Yellow" (Wallace and Ruhe, 1940).

The tenth question asked participants if *P. caninum* is motile or non-motile. Two participants did not reply to the question. Most participants (n = 150, 99%) answered "Motile". Two participants (1%) answered "Non motile".

The eleventh question asked, "What is the approximate size of an adult *P. caninum* mite?". Most participants (n = 105, 68%) correctly selected the answer "1.0-1.5 mm in length and 0.6-0.9 mm in width". The second most selected answer was "2.0-3.0 mm in length and 0.9-1.2 mm in width" by 27 participants (17%). Twenty-one participants (14%) chose "I do not know".

Most participants (n = 49, 38%) answered "I do not know" to the twelfth question "How many legs does *P. caninum* have?". Only 41 participants (31%) knew that the *P. caninum* mite has four pairs of legs located on the anterior part of the body. Thirty participants (23%) selected that they have three pairs of legs located on the anterior part of the body, which is true for the larvae of *P. caninum* (Wallace and Ruhe, 1940), but not for the adult mite and for that reason was considered an incorrect answer.

4.5 Knowledge of clinical signs

The answers to the multiple-choice question about clinical signs is summarised in Table 2. All participants at least knew that *P. caninum* can cause respiratory signs: for example, sneezing, reverse sneezing, coughing, and serous nasal discharge in dogs. The other correct answers were "Dermatological signs - for example facial pruritus", "Ocular signs – for example lacrimation, orbital cellulitis", "Other signs – for example head shaking, lack of scenting ability (hyposmia)" and "Central nervous system disturbances" (Papazoglou et al, 2000). None of the participants knew that *P. caninum* can cause central nervous system disorders.

Table 2. The number and proportion to the question "What are possible symptoms of infection with *Pneumonyssoides caninum*?"

Clinical signs	**Answers** (n from 154)	**Percentage of answers**
Respiratory signs - for example sneezing, reverse sneezing, coughing, serous nasal discharge	154	100%
Other signs - for example head shaking, epistaxis, lack of scenting ability (hyposmia)	71	46%
Dermatological signs - for example facial pruritus	65	42%
Ocular signs - for example lacrimation, orbital cellulitis	19	12%
Central nervous system disturbances	0	0%
Gastrointestinal signs - for example vomiting, diarrhea	1	1%
Signs of liver failure - for example icterus	0	0%
I do not know	1	1%

Correct options: respiratory signs – for example sneezing, reverse sneezing, coughing, serous nasal discharge. Other signs – for example head shaking, epistaxis, lack of scenting ability (hyposmia). Dermatological signs – for example facial pruritis. Ocular signs – for example lacrimation, orbital cellulitis. Central nervous system disturbances. Correct options are based on literature (Papazoglou et al, 2000).

The fourteenth question asked if infection with *P. caninum* is most often asymptomatic, mild, moderate or severe. Only 51 participants (33%) selected the correct answer "Asymptomatic". Most participants (n = 90, 58%) chose the option "Mild". The rest of the participants selected either "Moderate" or "I do not know". None of the participants selected the option "Severe" (Figure 6).

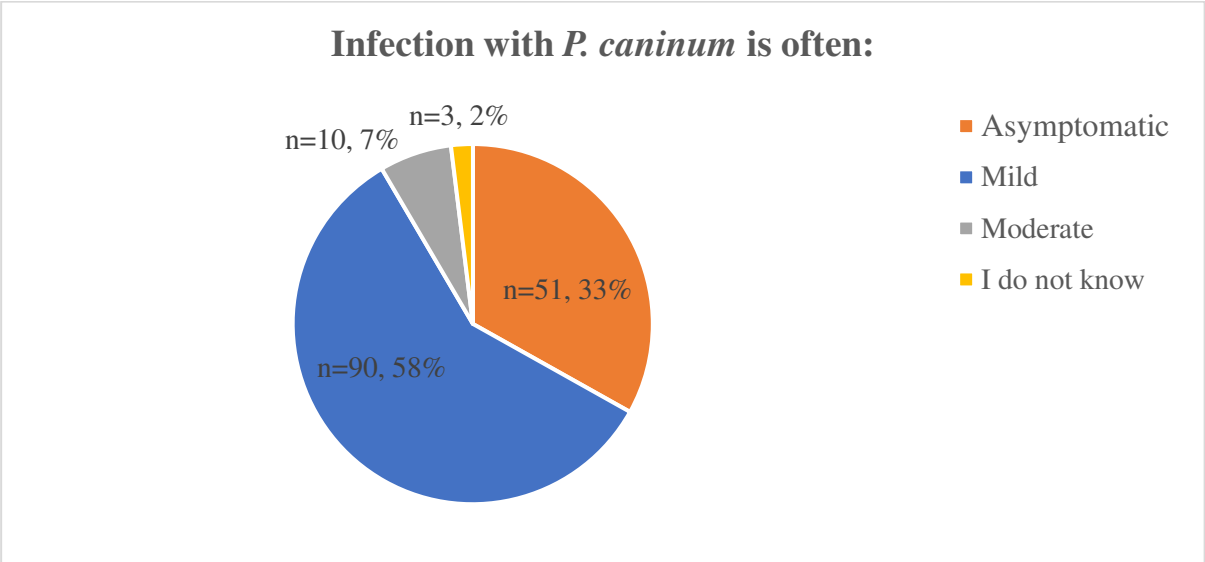

Figure 6. Results of the fourteenth question about infection with *Pneumonyssoides caninum.* The correct answer is "Asymptomatic" (Papazolglou et al, 2000).

