Strongyloides stercoralis in Swiss dogs – a retrospective study suggests an increasing occurrence of this potentially zoonotic parasite as a consequence of dog imports#

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Strongyloides stercoralis bei Hunden in der Schweiz – eine retrospektive Studie deutet auf ein zunehmendes Auftreten dieses potenziell zoonotischen Parasiten als Folge von Hundeimporten hin

Strongyloides stercoralis ist ein weltweit vorkommender Nematode, der Caniden und Primaten (einschliesslich des Menschen) infiziert und für eine weitgehend unterschätzte Zoonose verantwortlich ist. Wir stellen hier 18 Fälle mit insgesamt 20 von *S. stercoralis* betroffenen Hunden vor, die zwischen 2010 und 2020 in der Schweiz diagnostiziert wurden.

Bei zehn Hunden war die Baermann-Untersuchung positiv auf *S. stercoralis*-Larven, bei vier verdächtig, bei einem negativ und bei zwei Hunden wurde diese nicht durchgeführt. Bei drei Hunden wurde die Infektion nur bei der Sektion histologisch oder durch direkte Kot- oder Schleimhautabstriche aus dem Darmgewebe nachgewiesen. Die Bestätigung bei koproskopisch verdächtigen, sezierten sowie Baermann-negativen Hunden stützte sich auf genetische Analysen. Zwölf Hunde wurden anamnestisch aus Osteuropa (n=4), dem Mittelmeerraum (n=5) oder Deutschland (n=3) importiert. Sie waren 7 Wochen bis 9,5 Monate alt, und auch die angeblich in der Schweiz geborenen Hunde waren jünger als ein Jahr (ausser zwei Tiere, im Alter von 15 Monaten und 14 Jahren). Dreizehn Hunde waren Rüden und 6 Hündinnen (1 unbekannt). Die am stärksten vertretenen Rassen waren Chihuahuas (n=5), Französische Bulldoggen (n=4) und Zwergspitze (n=3). Die häufigste Symptomatik und Grund für die Konsultation war Durchfall, der bei 11/20 Tieren auftrat. Weitere gastrointestinale Symptome waren Erbrechen, Anorexie/Hyporexie, Adipsie, Dehydratation, ange-

Summary

Strongyloides stercoralis is a worldwide occurring nematode infecting canids and primates (including humans), responsible for a largely underestimated zoonotic disease. We here present 18 cases including overall 20 dogs affected by *S. stercoralis*, diagnosed in Switzerland between 2010 and 2020.

The Baermann examination was positive for *S. stercoralis* larvae in 10, suspicious in 4, negative in one and not performed in 2 dogs. In 3 dogs the infection was identified only at necropsy by histology or by direct faecal or mucosal smears from intestinal tissue. Confirmation of suspected, necropsied and Baermann-negative dogs relied on genetic analyses. Twelve dogs had a history of import from Eastern Europe (n=4), the Mediterranean basin (n=5) or Germany (n=3). They were 7 weeks to 9,5 months old, and also the dogs supposedly born in Switzerland were younger than one year (except two, aged 15 months and 14 years). Thirteen dogs were males and 6 females (1 unknown). The most represented breeds were Chihuahuas (n=5), French Bulldogs (n=4) and Pomeranians (n=3). The most frequent clinical sign and reason for presentation was diarrhoea, occurring in 11/20 animals. Further gastrointestinal symptoms were vomiting, anorexia/hyporexia, adipsia, dehydration, tense abdomen and tenesmus. Respiratory symptoms were the second most frequent, with coughing in 7/20 animals, followed by tachypnoea/dyspnoea in 5 and (reverse) sneezing in 3 dogs.

Treatment with 50 mg/kg BW fenbendazole p.o. over 5 days was successful in 4 cases in which a follow-up examination was performed 3–6 weeks later; prolonged treatment over 21 days was also effective. Ivermectin

https://doi.org/10.17236/sat00340

Eingereicht: 25.08.2021
Angenommen: 28.10.2021

#Prof. Dr. med. vet Peter Deplazes zur Pensionierung gewidmet.

spanntes Abdomen und Tenesmus. Am zweithäufigsten traten respiratorische Symptome auf, mit Husten bei 7/20 Tieren, gefolgt von Tachypnoe/Dyspnoe bei fünf und (Rückwärts-) Niesen bei drei Hunden.

Die Behandlung mit 50 mg/kg KG Fenbendazol p.o. über 5 Tage war in vier Fällen erfolgreich, basierend auf einer Nachuntersuchung nach 3–6 Wochen. Eine verlängerte Behandlung über 21 Tage war ebenfalls wirksam. In der Literatur beschriebene Ivermectin-Off-Label-Protokolle, z.B. 0,8 mg/kg KG s.c. oder 0,5 mg/kg KG i.m. und wiederholt nach 2 Wochen, waren erfolgreich, basierend auf Kontrolluntersuchungen nach 3–10 Wochen.

Infektionen mit *Strongyloides stercoralis* sind klinisch relevant, potenziell zoonotisch und müssen bei Magen-Darm- und Atemwegserkrankungen des Hundes, insbesondere bei jungen und importierten Hunden, in die Differenzialdiagnose einbezogen werden.

Schlüsselwörter: Tierhandel, Nematode, Welpen, Strongyloidose, Behandlung, Zoonose

off-label protocols described in the literature, e.g. 0,8 mg/kg BW s.c. or 0,5 mg/kg BW i.m. repeated after 2 weeks, were successful based on control examinations performed 3–10 weeks later.

Strongyloides stercoralis infections are clinically relevant, potentially zoonotic and need to be included in differential diagnoses in case of canine gastrointestinal and respiratory disorders, especially in young and imported dogs.

Keywords: animal trade, nematode, puppies, strongyloidosis, treatment, zoonosis

Introduction

Strongyloides stercoralis belongs to the Rhabditidae family and is a 3–8 mm slender intestinal nematode that infects dogs and wild canids, humans, non-human primates, and occasionally cats. The parasite is most commonly found in tropical and subtropical regions but may be diagnosed also in temperate regions.[48]

In its complex life cycle, only female *S. stercoralis* worms are parasitic. The adult females are embedded in the intestinal mucosa and reproduce asexually by parthenogenesis, releasing eggs into the gut lumen. First-stage larvae (L_1; rhabditiform larvae) hatch in the intestine and are shed with the faeces, or can develop directly into second- and infectious third stage larvae (L_3; filariform larvae) still in the intestine. The L_1 shed with faeces may develop into L_3 in the soil within 24 hours, or mature into non-parasitic female and male adult worms capable of reproducing sexually in the environment. This process can lead to a massive multiplication and contamination of the surroundings. The infectious L_3 of either cycle can penetrate the skin of the susceptible host, pass to the lungs via the systemic circulation, enter the airways, be swallowed, and ultimately reach the intestine, where they invade the mucosa and mature into adult females. Alternatively, hosts can get orally infected by L_3 or, epidemiologically less relevant, through transmammary (lactogenic) transmission. Additionally, autoinfections take place when L_1 already develop into L_3 in the intestine and reinfect their host by penetration of the intestinal mucosa or the perianal skin.[8] However, in dogs, autoinfection is considered a rare event, and associated to an immune suppressed state.[41]

Studies performed on various continents indicate variable but generally low prevalence in dogs. For instance, in Brazil, only two out of 215 (0,9 %) dogs from breeding kennels were copropositive in one study and 1/181 (0,6 %) in another study, but 3,4 % and 26,3 % in two consecutive years in household dogs from an urban area of the country.[12, 16, 32] In Japan, prevalences varied between 0,6–1,4 % among private household dogs but were higher e.g., in Cambodia (14,9 %).[24, 42] Higher prevalences (15–25 %) were found on the African continent, e.g., in Nigerian dogs, in contrast with more recent data indicating a prevalence of 1,6 %.[49, 26] In the United States, reports of single cases were complemented with a study with more than 7000 dogs, revealing a prevalence of 0,2 %.[42, 18, 35, 44]

Low prevalences have been described from European countries, e.g. from Germany, with numbers varying between 0,3 % (analysing more than 3000 dogs) and 3 % (of 82 adult dogs), or from dogs in Greece (0,1–1,8 %), or Italy (0,2–2,2 %).[11, 17, 28, 36, 38, 40] In eastern European countries, for instance in Romania, dog prevalence was 3,8 %, in Slovakia the prevalence varied from 1,2 % to 12 %.[34, 43, 45] Case reports were described also in Northern Europe, i.e. from Finland, and, recently, from the United Kingdom.[10, 21] However, these studies were conducted in limited geographic areas in selected countries, are based on testing different dog populations

and, importantly, applied different detection procedures. Thus, direct comparisons are challenging.

