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Infection by *Eucoleus aerophilus* in dogs and cats: Is another extra-intestinal parasitic nematode of pets emerging in Italy?

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ABSTRACT

The occurrence of the infection by the lungworm *Eucoleus aerophilus* (syn. *Capillaria aerophila*) in dogs and cats from Italy has been evaluated with conventional diagnostic procedures. Individual faecal samples from 569 dogs and 200 cats were undertaken to faecal flotation with sugar and zinc sulphate solution. Sixteen dogs (2.8%) and 11 cats (5.5%) scored positive for eggs of *E. aerophilus* when samples were processed with either of the two flotation solutions. Overall 14 of 16 dogs and eight of 11 cats infected by *E. aerophilus* showed respiratory symptoms and the most common were general respiratory distress, dry cough, wheezing and sneezing. These results indicate that *E. aerophilus* is not uncommon and that canine and feline capillariosis is of clinical importance. Given the impact that *E. aerophilus* infections may have upon animal health and its zoonotic potential, it is strongly advisable to routinely include this disease in the differential diagnosis of (cardio)-respiratory diseases of dogs and cats.

1. Introduction

Eucoleus aerophilus (syn. *Capillaria aerophila*) is a little known trichuroid parasitic nematode affecting cats, dogs and wild carnivores. The adult lungworms live embedded in the epithelium of bronchioles, bronchi and trachea of the definitive host. The females lay eggs that are coughed, swallowed and released via faeces into the environment. The eggs reach the infective stage in about 30–45 days. Alternatively, development to the infective larval stage may occur in earthworms (i.e. facultative intermediate hosts). Animals become infected by ingesting the embryonated eggs or the earthworms. After ingestion, the larvae migrate to the lungs, where they evolve into adulthood and reach their sexual maturity after about 3–6 weeks post infection (*p.i.*) (Anderson, 2000; Taylor et al., 2007; Burgess et al., 2008). The parasite is responsible for damage to lung parenchyma and the infection induces chronic bronchitis characterized by a wide range of symptoms, i.e. minimal respiratory signs (e.g. bronchovesicular sounds) to inflammation, sneezing, wheezing, and chronic dry or moist and productive cough; (i.e. especially when bacterial complications intervene). In the case of heavy parasite burden, the diseases can lead to mortality due to bronchopneumonia and respiratory failure (Holmes and Kelly, 1973; Bowman et al., 2002; Taylor et al., 2007; Burgess et al., 2008).

Canine and feline respiratory infection by *E. aerophilus* is considered sporadic and/or sub-clinical, but clinical cases have been reported in the past decade (Barrs et al., 2000; Foster et al., 2004a,b; Burgess et al., 2008) together with a relevant zoonotic potential. In fact, this parasite causes human capillariosis, characterized by fever, bronchitis, coughing, haemotisis, dyspnoea and, importantly, may induce relevant damage resembling bronchial carcinoma (Lalosević et al., 2008).

The infection by *E. aerophilus* is globally distributed and can be of importance in canine and feline medicine. Nonetheless knowledge of this lungworm is poor and published data on its presence in Italy are lacking. Indeed, the presence and distribution of bronchial capillariosis in Italy is anecdotal and the literature refers only to the infection in red fox (Rossi et al., 1983; Manfredi et al., 2003; Balestrieri et al., 2006) or stone marten (Ribas et al., 2004).

Recently, the presence of *E. aerophilus* was reported in a survey carried out to evaluate the presence of the cat lungworm *Aelurostrongylus abstrusus* in feline populations of central and southern Italy (Traversa et al., 2008). This article describes the occurrence of this respiratory parasitic nematode in dogs and cats in order to enhance knowledge about the distribution of *E. aerophilus* in Italy. Epidemiological aspects, practical importance and diagnostic features for *E. eucoleus* infection are also discussed.

2. Materials and methods

The faecal samples of 569 dogs and 200 cats were examined in 2006 and 2007.

The minimum number to be sampled to evaluate prevalence of infection was 199, calculated with the software Win Episcope 2.0

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and considering an infinite population, an expected prevalence of 5%, a maximum error desired 3% and a 95% level of confidence (95% CL). After 200 samples prevalence of *E. aerophilus* in dogs was very low, thus sample size was calculated again for dogs only and was set up at 497 dogs, lowering the expected prevalence at 3% and the maximum error desired at 2% in the calculation (Thrusfield, 2000).