The sixteenth question asked, "What symptom commonly presents in hunting dogs?". Most participants (n = 93, 60%) knew that the correct answer was "Hyposmia" (Bredal and Vollset, 1998). Fifty-nine (38%) selected "Reverse sneezing", two participants (1%) said they did not know, and one participant (1%) selected "Facial pruritus". None of the participants selected the other two answer options: "Epistaxis", "Icterus".

The seventeenth question asked, "What is the most common pathological sign of *P. caninum*?". Most participants (n = 137, 89%) correctly selected "Sinusitis" (Papazoglou et al, 2000). The rest of the participants chose either "I do not know" (n = 16, 10%) or "Orbital cellulitis" (n = 2, 1%). None of the participants selected any of the other two answer options: "Pulmonary and hepatic lesions", "Venous congestion of the gastrointestinal tract".

4.6 Knowledge of diagnostic methods

The questionnaire contained two questions about the diagnosis of *P. caninum*. Participants were asked to select which diagnostics methods can be used for the detection of *P. caninum*. Due to

an error in the questionnaire the answer "Only clinical signs" will be regarded as "Clinical signs". As there was no answer option of "Clinical signs" participants selected "Only clinical signs" as well as other answer options, which is contradictory. The answer option "ELISA" was only available in the questionnaire in Finnish and therefore was not included in the calculations. The correct answers were "Only clinical signs", "Rhinoscopy", "Nasal flushing". The responses are described in Table 3.

Table 3. The number and proportion of answers to the question about diagnostic methods for *Pneumonyssoides caninum*

Diagnostic methods	**Answers** (n from 154)	**Percentage of answers**
Only clinical signs	81	53%
Rhinoscopy	131	85%
Nasal Flushing	83	54%
Baermann test from feces for detection of larvae	1	1%
ELISA	1	1%
I do not know	4	3%

Correct options: only clinical signs, rhinoscopy, nasal flushing (Wills et al, 2008)
Incorrect options: xray, baermann test from feces for detection of larvae, enzyme linked immunosorbent assay (ELISA). No participant selected the answer option "Xray".

When participants were asked "What is needed to confirm infection with *P. caninum*?*"*, 87 participants (56%) selected the correct answer, "Direct observation of a mite" (Gunnarsson et al, 2000). Sixty participants (39%) selected "Positive response to treatment" and five (3%) answered that they did not know. Answer options not selected by participants were "Eosinophilic inflammation" and "Detection of larvae in feces" (Figure 7).

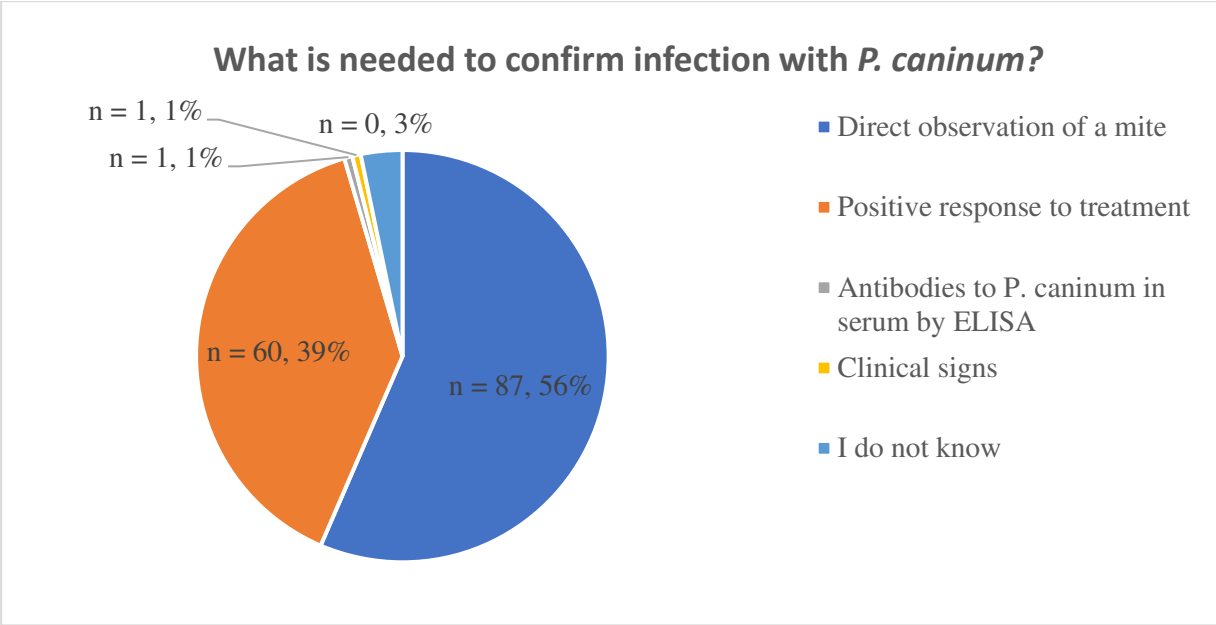

Figure 7. Answers to the question "What is needed to confirm infection with *P. caninum*?". The correct answer is "Direct observation of a mite" (Gunnarsson et al, 2000).