Canine strongyloidosis is reported to represent a frequent problem in breeding kennels, particularly during periods of warm temperatures and humidity.[22] Puppies develop clinical signs when infected with high numbers of parasites, while adult dogs may remain asymptomatic even with massive worm loads.[10, 14] Pathogenesis is related to the establishment of adult females in the small intestine, where the epithelium gets flatter due to their settlement at the base of the villi and, partially, in the intestinal glands, leading to diarrhoea.[8] Enteritis may be supported by autoinfections through the development of L_1 to L_3 in the intestine, causing chronically infected or even hyperinfected hosts, in which L_3 migrate also to other body sites. Especially in the lungs, migrating larvae can cause haemorrhages and local inflammations: in such cases, bronchopneumonia, cough, and dyspnoea are observed. Under experimental conditions, dissemination to other body sites than the intestine, e.g. mesenteric lymph nodes, kidney and prostate, was induced by immunosuppressive drugs.[41, 13, 19] Corticosteroids were shown to cause recrudescence of *Strongyloides* infections and to contribute to persistent infections. This suggested that initially asymptomatic infections may become symptomatic in cases of immunosuppression.[13, 19] Further clinical signs include lethargy, weakness, weight loss and other unspecific signs that may have a fatal outcome in puppies. [8, 18, 10, 21]

Recently, Basso et al. (2019)[1] reported on three clinical cases that were presented to the Small Animal Clinic and parasitologically confirmed at the Institute of Parasitology of the Vetsuisse Faculty in Bern. All dogs presented with diarrhoea, one dog with additional respiratory problems, one showed tremors and was comatose and hypothermic, and one was vomiting. They were between 3–11 months old and had been imported to Switzerland from France (n=2) or Belgium (n=1).[1] Based on data of the Federal Food Safety and Veterinary Office, approximately 25'000 dogs are imported yearly, with increasing numbers in 2020 (29'600). These numbers currently do not consider thousands of dogs that are ordered via internet and imported illegally (see brochure "Augen auf beim Welpenkauf" of the University of Zurich, https://www.zh.ch/ or https://www.kltmed.uzh.ch/de.html, and http://www.hundekauf.ch/), and that represent an uncontrolled source of infective agents. *Strongyloides stercoralis* is not only of clinical relevance for dogs: infected people were estimated to be at least 100 million worldwide. However, human strongyloidiasis is a neglected disease, and due to inaccuracy of diagnosis it was suggested that more than 370 million people may be affected.[5, 47] Infected humans complain about abdominal, respiratory and/or skin issues, and in immunosuppressed patients strongyloidiasis can become a life-threatening hyperinfection syndrome related to autoinfection.[5, 4] Morphologically, parasite isolates of dogs and humans are not distinguishable, and isolates obtained from humans were infective for dogs.[20] Several studies identified *S. stercoralis* in relevant percentages in humans and dogs within the same communities, but only more recent investigations showed that dogs and humans may share the same haplotypes, confirming the role of dogs as potential reservoir hosts.[42, 45, 39] On the other side, the use of nuclear and mitochondrial genetic markers indicated that two *S. stercoralis* populations exist in dogs: one seems to be dog-specific (defined as lineage B) and the other one is seen in both dogs and humans (defined as lineage A).[25] In the following, machine learning-based analyses relying on multi-locus sequence typing were able to combine data of more than 1'000 sequences obtained from different locations and hosts. The results indicated that *S. stercoralis* is a species complex comprehending different populations. Two among them seem to be over-represented in dogs while others are mainly found in humans.[2, 3] Interestingly, the isolates of the three above mentioned cases identified in Switzerland had an identical genetic background on both nuclear and mitochondrial gene sequences and were highly similar to other zoonotic isolates.[1]

An increasing number of diagnosed dog cases of *S. stercoralis* in Switzerland may be correlated to an increased import of dogs from countries with known occurrence of the parasite. Here, we summarise and analyse all 20 dogs parasitologically identified at the Institute of Parasitology, Vetsuisse Faculty in Zurich between 2010 and 2020 and include history, the reason for presentation in the veterinary practices and their follow-up (where available). Based on these data, we aim supporting clinicians and diagnostic laboratories in the identification of infected animals and with appropriate advice for preventing infections in humans.

Patients, Parasitological Methods and Results

Between 2010 and 2020, 20 *S. stercoralis* positive dog samples (including one pooled and 19 individual samples) were identified at the Parasitology Diagnostic Centre of the Institute of Parasitology (PDC), Vetsuisse Faculty in Zurich. Samples originating from the same animal owner family were considered as a single case, resulting in overall 18 cases (for details, see Table 1).

The dogs were presented at the Department for Small Animals of the Vetsuisse Faculty Zurich (Clinic for Small Animal Medicine and Section for Small Animal Reproductive Medicine, 3 cases each) and at 8 different veterinary practices throughout Switzerland, accounting for 1–4 cases each. In three cases dogs were necropsied,

either at the Institute of Veterinary Pathology in Zurich, or in a private laboratory.

Variably detailed information was available from the different cases. Case one and three were investigated more in-depth and can be considered as representative cases.

Faecal analyses

To date, diagnosis of *S. stercoralis* in dogs relies on the microscopic detection of larval stages shed in faecal samples, usually isolated by the Baermann funnel technique.[8] Samples must be as fresh as possible, and multiple samples increase diagnostic sensitivity. Larvae may only occasionally be observed when other, more commonly used diagnostic techniques (i. e. sedimentation/flotation) are applied. Specificity is linked to the morphological identification of the larvae requiring the need to differentiate between larvae of *S. stercoralis* and those of other parasitic or free living species.

Overall, Baermann examination was performed with 15 dog samples, of which 10 were positive for *S. stercoralis* larvae, and in 4 additional cases an infection was suspected (Table 1). In three more dogs, the infection was identified only at necropsy (histologically, direct faecal or mucosal smear). In one case Baermann examination was negative. In this and in the three necropsied animals, diagnostics relied on genetic analyses.

Faecal samples were also examined by the sedimentation/flotation technique for the presence of intestinal parasites in 12 dogs, resulting positive for *Strongyloides* larvae in two cases, and in 7 dogs examined by the SAFC (sodium acetate-acetic acid-formalin concentration)[8] technique 3 samples resulted positive for nematode larvae. Further parasitological analyses were performed directly in the veterinary practices or in laboratories other than the PDC at the Institute of Parasitology in Zurich, identifying additional infections with *Cystoisospora* and *Giardia* sp.. These results are mentioned in the appropriate case descriptions and in Table 1.

Genetic analyses

In 12/20 dogs, the presence of *S. stercoralis* was confirmed by PCR performed with faecal samples. Larvae collected by the Baermann technique were resuspended in 200 µl distilled water and DNA was isolated after freezing in liquid nitrogen using the Qiaamp Fast DNA Stool Mini Kit. A fragment of about 250–270 bp of the 18S rRNA gene of *Strongyloides* sp., which encompasses a variable region, was amplified by PCR.[30] In three cases (Case 2, 3b, 5), dogs died and necropsy was performed. A macroscopic examination of all inner organs according to standard procedures was followed by histological tissue samples examinations according to standard protocols and analogous procedures as described above were applied for detecting DNA in a direct faecal smear, in histological paraffine cuts and in a mucosal smear obtained during necropsy. PCR products were detected in 1,5 % agarose gels and sequenced by a private company (Microsynth, Switzerland) (cases 2, 3b and 5). In all cases sequence homologies with corresponding *S. stercoralis* sequences deposited in GenBank were >99 % to 100 %.