The majority of the animals included in the trial was referred to veterinary clinics or hospitals for a range of medical problems, while the remaining were randomly selected during their yearly examination for endoparasites at the Parasitological Unit of the Faculty of Veterinary Medicine of Teramo. All stool samples collected from each animal were subjected to macroscopic and microscopic faecal examination. The entire stool specimen from each animal was examined grossly for the presence of adult nematodes or tapeworm segments. Following this examination, each individual sample was processed by two different flotation procedures (Euzeby, 1981) employing a sugar solution with a 1.200 specific gravity (s.g.) and a 1.350 s.g. zinc sulphate solution. For each flotation procedure, approximately 5 g of faeces were added to 20 ml of solution and centrifuged at 600*g* for 5 min. An aliquot (~100 μl) of supernatant was subsequently aspirated with a Pasteur pipette, transferred to a glass slide and examined using a light microscope (Axioscope 40, Zeiss, Oberkochen, Germany) at 20× magnification.

All parasites found during the faecal examination were identified to existing morphological keys (Sloss et al., 1994). Operculate eggs of *E. aerophilus* were recognized by the morphometric and morphological characteristics, i.e. size (60–83 μm long × 25–40 μm wide), asymmetry of bipolar plugs and densely striated outer shell with a network of anastomosing ridges (Schoning et al., 1993; Barrs et al., 2000; Bowman et al., 2002).

3. Results and discussion

No parasites were detected at the gross examination of the faecal samples. Eggs of *E. aerophilus* (Fig. 1) were found in 16 (2.8%, CL interval 1.67–4.63) and 11 (5.5%, CL interval 2.92–9.89) of 569 dogs and 200 examined cats, respectively. All infected animals tested positive using the flotation with either sugar and zinc sulphate solution method. Fourteen (87.5%) and 8 (72.7%) of the 16 infected dogs and 11 cats exhibited respiratory symptoms. Five symptoms were detected, i.e. general respiratory distress (all symptomatic animals), dry (10 dogs and six cats) or moist (three dogs and one cat) cough, dyspnoea (one dog), wheezing (three dogs and five cats) and sneezing (five dogs and three cats). Two dogs and three cats did not show evident abnormalities on history and/or clinical examination (Table 1).

Fig. 1. Eggs of *Eucoleus aerophilus* (size bar 45 μm).

These are the first results reporting the occurrence of *E. aerophilus* infection in pets from Italy, showing that this parasite is present with infection rates of 2.8% and 5.5% in examined dogs and cats, respectively. In Italy infection by *E. aerophilus* is limited to the finding of the parasite during studies on the helminthofauna of necropsied wild mammals (Rossi et al., 1983; Manfredi et al., 2003; Ribas et al., 2004; Balestrieri et al., 2006). The occurrence of *E. aerophilus* in dogs and cats from Italy as well in other animals suggests that this parasitic infection is not occasional but is present and possibly spreading through Italy. Knowledge of the actual range of hosts and geographic distribution of *E. aerophilus* in domestic mammals in Italy is lacking, and epidemiological data from other countries are poor and sparse. Indeed, the infection rate of 2.8–5.5% found in this study is similar to that reported in cats from USA (Foster et al., 2004a,b) but, higher than values recorded in Germany (0.2%, Epe et al., 2004) and Spain (1.3%, Miró et al., 2004).

The majority of the infected animals were symptomatic. The absence of respiratory symptoms in few infected animals (i.e. two dogs and three cats) might be due to low parasitic burden or by a recent infection at the time animals were sampled. Also, it is possible that these animals displayed mild symptoms that were not noted, and thus, not referred by the owners or detected by the veterinarians.