4.7 Knowledge of treatment

There were two questions that asked the participants about the treatment of *P. caninum*. The first question asked participants to select which drugs can be used to treat infection with *P. caninum*. There were three correct answers: "Milbemycin oxime", "Selamectin", and "Ivermectin". One participant did not answer the question and therefore was not included in the calculations. The results to this question are shown in Figure 8 below.

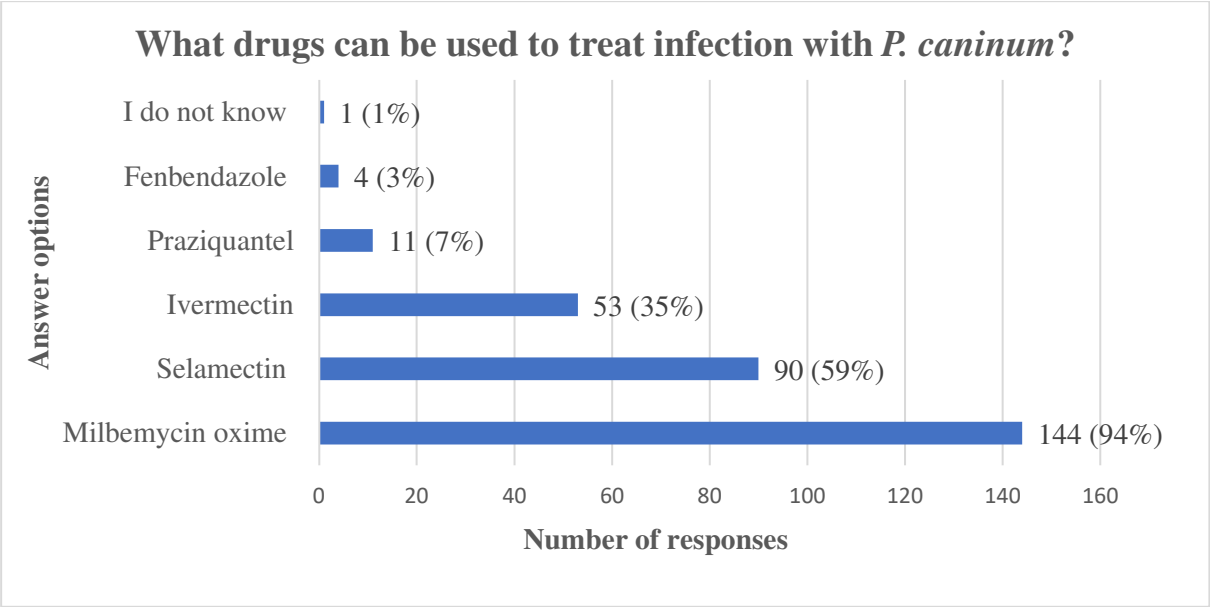

Figure 8. The responses to the question about which drugs can be used to treat infection with *Pneumonyssoides caninum*. The correct answers are "Milbemycin oxime" (Bredal and Vollset, 1998), "Selamectin" (Gunnarsson et al., 2004), and "Ivermectin" (Gunnarsson et al., 1999).

Only 42 participants (27%) selected all three correct answers, 52 participants (34%) selected at least two correct answers, and 57 participants (37%) selected only one correct answer. Twelve participants (8%) selected at least one wrong answer.

The second question asked if all the dogs in the same household need to be treated. The majority of participants (n = 145, 94%) knew that all dogs within the same household should be treated against *P. caninum* infection if one dog is suspected of being infected. Two participants (1%) answered "No" and seven participants (5%) said they did not know.

4.8 Level of knowledge

The total points of the participants are demonstrated in Figure 9. Most participants (n = 100, 65%) achieved a moderate level of knowledge based on the scale used in this study. One percent received less than or equal to seven points which was considered a poor level of knowledge. Around one third of participants (n = 51, 33%) received between 8 and 14 points and considered

to have a low level of knowledge. Only two participants (1%) received at least 22 or more points and were considered to have a high level of knowledge.