Strongyloides stercoralis: cases diagnosed at the Parasitology Diagnostic Centre (PDC) of the Institute of Parasitology, Zurich, between 2010 and 2020

Case 1

A 2 months old female Chihuahua puppy was presented as an emergency due to sudden onset of lethargy with a history of adipsia and anorexia for one day as well as diarrhoea and vomitus for 12 hours. The dog was collected by the owner the day before from a dog seller in Germany, but originated from a breeding station in the Czech Republic. Documents indicated that it had been vaccinated 6 days before, and also dewormed, but no information on the anthelmintics used was available.

At presentation the dog weighed 750 g with a Body Condition Score (BCS) of 4–5/9 and was markedly depressed. The rectal temperature was 39,3 °C, heart rate 200 per minute (min), respiratory rate 40/min, capillary refill time 2 seconds and mucous membranes were slightly pale. The puppy was assessed to be 6–8 % dehydrated. Other significant physical examination findings were a painful abdomen with fluid filled intestines. After oral administration of 50 % glucose solution as part of the initial emergency treatment, the dog was hospitalised. Emergency laboratory blood work revealed a marked fasting hypoglycemia of 1,3 mmol/L (reference interval [RI]: 4,8–7,2 mmol/L) and decreased electrolytes (Na 141 mmol/L, RI: 146–153 mmol/L; K 3,1 mmol/L, RI: 4,8–7,2 mmol/L). Using a faecal swab, occult blood (Haemoccult®, Sprothen) but no canine parvovirus antigen (Snap Parvo®, IDEXX) was detected. A presumptive diagnosis of hypoglycemia due to parasitic gastroenteritis was made. Over the next 3 days, fluid therapy (lactated Ringer's (LR) solution at 3 to 8 ml/kg body weight (BW)/h, depending on hydration status, with potassium and glucose supplementation based on serum levels) and parenteral amoxicillin-clavulanic acid (20 mg/kg BW) were administered intravenously every 8 hours. The dog's depression resolved overnight and vomiting but not diarrhea stopped.

Faecal flotation revealed the presence of *Giardia* cysts and oocysts of *Cystoisospora* sp.. Consequently, the dog was treated orally with toltrazuril (10 mg/kg BW for 5 days) and fenbendazole (50 mg/kg BW for 3 days). On day 3 of hospitalisation, glucose supplementation was discontinued. The dog remained stable during the day with multiple frequent feedings of a gastrointestinal diet (i/d® Canine Gastrointestinal Health Prescription Diet®) and was sent home the same evening. Five days later the puppy became severely depressed again with a history of several episodes of vomiting the same day, and hyporexia and tenesmus since being discharged. Within these five days the puppy lost 200 g of BW. On physical examination, it was assessed as thin (BCS 2/9) and dehydrated (again 6–8 %), with a tense abdomen. Blood work showed a non-regenerative anaemia (htc 29 %, reticulocytes 0,36 %), leucopenia (7×10³/µl with lympho- and neutropenia), increased urea (5,9 mmol/L), hypoproteinemia (33 g/L) and decreased electrolytes (Na 142 mmol/L, K 4,1mmol/L).

Postprandial serum bile acids, which were tested in order to exclude a portosystemic shunt, were with 2,1 µmol/L within the normal range (RI: <25 µmol/L). The puppy was hospitalized again with intravenous infusion as before and started on enrofloxacin (10mg/kg i.v. sid) in addition to amoxicillin-clavulanic acid. To prevent vomiting and reflux oesophagitis, maropitant (1mg/kg BW s.c. sid) and the proton pump inhibitor esomeprazole magnesium (0,7mg/kg BW i.v. sid) were administered. Additionally, the puppy received metamizole (20mg/kg i.v. tid) for analgesia. This time, examinations of faecal samples by both flotation and SAFC techniques were negative for the protozoans found before but revealed some non-identifiable larvae. Therefore, a further faecal sample was subjected to Baermann analysis for isolation of living larvae.

On the second day of hospitalization the puppy was still lethargic and showed a tense, painful abdomen as soon as the effect of metamizole was diminishing. A large number of rhabditiform (Figure 1) and filariform (Figure 2) *Strongyloides* larvae were isolated from the faecal sample. PCR amplification of larval DNA subsequently revealed an amplicon of the expected size. On the third day the dog was alert without any clinical signs. In the evening the puppy was discharged with the advice that it should be fed four times a day and dewormed the next day with a single dose of milbemycin-oxime and praziquantel (0,5 mg and 5 mg/kg BW, respectively). The animal recovered completely and no further testing was performed.

Case 2

A private laboratory for veterinary analyses was commissioned to dissect a 9,5 month old male Chihuahua, the reason of death being unknown. Pathological macroscopic analyses revealed that the dog was emaciated and that the intestinal wall was thin with circular stripes. Histologically, a high number of nematodes deeply embedded in the mucosa of the small intestine were observed, with dilatation of the crypts and massive lymphocytic enteritis. Also the lungs showed a strong congestion. Material from the small intestine conserved in formalin was PCR negative, whereas *S. stercoralis* DNA could be detected in material collected from paraffine sections.

Case 3

In a private breeding kennel, a Chihuahua / Cavalier King Charles Spaniel mixed-breed puppy, 7 weeks old, suddenly died, after showing recurring mild symptoms like listlessness, abdominal pain and mild diarrhoea for a few days. Hyperalbuminaemia was the only abnormality in the blood analysis. Because the other three puppies from the same litter showed similar signs, a pooled faecal sample was subjected to parasitological

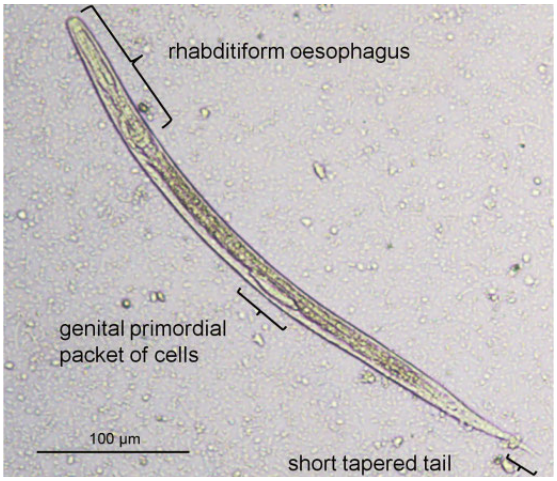

Figure 1: *Strongyloides stercoralis*, second-stage rhabditiform larva (measured length: 430 µm). First stage larvae have similar morphologically but are shorter (180–380 µm), with an oesophagus extended to 1/3 of the body length.

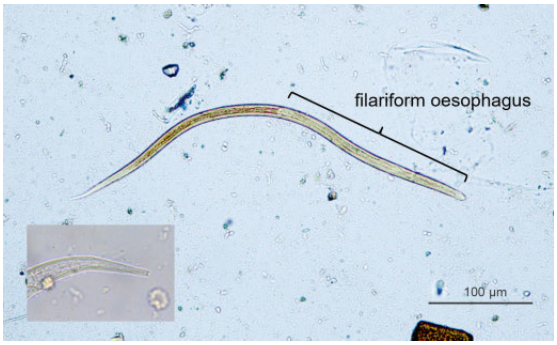

Figure 2: *Strongyloides stercoralis*, infective third-stage filariform larva (up to 600 µm); insert: notched tail.

examination. First, the sample was analysed by the flotation and the SAFC techniques. [8] In addition to *Cystoisospora* sp. oocysts, some unspecified larvae were detected. Based on morphology (size of the larvae between 280 µm to 465 µm, fast and whip-like movement, rhabditiform oesophagus, a genital primordial packet of cells, and a short tapered tail), the larvae were identified as *Strongyloides* sp. (L_1 and L_2). Consequently, the three pups and their bitch (pure-bred Cavalier King Charles Spaniel, 2,5 years old) were treated with milbemycin-oxime and praziquantel according to manufacturer's instructions (0,5 mg and 5 mg/kg BW, respectively), and toltrazuril (10 mg/kg BW for 5 days). Due to diarrhoea, supportive fluid therapy was recommended. The following day, a second puppy died. Necropsy indicated no specified alterations. Histological examination of the small intestine indicated expansion of the crypts, villous atrophy, and sections of parasitic stages (Figure 3). Mucosal scrapings showed nematode eggs (Figure 4) and larvae that were later on identified as *S. stercoralis* by PCR and sequencing. Post-treatment faecal samples were highly positive for *S. stercoralis* in the two puppies but negative in the bitch sample. Nevertheless, a direct faecal smear from the bitch showed few L_1. During the next 10 days, one puppy recovered clinically while the other one had increased diarrhoea and died 14 days after the initial treatment. Further faecal analysis still showed the presence of *Strongyloides* larvae in the surviving puppy and the bitch, while *Cystoisospora* sp. was no longer detected. The two dogs were therefore treated twice with ivermectin (0,5 mg/kg BW i.m.) two weeks apart. Follow up examinations of faecal samples one, five and ten weeks later were negative for both animals, and the puppy recovered completely.