Interestingly, in the past decade, other extra-intestinal parasitic nematodes of dogs and cats, for instance canine *Angiostrongylus vasorum* and *Spirocerca lupi* or feline lungworm *A. abstrusus* (see reviews by van der Merwe et al. (2008), Koch and Willesen (2008) and Traversa and Guglielmini (2008)), recently revived the attention of the scientific community because they appear to emerge in several areas of the World, including in Italy. The reasons for the increasing distribution of extra-intestinal parasites are still unclear and, thus, are merely speculative. This spreading could be due to several ecological and epidemiological factors, such as increasing density of definitive, intermediate and paratenic hosts, as well as to refined and more sensitive diagnostic methodologies. Concomitant infections by *Sarcoptes scabiei* and *E. aerophilus* have been found in foxes from Italy (Balestrieri et al., 2006) but the role of wild reservoirs in enabling parasite establishment and spreading in Italy is unclear.

Though the importance of *E. aerophilus*, the infection is not commonly included in differential diagnosis in current practice. Indeed, the infection by *E. aerophilus* is likely underestimated and neglected mainly because it may occur asymptomatically and many cases are not diagnosed, or misdiagnosed with nasal *Eucoleus boehmi*, and, more often, with intestinal *Trichuris* spp. Eggs of *E. boehmi* are smaller (50–60 μm long × 30–35 μm wide) than those of *E. aerophilus* and have tiny pits on the surface, while eggs of *Trichuris* spp. are bigger (70–80 μm long × 30–50 μm wide), are not asymmetrical, have a ring-like thickening at the base of the bipolar plugs and a smooth shell surface (Campbell, 1991; Schoning et al., 1993; Burgess et al., 2008). Also, radiographic modalities do not permit an aetiological diagnosis because the abnormalities are nonspe-

Table 1
Percentage of clinical signs in the 14 dogs and 8 cats diagnosed with *Eucoleus aerophilus* infection and presenting respiratory clinical signs.

Clinical signs	Number of dogs (=16)	Number of cats (=11)
General distress	14 (87.5%)	8 (72.7%)
Dry cough	10 (71.4%)	6 (75%)
Moist cough	3 (21.4%)	1 (12.5%)
Wheezing	3 (21.4%)	5 (62.5%)
Sneezing	5 (35.7%)	3 (37.5%)
Dyspnoea	1 (7.1%)	0 (0%)
None	2	3

cific, with patchy interstitial to alveolar infiltrates (Burgess et al., 2008). The limits of conventional clinico-pathologic, radiographic and coprological diagnostic methods can impair an adequate estimation of the presence and spread of the infection in cats and dogs. Given that veterinary practitioners often do not take into account eggs of nematodes belonging to the *Eucoleus* genus when lemon-like eggs are found in stool samples, it is likely that in most cases these are mistaken for the more known eggs of intestinal *Trichuris*.

Hence, in the light of the present results *E. aerophilus* is probably present more frequently than it is currently diagnosed. In this study all animals positive using the flotation with zinc sulphate solution also were positive using the floatation with the sugar solution, which is among the most used in the current practice in veterinary clinics and hospitals. Thus, detection and correct identification of *E. aerophilus* eggs should be relatively easy for skilled and well-trained microscopists.

From a practical standpoint, respiratory capillariosis is of clinical importance, even though it may be misdiagnosed with several other respiratory distresses. Specifically, the infection in cats should be differentiated by other parasitoses sharing overlapping respiratory distress and signs, abnormal radiographic and haematologic findings, i.e. those caused by *Dirofilaria immitis* or *A. abstrusus*, as well as by viral, bacterial and upper respiratory tract diseases or naso-pharyngeal polyps (Calvert and Mandell, 1982; Willard et al., 1988; Pechman., 1995; Foster et al., 2004a,b; Helps et al., 2005). Capillariosis-like symptoms in dogs may be caused by several other parasites, e.g. *D. immitis*, *A. vasorum*, *Crenosoma vulpis* and *Filaroides* spp. (Traversa and Guglielmini, 2008; Burgess et al., 2008) as well as foreign bodies and infectious causative agents should be considered differential diagnoses in suspected respiratory diseases (Chalker et al., 2004; Erles and Brownlie, 2005, 2008; Leib and Sartor, 2008).

In conclusion, given the impact *E. aerophilus* may have for the animal health, its zoonotic potential and its presence in Italy as well as in other countries, this parasite should be included into the differential diagnosis of (cardio)-respiratory diseases of dogs and cats. Veterinarians and parasitologists should be aware of the occurrence of *E. aerophilus* in pets, and its ability to induce respiratory damages and symptoms as well as its role in causing relevant lung diseases in humans.

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