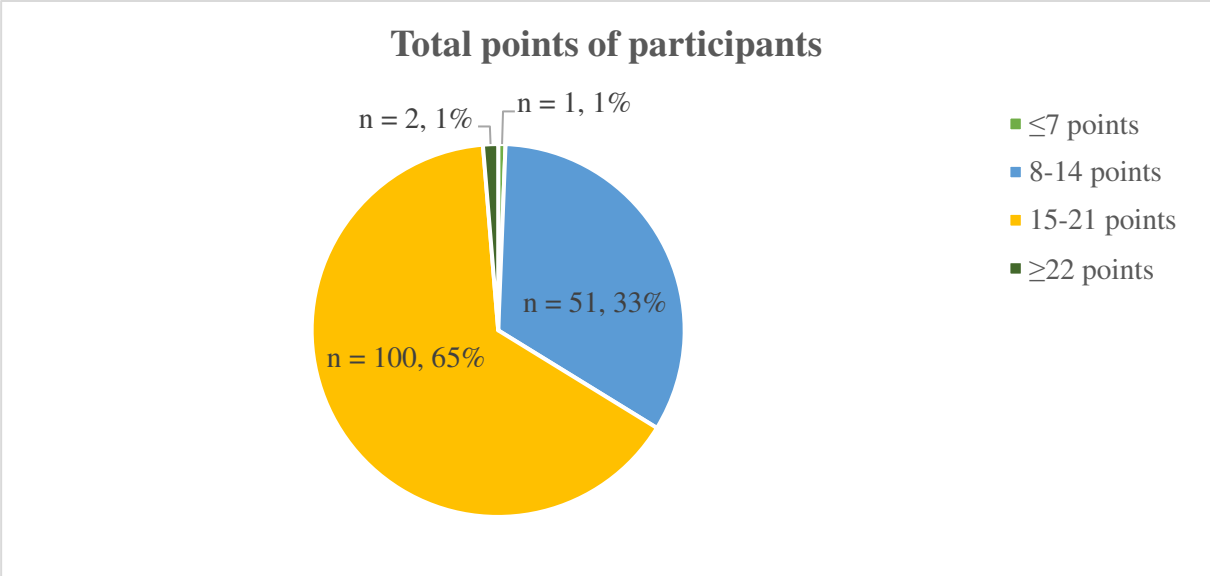

Figure 9. The total points of participants describing the level of knowledge. A point score of less than or equal to seven points out of a total of 31 points was considered a poor level of knowledge. A score of 8-14 points was considered a low level of knowledge. A score of 15-21 points was considered a moderate level of knowledge. A score of more or equal to 22 points was considered a high level of knowledge.

The percentage of participants who received a point from questions with one correct answer are displayed in Figure 10 below. The question most often answered correctly was whether *P. caninum* is motile or non-motile. Ninety-nine percent of participants received one point from the question. The question with one correct answer that was most often answered incorrectly was "What is the colour of *P. caninum*?", as only 6% of participants received one point from this question.

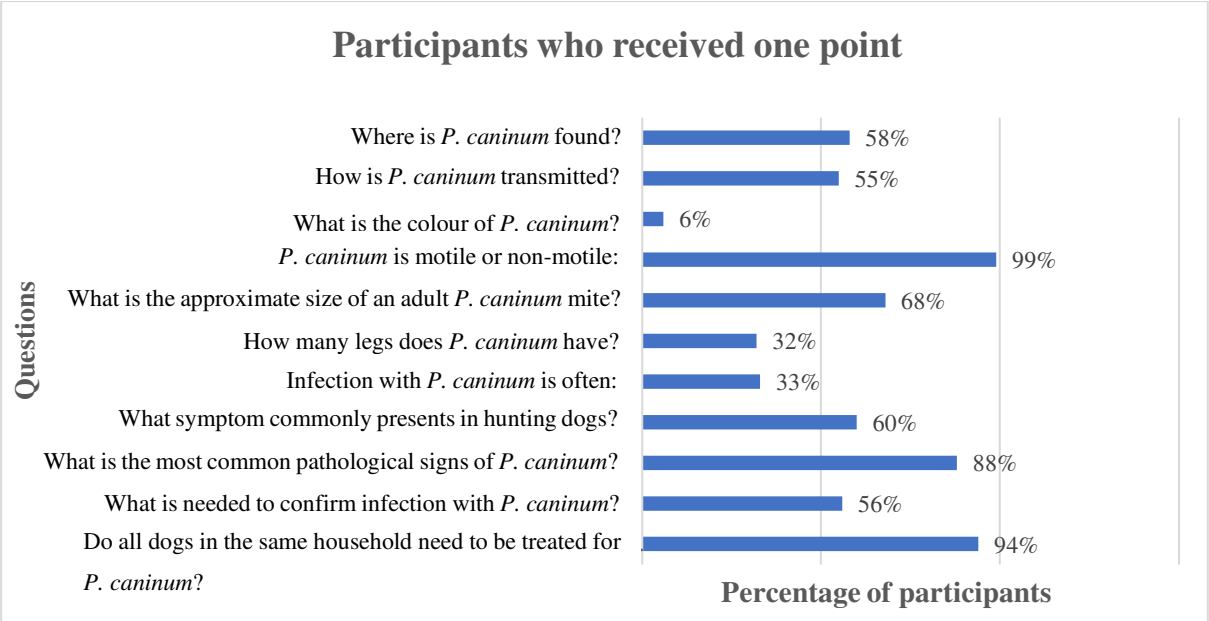

Figure 10. The percentage of participants from 154 who received a point from questions with one correct answer.

From multiple choice questions with more than one correct answer, the percentage of participants who selected all the correct answers are displayed in Figure 11. Most participants (47%) received full points from the question "*P. caninum* inhabits:" by selecting both correct options "Caudal nasal passages" and "Paranasal sinuses". None of the participants (0%) received full points from the questions about clinical signs.