Next to the affected group, another bitch (pure-bred Chihuahua) and a stud dog (pure-bred Chihuahua, father of the puppies) from the private kennel (but kept separate) were always negative in the faecal examinations, and therefore they were not treated. A comprehensive history revealed that the bitch had been purchased in Israel and imported into Switzerland at the age of 6 months and never left the country since. The *Strongyloides* infections were observed in the first litter of this bitch. The breeder told that they never had any problems with previous litters in the kennel and always tried to maintain a high hygienic standard, including disinfection of the environment with liquid bleach (2 % sodium hypochlorite).

Case 4

The reason of presentation at a private veterinary clinic of a 11,5 month old male Bulldog was diarrhoea. The dog had been imported from Germany. Amongst other analyses, SAFC and flotation procedures revealed the presence of larvae, that were confirmed as *S. stercoralis* by PCR. The dog was treated with fenbendazole (50 mg/kg BW p.o. for five days) and metronidazole (50 mg/kg BW, p.o., also for five days). Three weeks later, the dog was *Strongyloides* negative but positive for *Cystoisospora* sp.. It was additionally treated with toltrazuril (10 mg/kg BW p.o.). Four weeks after the initial presentation, a faecal sample was negative for parasites and faecal consistency was good.

Case 5

In this case, similar to case 2, direct smears of small and large intestines of a necropsied dog resulted positive for nematode larvae. Their identification as *S. stercoralis* was confirmed by genetic analyses. The dog was diagnosed

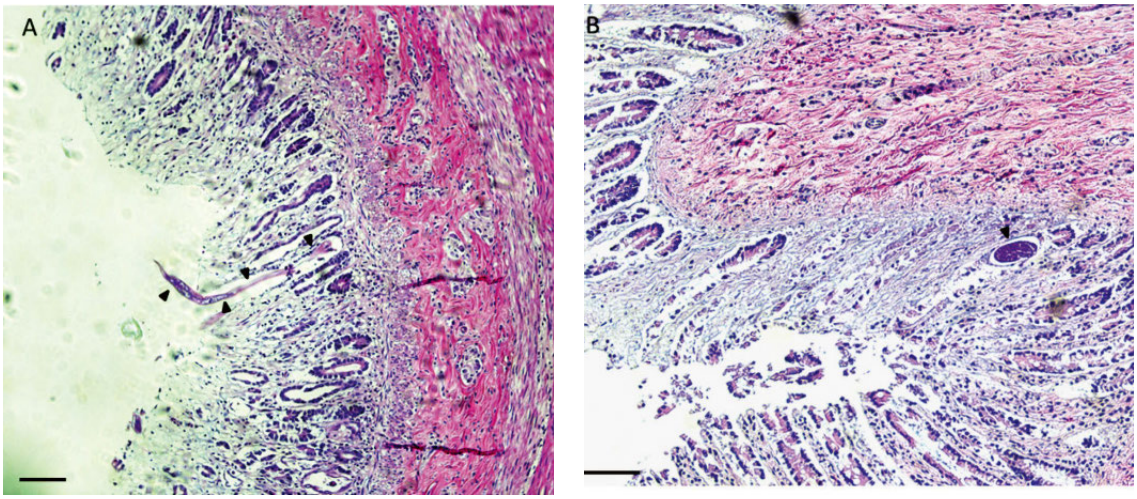

Figure 3: Histological section (haematoxylin and eosin stain) of the small intestine of a puppy infected with *Strongyloides stercoralis* (Case 3b). The adult parasitic stage is marked by arrow heads. A. Longitudinal section. B. Cross section (bar in the bottom left corner: 100 µm).

having a vitamin B12 deficiency and had been euthanised. No more data were available.

Case 6

A male French Bulldog, aged 6 months, was presented to a private veterinary clinic due to previous occasional coughing and currently more frequent coughing for 3–4 days, and due to watery diarrhoea for 2–3 days. The dog had been dewormed with milbemycin-oxime/praziquantel orally two weeks before. Faecal parasitological examination revealed the presence of *S. stercoralis* larvae by the Baermann technique, confirmed by PCR, and of *Giardia* cysts by flotation. The dog was treated with fenbendazole (50 mg/kg BW, p.o., for five days). Treatment was repeated after 2 weeks and a control performed 6 weeks after diagnosis indicated that the dog was healthy and coproscopically negative.

Case 7

A male Pomeranian, aged 4,5 months, was presented as an emergency to a private veterinary clinic in general bad clinical condition, dehydration and hypoglycaemia (Table 1, case 7a). The dog had been imported from Portugal one week earlier. The animal received symptomatic treatment and fenbendazole and toltrazuril. One week later, the animal was presented as an emergency due to diarrhoea and vomiting. The dog's general condition was severely reduced. The dog was dehydrated and laboratory work indicated hypoglycaemia, anaemia, hypoproteinaemia, slight leucocytosis with left shift and monocytosis. Ultrasonography of the abdomen showed fluid filled and paralytic intestines, with thickened mucosa, indicating severe enteritis. The dog was treated symptomatically, including blood transfusion, antibiotics, antiemetics, proteon-pump inhibitor and nasogastric tube feeding. Faecal analysis indicated a suspected presence of *S. stercoralis* by the Baermann technique (which was then confirmed by a positive PCR result). Therefore, the dog was again treated with fenbendazole (50 mg/kg BW, p.o., for five days). Nine days later, larvae were still present in the faeces, but the dog was clinically stable, eating by himself, and therefore discharged from the hospital with the advice to continue fenbendazole treatment for three weeks and then to repeat the faecal analysis. At home the appetite of the dog was good, but when eating too fast the owner reported regurgitation and/or vomiting. Sucralfate was prescribed as an antiulcer protectant. Due to ongoing problems of swallowing dry food one months after first admission, a videofluoroscopic swallow study with fluid, soft and solid food was recommended. It revealed accumulation of boluses in the thoracic oesophagus with prolonged passage. Transient oesophageal dysmotility and/or hypermotility due to oesophagitis was assumed and additionally to sucralfate, omeprazole was administered for further 3 weeks with the advice to temporarily switch to liquid food. Four weeks later the dog was presented for vaccination in good general condition.

Interestingly, the same day when this dog was diagnosed with *S. stercoralis*, larvae also highly suspicious for *S. stercoralis* were identified in a faecal sample of another male Pomeranian and the morphological identification was also confirmed by a positive PCR result (Table 1, case 7b). This dog was presented to another private practice, due to coughing. The dog was 6 months old and also imported from Portugal. In addition, *Giardia* cysts were identified by the SAFC method. The dog was treated with fenbendazole (50 mg/kg BW, p.o.) for five days, without further follow-up.

There is a strong suspicion that these two cases (7a, 7b) were related, as the two dogs had been imported from Portugal and the owners had the same surname (but different postal addresses).

Case 8

A male Chihuahua, 3 months old and acquired from a Swiss breeding facility, vaccinated and dewormed one month before, was presented as an emergency with vomiting and diarrhoea. The day before presentation, diarrhoea contained blood and the dog had reduced appetite. At clinical examination the dog excreted orange coloured unformed faeces and showed abdominal pain. Its overall condition was reduced and the dog was mildly dehydrated. Haematology and blood chemistry values were within the normal ranges. Ultrasonography of the abdomen showed a filled stomach and moderately hypomotile intestines, indicating gastroenteritis. The following day, the dog was in good clinical condition and showed appetite. Faecal examination revealed a considerable number of larvae at Baermann examination that could not be definitely identified morphologically. PCR confirmed the presence of *S. stercoralis* DNA. Symptomatic therapy was then complemented with

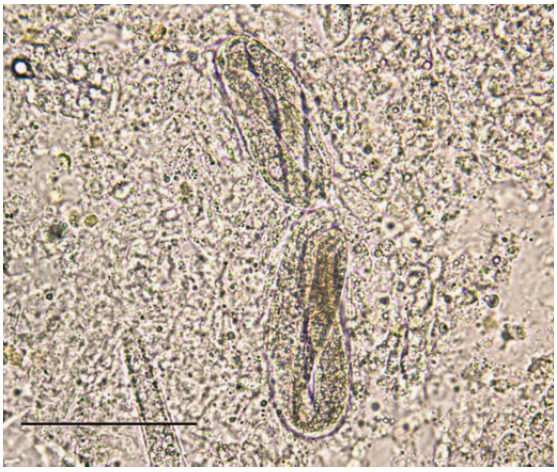

Figure 4: : Embryonated eggs of *Strongyloides* sp. obtained from a scraped intestinal mucosal sample (Case 3b).

Table 1: Breed, sex, age, country of origin and presence of gastrointestinal and respiratory signs in 20 dogs with *Strongyloides stercoralis* diagnosed at the Diagnostic Centre of the Institute of Parasitology, Vetsuisse Faculty in Zurich, between 2010 and 2020.

Case no.	Year	Breed	Sex	Age	Origin	Gastrointestinal signs	Respiratory signs	Microscopy (procedure)	PCR/ Sequencing	Other
1	2010	Chihuahua	F	9 weeks	Czech Republic (Germany),	yes	no	POS (Baermann)	POS	*Cystoisospora, Giardia*
2	2013	Chihuahua	M	7 weeks	Hungary	nd	nd	POS (histology)	POS	
3a	2013	Chihuahua/ Cavalier King Charles Spaniel mix	M	7 weeks (pooled sample 3 puppies, plus bitch)	Israel (bitch, 2 years before)	yes	no	POS (Baermann)	nd	*Cystoisospora*
3b		Chihuahua/ Cavalier King Charles Mix	M	7 weeks	Israel (bitch, 2 years before)	yes	no	POS (mucosal smear at necropsy)	POS	
4	2015	French Bulldog	M	7 months	Germany	yes	no	nd	POS	
5	2015	unknown	unknown	unknown	unknown	nd	nd	POS (direct smear)	POS	
6	2016	French Bulldog	M	6 months	unknown	yes	yes	Suspected (Baermann)	POS	*Giardia*
7a	2018	Pomeranian	M	4,5 months	Portugal	yes	no	Suspected (Baermann)	POS	
7b	2018	Pomeranian	M	6 months	Portugal	no	yes	Suspected (Baermann)	POS	*Giardia*
8	2019	Chihuahua	M	3 months	Switzerland	yes	noo	Suspected (Baermann)	POS	
9	2019	Samoyed	M	3 months	Switzerland	no	yes	POS (Baermann)	POS	*Cystoisospora*
10	2019	Chihuahua	F	4 months	Italy	no	yes	negative (Baermann)	POS	
11	2020	Springer Spaniel	M	11,5 months	Switzerland (animal shelter)	yes	yes	POS (Baermann)	nd	
12	2020	Pomeranian	M	3 months	Germany	no	yes	POS (Baermann)	nd	
13	2020	Border Collie	M	10 months	unknown	yes	no	POS (Baermann)	nd	
14	2020	Mix	F, spayed	15 months	Hungary	no	yes	POS (Baermann)	POS	
15	2020	Poodle	M, castrated	14 years	no travel abroad in the last years	yes	yes	POS (Baermann)	nd	
16	2020	French Bulldog	F, spayed	6 months	Russia	yes	no	POS (Baermann)	nd	*Cystoisospora*
17	2020	Mix	F	3,5 months	Switzerland	yes	no	nd	POS	
18	2020	French Bulldog	F, spayed	4,5 months	Germany	yes	yes	POS (Baermann)	POS	

POS: positive
nd: not determined

fenbendazole (25 mg/kg BW p.o.) for 5 days, to be repeated in two weeks. The dog was discharged and returned to the referring colleague for further treatment, and no further follow-up information was available.

Case 9

A 3 months old male Samoyed was presented at a private clinic with tachypnoea. Overall the dog was in bad clinical condition and died after one month. No further clinical details were available. However, based on the available information, the dog originated from Switzerland. Parasitological and genetic analyses had revealed a high number of *S. stercoralis* larvae in its faeces.

Case 10

A 4 months old female Chihuahua, imported from Italy, presented with coughing. After faecal examination that was negative by Baermann examination but positive by PCR a *S. stercoralis* infection was diagnosed and the dog was treated with fenbendazole (50 mg/kg BW, p.o.) for 5 days. No follow-up information was available.

Case 11

A one year old Springer Spaniel had a history of acute coughing after a stay at a boarding kennel, but no history of staying abroad. It was initially treated at a private practice with antibiotics and NSAIDs and, after diagnosing an *A. vasorum* infection based on a faecal analysis performed at the same practice, twice with imidacloprid/moxidectin according to the packing leaflet, and with prednisolone. In the following days, the dog was suffering from intermittent diarrhoea, and was repeatedly diagnosed positive for *Giardia* and therefore treated with metronidazole. As the dog continued to be weak and lethargic, faeces were analysed again and lungworm larvae were diagnosed. Thus, the dog received weekly milbemycin-oxime dosed according to its weight. As the dog still had diarrhoea, he was prescribed a hypoallergenic diet, that was followed by stabilisation and weight increase, despite still being effort intolerant. In addition, the dog showed increase sneezing without nasal discharge. The dog was then transferred to a private referral clinic for further work-up. On thoracic radiographs, a mild diffuse bronchial pattern was observed, attributed to the previously diagnosed *A. vasorum* infection. However, serology performed at the PDC was negative for circulating *A. vasorum* antigens and for antibodies against this parasite. In the following faecal analyses performed at the PDC, *S. stercoralis* larvae were microscopically diagnosed. The dog was referred back to the first private practitioner, and no further details on treatment and outcome were obtained.

Case 12

A male Pomeranian, 12 weeks old, originating officially from Germany, was presented with severe coughing. Laboratory work indicated leucocytosis, mild monocytosis, neutrophilia and anaemia. Previously performed thoracic radiographs did not indicate particular alterations of the lungs. As a rapid assay for *Giardia* antigen detection was positive and the presence of cardiopulmonary lung worms was suspected, a treatment with 50 mg/kg BW fenbendazole, p.o., was initiated. The next day, faecal analyses revealed the presence of *S. stercoralis* larvae. Fenbendazole treatment was recommended for three weeks, together with antibiotics and codein. Four days later the dog was presented because of limping, after falling down. After one more week, coughing had ameliorated considerably but persisted on a low level for another ten days. At this time faecal analysis was negative for *S. stercoralis* and, based on owner's feedback, the dog was considered cured.

Case 13

This male, 10 month old male Border Collie arrived as an emergency to a private clinic due to intermittent soft to watery diarrhoea and tenesmus. Based on the available information, the dog had not been abroad. He had a history of being diagnosed with *Giardia*. Appetite was good and it was reported to be regularly dewormed. After diagnosis of *S. stercoralis*, the dog was treated with metronidazole (15 mg/kg BW bid, p.o.) for five days. No follow-up information was available.

Case 14

A 15 month old mongrel dog, originally from an animal shelter in Hungary and being with the owners only for 2 weeks, was presented due to an acute onset of seizures. In addition, the dog had previously showed coughing, dyspnoea, occasional snoring and reverse sneezing and was reported to be exercise intolerant. Thorax radiographs indicated a mild bronchial pattern, with a small nodule that was not confirmed as a granuloma. After faecal analysis and diagnosis of an infection with *S. stercoralis*, confirmed by a positive PCR result, the dog was treated with fenbendazole (50 mg/kg BW for 5 days). In follow-up analyses performed 3 and 5 weeks later faecal samples were negative.

Case 15

This 14 year old castrated male poodle was presented with coughing, occasionally with blood, and dyspnoea. There was no history of being abroad in the last few years. Thorax radiography indicated a bronchial pattern. Suspecting the potential presence of lungworms, a faecal analysis by a Baermann funnel was performed, revealing the presence of *S. stercoralis*. The dog was treated with milbemycin-oxime in dosages according to package leaflet. A follow-up faecal examination 2 months later was negative.