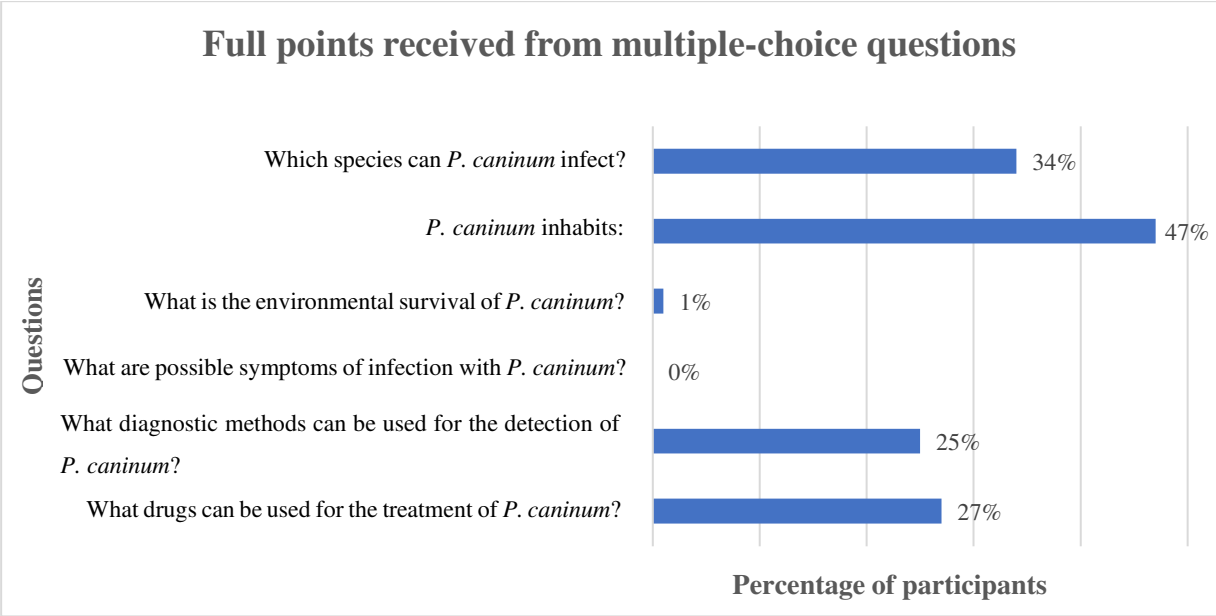

Figure 11. Percentage of participants from 154 who received full points from multiple-choice questions.

5. DISCUSSION

The aim of this study was to evaluate the knowledge of *P. caninum* in veterinarians in Finland. To our knowledge, this is the first study aimed at assessing the knowledge of *P. caninum* in veterinarians in Finland.

The results from this study indicate that most veterinarians had a moderate amount of knowledge of *P. caninum* according to the point scale used. The median point score was 16 points. This means most participants correctly answered around 50% of the questions in the questionnaire. However, the results also demonstrate that only two participants (1%) achieved a high level of knowledge and around one third of participants (n = 51, 33%) achieved a low level of knowledge. As *P. caninum* is considered endemic in Scandinavia (Gunnarsson et al., 2004) and prevalence in Sweden has increased over the past years (Gunnarsson et al., 2001), knowledge of this mite is relevant for veterinarians working in Finland. The results of this study suggest that further awareness and knowledge of this mite is desirable.

Almost all participants (n = 153, 99%) had heard of *P. caninum* before. The same number of participants had treated dogs for *P. caninum.* Veterinarians in Finland seemed well informed that all dogs living in the same household should be treated for *P. caninum* if one is suspected of being infected, yet not all participants knew this. When asked which drugs can be used for the treatment of *P. caninum* only 27% of participants selected all three correct answers and 8% of participants selected at least one wrong answer. This causes concern that veterinarians in Finland are using anthelmintic drugs that are ineffective for the treatment of *P. caninum*. This leads to a financial loss for pet owners. Moreover, ineffective treatment likely results in the dog owners returning to the clinic with the same complaint. This may cause issues with client satisfaction and inefficient use of the veterinarian's time. Additionally, there may be an increase in the risk for re-infection in multi-dog households where not all dogs have been treated against *P. caninum.* As many dogs can be infected asymptomatically (Papazolglou et al, 2000) it is

important to remember to treat all dogs in the same household even if not all are showing clinical symptoms.

Even though 100% of participants knew that *P. caninum* is not zoonotic, 19% of participants answered that it can infect felines. To our current knowledge, *P. caninum* does not infect felines. This could lead to an unnecessary use of anthelmintics in felines for the treatment of *P. caninum*.

All participants knew that *P. caninum* can cause respiratory signs, but not all recognised the other clinical signs it can cause. As *P. caninum* is often treated based on clinical signs and suspicion of infection as diagnostic methods are expensive and labour intensive (Gunnarsson and Zakrisson., 2000), it is important for veterinarians to be able to recognize the variable clinical signs that can be caused by *P. caninum.* While reverse sneezing is the most common clinical sign, it does not present in all dogs (Gunnarsson et al., 1999). Due to an error the questionnaire in Finnish did not have the answer option "I do not know", meaning that more participants may have selected this if the option was available. However, this would not have affected the total point score.

While 85% of participants knew that rhinoscopy can be used to detect *P. caninum*, only 54% knew that nasal flushing can be performed. While studies have shown that infected dogs can have antibodies to *P. caninum* detected with ELISA, this method has not been evaluated as a diagnostic method for the detection of *P. caninum*, and is not commercially available (Baneth and Bornstein, 2021). Therefore, in this study it was considered an incorrect answer. Similarly, nasal radiography has been performed but was ineffective at showing nasal mites (Papazoglou et al, 2000) and therefore was considered an incorrect answer.

It is concerning that only 56% of participants knew that *P. caninum* can only be confirmed by visual detection of a nasal mite. Thirty-nine percent said that it can be confirmed by a positive response to treatment, however, infection cannot be confirmed based on the resolution of clinical signs. In general practice settings where the definitive diagnosis of nasal mites may be

considered impractical, the resolution of clinical signs might be considered to be a satisfactory result and suggest the suspicion of *P. caninum* was correct.

The question with one correct answer that was most often answered incorrectly was regarding the colour of *P. caninum*. While the correct answer in the questionnaire was "Yellow", *P. caninum* has been described as pale yellow (Wallace and Ruhe, 1940) which may be mistaken for the colour white. The multiple-choice question that no participant received full points on was about the clinical signs, as no one selected that central nervous system disorders may occur. However, these occur rarely and are not a typical clinical sign of *P. caninum* (Papazoglou et al., 2000).

Just over half (58%) of the participants knew that *P. caninum* is found worldwide. Twenty percent said they did not know where it could be found. While it is considered uncommon in countries outside of Scandinavia (Bredal, 1998a), its widespread geographical distribution may indicate that it is not as uncommon as suspected (Bredal, 1998b). The participants' opinions on what the prevalence in Finland is was quite variable. It may be interesting to have further studies on the prevalence of *P. caninum* in Finland.

As there have been no other similar studies conducted about the knowledge of *P. caninum* in veterinarians in Finland nor in other countries, it is challenging to compare the results of this study to see if knowledge and awareness of this mite has increased over the years in Finland or compare the knowledge of veterinarians in Finland with those of another country.

There are however limitations to this study and results should be interpreted with caution. The data was collected only through a social media group for veterinarians in Finland and was only available for a limited time of 26 days. The number of participants was relatively low as there are 3080 licensed veterinarians in Finland. This figure was provided from January 2022 and includes retired veterinarians (*Laillistettujen laaja osaamista*, 2022).

In multiple choice questions participants often selected "I do not know" additionally to other answer options. No points were deducted for doing so. It was assumed that participants knew

some of the answers but felt they did not know all the correct answers. However, it may be that participants were not sure of their answers and multiple-choice questions allow the opportunity of participants to choose correct answers by guessing.

Some veterinarians may have submitted the questionnaire more than once as there was no method of regulating the number of times the questionnaire could be submitted. Due to some differences between the English and Finnish questionnaires the answer options were not identical and thus may have influenced the results. Additionally, the questionnaire was not provided in Swedish which is one of the official languages in Finland (*Languages of Finland)* and this may have limited the number of respondents.

CONCLUSION

The results of this study showed that most veterinarians in Finland had a moderate level of knowledge of *P. caninum*, but 1% had a poor level of knowledge and around one third of veterinarians had a low level of knowledge. This indicates there is a need for increasing awareness and knowledge of this mite among veterinarians in Finland. However, results should be interpreted with caution due to the limited sample size and the differences between the English and Finnish questionnaires.

As *P. caninum* is endemic in dogs in Scandinavia and also found and treated in Finland, it is therefore important for veterinarians working in Finland to be aware of the clinical signs associated with *P. caninum*, as well as their morphology, diagnosis and effective treatment.

Few studies have been conducted regarding *P. caninum* and much is still not known about this mite. Through this study we aimed to increase awareness and bring to light the lack of information about *P. caninum* in Finland and the need for further studies. In the future, a study with a larger sample size would provide more accurate results. Additionally, the questionnaire can also be provided in Swedish as this is one of the official languages in Finland.

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APPENDIXES

Appendix 1. Questionnaire in English

Veterinary Knowledge of Nasal Mites (Pneumonyssoides caninum) in Finland

The questions mainly cover distribution, anatomy, diagnosis, and treatment. The questionnaire will only take a few minutes to fill out.

Please note that some questions allow for selection of more than one option.

*Required

1. Do you give your consent to take part in this study? *

Mark only one oval.

- ◯ Yes
- ◯ No

2. Are you licensed to work as a veterinarian in Finland? *

Mark only one oval.

- ◯ Yes
- ◯ No

3. Have you heard of nasal mites (Pneumonyssoides caninum) before?

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ I do not know

Appendix 1 continued

4. Where is P.caninum found?

Mark only one oval.

- ◯ Worlwide
- ◯ Europe
- ◯ Only in Norway, Sweden, and Finland
- ◯ Northern hemisphere
- ◯ I do not know

5. What do you assume is the prevalence of P.caninum in Finland?

Mark only one oval.

- ◯ <10%
- ◯ 20%
- ◯ 40%
- ◯ >50%
- ◯ I do not know

6. Which species can P.caninum infect ?

Tick all that apply.

- ☐ Canine
- ☐ Feline
- ☐ Cattle and sheep
- ☐ Fox
- ☐ Human
- ☐ I do not know

7. How is P.caninum transmitted?

Mark only one oval.

- ◯ Directly
- ◯ Indirectly
- ◯ Directly and indirectly
- ◯ I do not know

8. P.caninum inhabits:

Tick all that apply.

- ☐ Lungs
- ☐ Caudal nasal passages
- ☐ Paranasal sinuses
- ☐ Gastrointestinal tract
- ☐ Liver
- ☐ I do not know

9. What is the colour of P.caninum?

Mark only one oval.

- ◯ White
- ◯ Yellow
- ◯ Red
- ◯ Brown
- ◯ I do not know

10. P.caninum is:

Mark only one oval.

- ◯ Motile
- ◯ Non motile
- ◯ I do not know

11. What is the approximate size of an adult P.caninum mite?

Mark only one oval.

- ◯ 1.0-1.5 mm in length and 0.6-0.9 mm in width
- ◯ 2.0-3.0 mm in length and 0.9 -1.2 mm in width
- ◯ 5.0 mm in length and 2.0-2.5 mm in width
- ◯ 6.0 mm in length and 1.5 -2.0 mm in width
- ◯ I do not know

12. How many legs does P.caninum have?

Mark only one oval.