Case 16

A 6 months old female French Bulldog was presented with anorexia, lethargy, vomiting and soft faeces, shortly after being imported from Russia. The dog had been dewormed three times based on information in his documents.

Radiographs of the abdomen indicated diarrhoeic material in the large intestine; intestinal obstruction was excluded and enterocolitis was suspected. The following day pasty faeces were observed and the general condition of the dog was without particular findings. Symptomatic therapy (intravenous infusion, together with an analgesic and antipyretic spasmolytic (metamizole) and antiemetic (maropitant) and a probiotic (Pro-Kolin)) was complemented with fenbendazole at 50 mg/kg BW, p.o. However, while hospitalized, the dog developed difficulties with breathing and started coughing. For this reason, thorax radiographs were performed, indicating a diffuse moderate alveolar pattern, more pronounced in the cranioventral and caudodorsal region, as well as moderate pleural effusion. A tentative diagnosis was gastroenteritis and pneumonia due to aspiration, distemper, parasites or bacteria. Faecal analysis revealed *S. stercoralis* and *Cystoisospora* sp.. Over the following days, the dog`s respiratory and gastrointestinal problems slowly improved, and he was dismissed at the request of the owner. It was recommended to pursue the fenbendazole treatment for 5 days and to consider the infection as a potential zoonosis. No further follow-up information was available.

Case 17

A 14 weeks old female mongrel dog, originating from Switzerland and never been abroad, had pasty faeces for several days. When it became lethargic and had yellow-brownish diarrhoea, it was admitted as an emergency. The general condition of the dog was reduced; in particular, the dog showed tachypnoea, hyperthermia and trembling. With a differential diagnosis of parvovirus infection, distemper or parasites, the dog was initially treated with an analgesic and antipyretic spasmolytic (metamizole), antibiotics and fenbendazole 25 mg/kg BW. The following day general condition was mildly reduced and the dog still had diarrhoea, suggesting mild enteritis possibly due to parasites, or intestinal disorders due to food allergy. The next day the dog's condition was without particular findings and treatment with fenbendazole and antibiotics was continued. The dog was dismissed the next day. One week later, faecal samples were analysed for the presence of *Strongyloides* and *S. stercoralis* DNA was detected by PCR. Treatment with milbemycin-oxime was then initiated through the private practice and owners informed regarding the difficulty to eliminate the infection and its zoonotic potential.

Case 18

A 4.5 months old female spayed French Bulldog, imported from Germany at the age of 8 weeks and with a routine history of vaccination and deworming, had ocular and nasal discharge five weeks before presentation. Weight loss, dyspnoea and a severely reduced general condition were the reason for presentation to the emergency service. The dog also showed strong coughing, retching and reverse sneezing. This was followed by a 3 weeks stay mostly at the intense care unit due to severely reduced general condition with dyspnoea, tachypnoea and retching. Diagnostic imaging and parasitological evaluations were suggestive for aspiration pneumonia and *Crenosoma vulpis* infection. In addition to a broad range of therapeutic measures, including ventilation and oxygen supply, the dog was treated with fenbendazole (50 mg/kg BW); this latter treatment was recommended to be completed after dismissal, for overall 21 days. Three weeks after dismissal the dog was presented for a control examination of the lungs. At this stage, the dog had diarrhoea and therefore a faecal parasitological examination was performed, which was positive for *S. stercoralis* larvae, confirmed by a positive PCR result. Initially, treatment was performed with spot on moxidectin/imidacloprid (2,5 mg/kg BW moxidectin, 10 mg/kg BW imidacloprid). A faecal control examination 3 weeks later was negative for *S. stercoralis* larvae, but positive for *Giardia* sp. (which was not treated as the dog was asymptomatic). Further 3 weeks later, 2 larvae were visible in the coproscopic examination; at this stage, a treatment with ivermectin (0,5 mg/kg BW, intramuscularly) to be repeated after 2 weeks was initiated. One week after the second treatment, the dog still excreted a high number of *Giardia* cysts, but not enough material for Baermann examination. Intensive hygiene measures were discussed. Five 5 weeks later the complete faecal parasitological examination was negative. However, as the dog had again bloody diarrhoea 3 months later, faeces were examined and the presence of *S. stercoralis* larvae was confirmed again by PCR. A treatment with ivermectin, 0,8 mg/kg BW s.c. was done. Parasitological control examinations were negative 3 and 7 weeks later.

Zoonotic aspects

The dog of case 18 had a long medical history in private practices and was an inpatient at the Department for Small Animals at the Vetsuisse Faculty in Zurich for a total of about 3 weeks in November 2020 and then again in December 2020 and January 2021. From December 2020 onwards, the dog suffered regularly from (bloody) diarrhoea. During its stay at the Small Animal Clinic, 12 staff members (veterinarians and veterinary technicians) had repeatedly been in close contact with the dog. Although wearing examination gloves was mandatory, accidental direct skin contact to animal secretions could not be ruled out completely. After discussions with infectiologists of the University Hospital in Zürich, the occupational physician in charge decided to have all close contacts examined for the presence of *S. stercoralis* larval stages in stool samples and of specific antibodies in serum samples three months after the detection of *S. stercoralis* larvae in the dog's faeces. The same examinations were also recommended to the dog owners.

Larval stages or DNA of *S. stercoralis* could not be detected in any of the 12 stool samples examined. Serologically, 9 of 11 samples (one staff member refused testing) were negative by ELISA (validated in house test, Institute of Parasitology, University of Zurich). In two samples equivocal results were recorded: these results could not be confirmed by enzyme-linked immunoelectro transfer blot nor by follow-up examinations after 6–8 weeks and were therefore considered unspecific.[7]

Discussion

The breed most frequently affected by *S. stercoralis* in this series of cases was the Chihuahua (n=6), followed by French Bulldogs (n=4) and Pomeranians (n=3). Therefore, in 13/20 dogs "trendy breeds" were involved, known to be frequently imported from abroad. Import was confirmed in 12 of them. Among dogs of other breeds (n=7), only one dog originated from abroad, while for two dogs this information was not available. Import areas included Eastern Europe (4 dogs), Germany (3 dogs) and the Mediterranean basin (5 dogs). Recently, Basso et al. (2019)[1] reported on 3 dogs with *S. stercoralis* diagnosed in Switzerland between 2017 and 2018: the involved dog breeds were Yorkshire Terrier, French Bulldog and Chihuahua, and they all had a history of import as well (France, Belgium). Furthermore, these authors stated that there had not been reports of this parasite at the Institute of Parasitology in Bern in the past 10 years, but that in conjunction with imported dogs, also locally born dogs in breeding kennels had been recently affected.[1] Our findings evidence that *S. stercoralis* was present at least since 2010. The severe course of infection in single dogs may have accounted for increased disease awareness, leading to an apparent increase of cases in the country in the last years. However, the occurrence of *S. stercoralis* in dogs in Europe is described for several countries, based on case reports and on prevalence studies that indicate prevalences around 2% in i.e. Spain, Italy and Slovakia (reviewed in [1, 23]). These countries may come closer to the tropical and subtropical climates that appear to favour the survival of the parasite in the environment, as evidenced by recent studies identifying *S. stercoralis* in soil samples.[45, 46] Therefore, considering intense dog travel and import for commercial and non-commercial reasons also via illegal channels, a true increase of this parasite in previously non-endemic countries would not be surprising. Furthermore, given the overlap of recreational walking areas of dogs with roaming areas of foxes, the latter ones may act as wildlife reservoirs, as shown for other parasites such as *Angiostrongylus vasorum*.[9, 15] For instance, in The Netherlands, 0,7% of red foxes were *S. stercoralis* positive and, interestingly, *Strongyloides* sp. eggs were identified in 6/1481 (0,4%) of fox faeces collected in Switzerland around the year 2011, although not confirmed by genetic analyses.[6, 27]