- ◯ Two pairs of legs located on the anterior part of the body
- ◯ Three pairs of legs located on the anterior part of the body
- ◯ Four pairs of legs located on the anterior part of the body
- ◯ Four pairs of legs located on the posterior of the body
- ◯ I do not know

13. What is the environmental survival of P.caninum?

Tick all that apply.

- ☐ P.caninum cannot survive in the environment
- ☐ P.caninum can survive ten days in cool environments (+1-3°C)
- ☐ P.caninum can survive nineteen days in cool and humid environments (+4-8°C)
- ☐ P.caninum can survive three weeks in warm and humid environments (+18-20°C)
- ☐ P.caninum can survive for up to twenty-four hours in dry environments
- ☐ I do not know

14. Infection with P.caninum is often:

Mark only one oval.

- ◯ Asymptomatic
- ◯ Mild
- ◯ Moderate
- ◯ Severe
- ◯ I do not know

15. What are possible symptoms of infection with P.caninum?

Tick all that apply.

- ☐ Dermatological signs - for example facial pruritus
- ☐ Respiratory signs - for example sneezing, reverse sneezing, coughing, serous nasal discharge
- ☐ Gastrointestinal signs - for example vomiting, diarrhea
- ☐ Central nervous system disturbances
- ☐ Ocular signs - for example lacrimation, orbital cellulitis
- ☐ Signs of liver failure - for example icterus
- ☐ Other signs - for example head shaking, epistaxis, lack of scenting ability (hyposmia)
- ☐ I do not know

16. What symptom commonly presents in hunting dogs?

Mark only one oval.

- ◯ Reverse sneezing
- ◯ Epistaxis
- ◯ Hyposmia
- ◯ Facial pruritus
- ◯ Icterus
- ◯ I do not know

Appendix 1 continued

17. What is the most common pathological sign of P.caninum?

Mark only one oval.

- ◯ Orbital cellulitis
- ◯ Pulmonary and hepatic lesions
- ◯ Sinusitis
- ◯ Venous congestion of the gastrointestinal tract
- ◯ I do not know

18. What diagnostic methods can be used for the detection of P.caninum?

Tick all that apply.

- ☐ Only clinical signs
- ☐ Rhinoscopy
- ☐ Nasal Flushing
- ☐ Xray
- ☐ Baermann test from feces for detection of larvae
- ☐ I do not know

19. What is needed to confirm infection with P.caninum?

Mark only one oval.

- ◯ Clinical signs
- ◯ Positive response to treatment
- ◯ Direct observation of a mite
- ◯ Antibodies to P.caninum in serum by ELISA
- ◯ Eosinophilic inflammation
- ◯ Detection of larvae in feces
- ◯ I do not know

Appendix 1 continued

20. What drugs can be used for the treatment of P.caninum?

Tick all that apply.

- [ ] Ivermectin
- [ ] Selamectin
- [ ] milbemycin oxime
- [ ] praziquantel
- [ ] Fenbendazole
- [ ] I do not know

21. Do all dogs in the same household need to be treated for P.caninum?

Mark only one oval.

- ◯ Yes
- ◯ No
- ◯ I do not know

22. Have you treated dogs for P.caninum in Finland?

Mark only one oval.

- ◯ Yes
- ◯ No

Appendix 2. Questionnaire in Finnish

Eläinlääkintätieto Nenäpunkeista (Pneumonyssoides caninum) Suomessa

Kysymykset kattavat pääasissa jakelun, anatomian, diagnoosin ja hoidon. Kyselyn täyttäminen vie
vain muutaman minuutin.

Huomaa, että joissakin kysymyksissä voi valita useamman kuin yhden vaihdoehdon.

*Required

1. Annatoko suostumuksesi osallistua tähän tutkimukseen? *

   Mark only one oval.

   - ◯ Kyllä
   - ◯ Ei

2. Onko sinulla oikeus toimia elöinlääkärina Suomessa? *

   Mark only one oval.

   - ◯ Kyllä
   - ◯ Ei

3. Oletko kuullut nenäpunkeista (Pneumonyssoides caninum)) aiemmin?

   Mark only one oval.

   - ◯ Kyllä
   - ◯ Ei
   - ◯ En tiedä

4. Missä P.caninum esiintyy?

Tick all that apply.

- [ ] Maailmanlaajuisesti
- [ ] Euroopassa
- [ ] Vain Norjassa, Ruotsissa, ja Suomessa
- [ ] Pohjoisella pallonpuoliskolla
- [ ] En tiedä

5. Mikä on mielestäsi P.caninumin esiintyvyys Suomessa?

Mark only one oval.

- ◯ <10%
- ◯ 20%
- ◯ 40%
- ◯ >50%
- ◯ En tiedä

6. Mihin eläinlajeihin P.caninum voi tarttua?

Tick all that apply.

- [ ] Koira
- [ ] Kissa
- [ ] Nauta ja lampaita
- [ ] Kettu
- [ ] Ihminen
- [ ] En tiedä

7. Miten P.caninum tarttuu?

Mark only one oval.

- ◯ Suorassa kontaktissa
- ◯ Epäsuorassa kontaktissa
- ◯ Suorassa ja epäsuorassa kontaktissa
- ◯ En tiedä

8. Missä P.caninum elää kehossa?

Tick all that apply.