Of the 20 dogs involved, 13 were males and 6 females (1 unknown). The imported dogs were 7 weeks to 9,5 months old, and the remaining dogs were mostly younger than one year as well: only two dogs were older, i.e. 15 months (case 14) and 14 years (case 15). Age, together with environment and housing situation, is considered to strongly influence the onset of clinical signs.[48] Furthermore, immunosuppression and immunosuppressive treatments may favour a longer and more severe clinical course.[41, 19] Young age, breeding kennels (in case of overcrowding and poor hygiene) and stress factors such as transport may therefore contribute to a severe clinical picture in *S. stercoralis* infected animals.[22]

The most frequent clinical sign and reason for presentation was diarrhoea, occurring in 11/20 animals. Five of them also showed vomiting. Further symptoms associated to gastrointestinal issues were anorexia/hyporexia, adipsia, dehydration, tense abdomen and tenesmus. Respiratory signs were however the second most frequent ones, with coughing in 7/20 animals, followed by tachypnoea/dyspnoea in 5 and (reverse) sneezing in 3 dogs. In five dogs, thoracic radiographs were performed: in four of them (case 11, 14, 15, 16), lung alterations were observed. Interestingly, a bronchial pattern was observed in 3 dogs, and a moderate alveolar pattern in one dog. Such patterns are also observed in e.g. *A. vasorum* infected dogs (case 11).[29] Differentiation between infections with *S. stercoralis* and cardiopulmonary nematodes by other means has to be considered. Overall, 13 animals presented with gastrointestinal signs and 9 with respiratory signs. Two dogs presented with seizures and trembling (case 14 and 17). Lethargy, emaciation and exercise intolerance were additionally observed unspecific signs. A broad spectrum of clinical signs including respiratory symptoms were therefore indicative for canine strongyloidosis. Where available, laboratory work indicated anaemia (n=5), but also hypoproteinaemia, hypoglycaemia, leucocytosis, monocytosis, neutrophilia and increased blood urea nitrogen had been observed in single dogs. Importantly, dogs of cases 2, 3b, 5 and 9 died due to the consequences of *S. stercoralis* infection. As advanced, a severe clinical picture is more probable in young animals, while adult animals may pass unobserved for years until they give birth (for instance, the bitch of case 3 was imported 2 years before). The clinical history of case 18 illustrates a particularly elaborate course, during which very intensive treatment was necessary at times in order to rescue the puppy, leading to massive treatment costs.

Currently, the Baermann technique is considered as method of choice for the in vivo detection of *S. stercoralis* larvae in faecal samples. In the current series, this method was applied in 15 dogs. In the remaining cases diagnosis was based on the detection of *S. stercoralis* DNA by PCR in different sample materials. In 10 cases both meth-

ods were performed in parallel. Positive results with both techniques were however observed in 5 cases only, while in one dog Baermann examination was negative and PCR gave a positive result, and in 4 cases in which the unequivocal morphological identification of larvae was not possible, definitive identification was based on DNA detection. Therefore, this procedure may be helpful in dogs where cardiopulmonary nematodes are suspected but a *S. stercoralis* infection cannot be excluded.

Fenbendazole and ivermectin were the most frequently used compounds in this case series and also in the literature, although there is currently no indication of these compounds for the treatment of *S. stercoralis*. [1, 31, 38, 37] Oral administration of fenbendazole was mostly employed in a dosage of 50 mg/kg BW. The outcome of case 1 and 17 suggests that three days and 25 mg/kg BW, respectively, may not be sufficient. In contrast, 50 mg/kg BW fenbendazole over 5 days was successful in the cases where a follow-up examination was performed 3–6 weeks later (case 4, 6, 12, 14), and also when the treatment was prolonged over 21 days (case 12).

Among macrocyclic lactones registered for dogs, milbemycin-oxime applied according to leaflet dosages was not successful in case 2 but successful in case 15. However, this latter dog was the oldest dog diagnosed with *S. stercoralis* (14 years). Therefore, as described for adult dogs, the infection may have also cleared on its own.[19, 20] Moxidectin (combined with imidacloprid, according to leaflet dosage) was used in case 18, resulting in a faecal negative sample 3 weeks later, but the dog was positive again 3 weeks later, indicating a possible temporary suppression of larval production, or a reinfection. The dog was then treated with ivermectin (0,5 mg/kg BW, administered intramuscularly), repeated after 2 weeks, resulting in a negative faecal sample 6 weeks later. As the dog was *S. stercoralis* positive again 3 months later, ivermectin dosage was increased to 0,8 mg/kg, resulting in negative faecal samples 3 and 7 weeks later. In another dog, an ivermectin dosage of 0,5 mg/kg BW administered intramuscularly and repeated 2 weeks later resulted in negative faecal samples up to 10 weeks later (case 2). These recommendations were extracted from previous studies in which ivermectin had been tested at dosages of 0,2 and 0,8 mg/kg BW orally and was effective against adult females as well as against L_1-L_3, but not against those in extraintestinal localisations.[31] Under particular conditions such as large breeding kennels with multiple diagnosed positive animals, ivermectin (0,2–0,4 mg/kg BW) was given up to five times.[1] Alternatively, relying on human protocols, the oral administration of 0,2 mg/kg BW was successful in 17 sheltered dogs.[37] In addition, the combined use of fenbendazole and ivermectin may be suggested and was successful in complex cases.[1] However, the use of ivermectin in these dosages is always off-label and definitively not recommended in ivermectin sensitive dogs.[33]

Additionally, accompanying measures such as good hygiene and disinfection wherever possible are recommended, particularly in view of the zoonotic potential of *S. stercoralis*. The zoonotic nature of *S. stercoralis* is currently being discussed. Most recent data suggest that several populations exist that are predominantly or exclusively found in dogs or in humans.[3] Since a zoonotic transmission could not be ruled out definitely based on the data available, by way of precaution all close contacts of case 18 had been strongly advised to have coproscopical and serological check-ups. Whether this should be recommended routinely in all cases needs further discussions between parasitologists, veterinarians and infectiologists.

Conclusions

Our retrospective analysis indicates that *S. stercoralis* is present in Switzerland at least since 2010. Therefore, this parasite needs to be included into the differential diagnoses in cases of canine gastrointestinal and respiratory disorders, especially in young and imported dogs. Due to the clinical relevance and the zoonotic potential, we strongly recommend to perform parasitological analyses, importantly the Baermann funnel technique, in all animals with a history of import and in animals potentially originating from large breeding kennels. PCR should be performed in all cases presenting with respiratory symptoms and suspected infections with cardiopulmonary nematodes when larval stages of *S. stercoralis* have to be differentiated from the more frequently occurring L_1 of *A. vasorum* and *Crenosoma vulpis*, and generally in all cases where the unequivocal morphological identification of larval stages is not possible.

Acknowledgements

We would like to express our sincere thanks to everybody who has contributed! The collaborators of the Department for Small Animals, of the Institutes of Parasitology (PDC, Claudia Bremen) and Veterinary Pathology (Monika Hilbe, Udo Hetzel) of the Vetsuisse Faculty in Zurich, Bessy's Kleintierklinik, Watt/Regensdorf (Claudia Braun, Imelda und Rico Vannini), the Centro Veterinario Airone, Morbio Inferiore (Miriam Galeandro, Luca Galeandro), the Kleintierpraxis «Am Ring», Basel, the Tierklinik Aarau West, Oberentfelden, the Kleintierpraxis Horus, Volketswil (Mohammed Ebeid), the Vet Zentrum, Winterthur (Danielle Bass, José Ignacio Casado), Veterinario Volonté, Melide (Cristina Volonté), the Tierklinik Masans, Chur (Lisa Meng), the Institut Galli-Valerio, Lausanne (Valérie Chaignat).

«Diese Arbeit ist Prof. Peter Deplazes zu seiner Emeritierung gewidmet.»

Strongyloides stercoralis chez les chiens suisses – une étude rétrospective suggère une apparition croissante de ce parasite potentiellement zoonotique en raison des importations de chiens

Strongyloides stercoralis est un nématode présent dans le monde entier et infectant les canidés et les primates (y compris les humains), responsable d'une zoonose largement sous-estimée. Nous présentons ici 18 cas incluant au total 20 chiens atteints de *S. stercoralis*, diagnostiqués en Suisse entre 2010 et 2020.

L'examen de Baermann était positif pour les larves de *S. stercoralis* chez 10, suspect chez 4, négatif chez un et non réalisé chez 2 chiens. Chez 3 chiens, l'infection n'a été identifiée qu'à l'autopsie par histologie ou par frottis fécal ou muqueux de tissu intestinal. La confirmation des chiens suspects, autopsiés et Baermann-négatifs reposait sur des analyses génétiques. Douze chiens avaient des antécédents d'importation d'Europe de l'Est (n=4), du bassin méditerranéen (n=5) ou d'Allemagne (n=3). Ils étaient âgés de 7 semaines à 9,5 mois, et les chiens supposément nés en Suisse avaient moins d'un an (sauf deux, âgés de 15 mois et 14 ans). Treize chiens étaient des mâles et six des femelles (1 inconnu). Les races les plus représentées étaient les Chihuahuas (n=5), les Bouledogues français (n=4) et les Poméraniens (n=3). Le signe clinique et le motif de présentation les plus fréquents étaient la diarrhée, survenant chez 11/20 animaux. D'autres symptômes gastro-intestinaux étaient des vomissements, anorexie/hyporexie, adipsie, déshydratation, tension abdominale et ténesme. Les symptômes respiratoires étaient les seconds plus fréquents, avec une toux chez 7/20 animaux, suivie d'une tachypnée/dyspnée chez 5 et d'éternuements (inverses) chez 3 chiens.

Un traitement avec 50 mg/kg de poids corporel de fenbendazole p.o. durant 5 jours a réussi dans les 4 cas dans lesquels un examen de suivi a été effectué 3 à 6 semaines plus tard ; un traitement prolongé sur 21 jours a également été efficace. Les protocoles hors AMM avec de l'ivermectine décrits dans la littérature, par ex. 0,8 mg/kg de poids corporel s.c. ou 0,5 mg/kg de poids corporel i.m. répétés après 2 semaines, ont été couronnés de succès sur la base de contrôles effectués 3 à 10 semaines plus tard.

Les infections à *Strongyloides stercoralis* sont cliniquement pertinentes, potentiellement zoonotiques et doivent être incluses dans les diagnostics différentiels en cas de troubles gastro-intestinaux et respiratoires canins, en particulier chez les jeunes chiens et les chiens importés.

Mots clés: commerce d'animaux, nématode, chiots, strongyloidose, traitement, zoonose

Strongyloides stercoralis nei cani svizzeri – uno studio retrospettivo ipotizza un aumento dell'occorrenza di questo parassita potenzialmente zoonotico come conseguenza dell'importazione di cani

Lo *Strongyloides stercoralis* è un nematode presente a livello mondiale che infetta i canidi e i primati (compreso l'uomo) ed è responsabile di una malattia zoonotica altamente sottovalutata. In questo studio presentiamo 18 casi con 20 cani affetti da *S. stercoralis* diagnosticati in Svizzera tra il 2010 e il 2020.

Il test di Baermann è risultato positivo alle larve di *S. stercoralis* in 10, sospetto in 4, negativo in uno e non è stato eseguito in 2 cani. In 3 cani l'infezione è stata identificata solo durante la necroscopia, tramite istologia o via gli strisci fecali o mucosali del tessuto intestinale. La conferma nei cani sospetti, sezionati e negativi al test di Baermann è avvenuta tramite analisi genetiche. Dodici cani erano stati importati dall'Europa orientale (n=4), dal bacino mediterraneo (n=5) o dalla Germania (n=3) ed erano di età compresa tra le 7 settimane e i 9,5 mesi. Pure i cani presumibilmente nati in Svizzera erano di età inferiore a un anno (eccetto due dell'età di 15 mesi e di 14 anni). Tredici cani erano maschi e 6 erano femmine (uno sconosciuto). Le razze più rappresentate erano Chihuahua (n=5), Bulldog francese (n=4) e volpino di Pomerania (n=3). Il segno clinico e il motivo della visita più frequente era la diarrea, presente in 11/20 animali. Seguivano quindi sintomi gastrointestinali come vomito, anorressia/iporessia, adipsia, disidratazione, addome teso e tenesmo. I sintomi respiratori erano al secondo posto in frequenza, con tosse in 7/20 animali, tachipnea/dispnea in 5, e starnuti (inversi) in 3 cani.

Il trattamento somministrato di 50 mg/kg PC di fenbendazolo p.o. per 5 giorni ha avuto successo in 4 casi che hanno subito un esame di controllo dopo 3–6 settimane. Il prolungamento del trattamento fino a 21 giorni è risultato anch'esso efficace. I protocolli con ivermectina descritti nella letteratura, come per esempio 0,8 mg/kg PC s.c. oppure 0,5 mg/kg PC i.m. ripetuti dopo 2 settimane sono , stati efficaci in base ai controlli effettuati dopo 3–10 settimane.

Le infezioni da *Strongyloides stercoralis* sono rilevanti a livello clinico, potenzialmente zoonotiche e devono essere incluse nelle diagnosi differenziali nel caso di disturbi gastrointestinali e respiratori specialmente nei cani giovani e importati.

Parole chiave: commercio di animali, nematode, cuccioli, strongiloidosi, trattamento, zoonosi

Strongyloides stercoralis in Swiss dogs – a retrospective study suggests an increasing occurrence of this potentially zoonotic parasite as a consequence of dog imports

M. Schnyder et al.

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Strongyloides stercoralis tier tgauns svizzers – in studi retrospectiv lai concluder l'existenza augmentonta da quei parasit potenzial zoonotic sco consequenza digl import da tgauns

Strongyloides stercoralis ei in nematod derasau sigl entir mund che infectescha tgauns e primats (inclusiv carstgauns) ed ei responsabels per in malsogna zoonotica considerablamein sutvaletada. Nus presentein cheu 18 cass cumpriu en tut 20 tgauns affectai da *S. stercoralis* diagnosticai en Svizra denter 2010 e 2020.

L'examinaziun cun Baermann era positiva per larvas da *S. stercoralis* tier 10, suspectusa tier 4, negativa tier in e buc intercuretga tier 2 tgauns. Tier 3 tgauns ei l'infeczi-un vegnida anflada mo entras histologia duront l'autopsia cun strihar ora excrements ni mucosa dalla beglia. La confirmaziun tier tgauns suspectus, negativs cun Baermann ed ell'autopsia, sebasa sin analisas geneticas. Dudisch tgauns havevan ina prehistoria dad import dall'Europa orientala (n=4), dil contuorn dalla Mar mediterrana (n=5) ni Tiaratudestga (n=3). Els eran 7 jamnas tochen 9,4 meins vegls, ed era ils tgauns ch'eran propablamein naschi en Svizra eran pli giuvens ch'in onn (priu ora dus, 15 meins e 14 onns vegls). Tredisch tgauns eran masculins e sis feminins (in buc enconuschent). Las rassas representadas il bia eran chihuahua (n=5), bulldog franzos (n=4) e pommerian (n=3). L'anzenna clinica la pli frequenta e raschun per presentar era diarrea, secattau en 11/20 animals. Auters simtoms gastrointestinals eran rietscher, anorexia/hiporexia, adipsia, dehidraziun, venter sut tensiun e tenesmus. Secund savens eran simtoms respiratorics sco tuas tier 7/20 animals, suandau da tachipnea/dispnea tier 5 e sturnidar (anavos) tier 3 tgauns.

Tractament cun 50 mg/kg BW fenbendazol p.o. duront 5 dis ha mussau succes en 4 cass, ils quals ein vegni examinai 3–6 jamnas pli tard; in tractament prolungiu sin 21 dis era medemamein effectivs. Protocols cun ivermectin off-label ch'ein descrets en la literatura, p.ex. 0,8 mg/kg BW s.c. ni 0,5 mg/kg BW i.m. repettiu suenter 2 jamnas, han mussau success confirmau en controllas 3–10 jamnas pli tard. Infecziuns cun *Strongloides stercoralis* ein clinicamein relevontas, potenzialmein zoonoticas e ston vegni includadas en diagnosas differnzialas en cass da mals gastrointestinals ni respiratorics, spezialmeni tier tgaus giuvens ed importai.

Plaids-clav: Fatschenta cun animals, nematods, cagneuls, strongyloidosa, tractament, zoonosa

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