- ☐ Keuhkoissa
- ☐ Nenäontelon takaosassa
- ☐ Nenänsivuonteloissa
- ☐ Ruoansulatuskanavassa
- ☐ Maksassa
- ☐ En tiedä

9. Mikä värinen on P.caninum?

Mark only one oval.

- ◯ Valkoinen
- ◯ Keltainen
- ◯ Punainen
- ◯ Ruskea
- ◯ En tiedä

10. P.caninum on:

Mark only one oval.

- ◯ Liikkuva
- ◯ Liikkumaton
- ◯ En tiedä

Appendix 2 continued

11. Mikä on suunnilleen aikuisen P.caninum-punkin koko?

Mark only one oval.

- ◯ 1.0-1.5mm pituudessa ja 0.6-0.9mm leveydessä
- ◯ 2.0-3.0mm pituudessa ja 0.9-1.2mm leveydessä
- ◯ 5.0mm pituudessa ja 2.0-2.5mm leveydessä
- ◯ 6.0mm pituudessa ja 1.5-2.0 leveydessä
- ◯ En tiedä

12. Kuinka monta jalkaa P.caninumilla on?

Mark only one oval.

- ◯ Kaksi paria jalkoja, jotka sijaitsevat kehon etuosassa
- ◯ Kolme paria jalkoja, joka sijaitsevat kehon etuosassa
- ◯ Neljä paria jalkoja, joka sijaitsevat kehon etuosassa
- ◯ Nejlä paria jalkoja, joka sijaitsevat kehon takaosassa
- ◯ En tiedä

13. Kuinka kauan P.caninum selviytyy ympäristössä?

Tick all that apply.

- ☐ P.caninum ei voi selviytyä ympäristössä
- ☐ P.caninum selviytyy 10 päivää viileässä ympäristössä (+1-3°C)
- ☐ P.caninum voi selviytyä 19 päivää viileässä ja kosteassa ymptärisössä (+4-8°C)
- ☐ P.caninum voi selviytyä kolme viikkoa lämppimässä ja kosteassa ympäristössä (+18-20°C)
- ☐ P.caninum voi selviytyä jopa 24 tuntia kuivassa ympäristössä
- ☐ En tiedä

14. P.caninum infektio on usein:

Mark only one oval.

- ◯ Oireeton
- ◯ Lievä
- ◯ Kohtalainen
- ◯ Vakava
- ◯ En tiedä

15. Mikä ovat mahddollisia P.caninum - infektion oireita?

Tick all that apply.

- ☐ Dermatologiset oireet - esim. kasvojen kutina
- ☐ Hengityselimistön oireet - esim. aivastelu, käänteinen aivastelu "reverse sneezing", yskä, sierainvuoto
- ☐ Ruoansulatuskanavan oireet - esim. oksentelu, ripuli
- ☐ Keskushermoston häiriöt
- ☐ Silmäoireet - esim. kyynelvuoto, silmäkuopan alueen tulehdus/orbitaselluliitti
- ☐ Maksan vajaatoiminta - esim. ikterus
- ☐ Muut oireet - esim.pään vapina, nenäverenvuoto, hajuaistin heikentyminen

16. Mitä oireita esiintyy yleensä metsästyskoirilla?

Mark only one oval.

- ◯ Käänteinen aivasteul "reverse sneezing"
- ◯ Nenäverenvuoto
- ◯ Hajuaistin heikentyminen
- ◯ Kasvojen kutina
- ◯ Ikterus
- ◯ En tiedä

17. Mikä on P.caninumin yleisin patologinen merkki?

Mark only one oval.

- ◯ Silmäkuopan alueen tulehdus/orbitaselluliitti
- ◯ Keuhko- ja maksavauriot
- ◯ Sinuiitti
- ◯ Ruansulatuskanavan verentungos
- ◯ En tiedä

18. Mitä diagnostisia menetelmiä voidaan käyttää P.caninum tartunnan osoittamiseen?

Tick all that apply.

- ☐ Vain oirekuva
- ☐ Rinoskopia
- ☐ Nenäontelon huuhtelunäyte
- ☐ Röntgenkuvantaminen
- ☐ ELISA
- ☐ Baermannin menetelmä ulostenäytteestä toukkies havaitsemiseksi
- ☐ En tiedä

19. Miten P.caninum - tartunta voidaan vahvista?

Mark only one oval.

- ◯ Oirekuva
- ◯ Positiivinen vaste hoitoon
- ◯ Nenäpunkin suora havainto
- ◯ P.caninum vasta-aineet ELISA:lla
- ◯ Eosinofiilinen tulehdus
- ◯ Toukkien havaitseminen ulosteesta
- ◯ En tiedä

20. Mitä lääkeitä voidaan käyttää P.caninumin hoitoon?

Tick all that apply.

- [ ] Ivermektiini
- [ ] Pratsikvanteli
- [ ] Milbemysiini-oksiimi
- [ ] Fenbendatsoli
- [ ] Selamektiini
- [ ] En tiedä

21. Pitääkö kaikki sama kotitalouden koirat hoitaa P.caninum-taudin varalta?

Mark only one oval.

- ◯ Kyllä
- ◯ Ei
- ◯ En tiedä

22. Oletko hoitanut koiran P.caninum tartuntaa Suomessa?

Mark only one oval.

- ◯ Kyllä
- ◯ Ei
- ◯ En tiedä

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