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ORIGINAL PAPER

Occurrence and regional distribution of *Aelurostrongylus abstrusus* in cats in Germany

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Abstract Infections with the metastrongyloid nematode *Aelurostrongylus abstrusus* in cats have been reported sporadically from Germany. To assess the occurrence and regional geographical distribution of *A. abstrusus* in Germany, faecal samples from 391 cats with symptoms of respiratory disease were collected from December 2009 to November 2011. The zinc chloride/sodium chloride flotation and Baermann funnel technique were used to examine the samples for the presence of lungworm larvae. The collected data were analyzed using a geographic information system (GIS). Infections with lungworms were diagnosed in 26 (6.6 %) of the examined cats. The infection rates did not show significant differences in the age groups up to 7 years. Only cats older than 7 were significantly less infected with lungworms than young cats. Sixteen of the 192 female cats examined and 7 of the 186 males were positive for *A. abstrusus*, but there were no significant differences for the variable 'gender infection rate'. Most of the *A. abstrusus*-positive cats were located in Baden-Wuerttemberg, followed by Lower Saxony, Bremen, North Rhine-Westphalia, Bavaria, Hesse, Mecklenburg-Western Pomerania, Saarland, Saxony and Schleswig-Holstein. The majority of infected cats showed severe clinical symptoms characterised by coughing and dyspnoea, increased breathing rate, weight loss, bronchopneumonia, generally poor condition, sneezing and nasal discharge. The high number of lungworm-positive cats and the severe clinical symptoms should encourage veterinarians in Germany to consider infections with *A. abstrusus* as a differential diagnosis in cats with symptoms of respiratory disease.

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Introduction

Aelurostrongylus abstrusus is a metastrongylide nematode parasite, which is known to infect the lungs of cats and other felids such as the Amur cat (*Felis bengalensis euptilurus*) (Gonzáles et al. 2007) and the Eurasian lynx (*Lynx lynx*) (Szczesna et al. 2006). This nematode is widespread and has been found repeatedly in almost all countries in Europe, frequently in Australia, several times in North and South America and sporadically in Asia and Africa. Prevalence rates of *A. abstrusus* in cats are rare, difficult to compare and often variable. The data depend on geographical region, country, keeping conditions (feral or domestic cats) and method of parasitological examination (faecal samples and Baermann technique, examination of bronchoalveolar lavage fluid, post-mortem dissection). Global prevalence rates vary from 50 % in free-roaming cats in Albania (Knaus et al. 2011) to 1 % in a mixed cat population in Spain (Miró et al. 2004) (see Table 1).

In Germany, the results of post-mortem dissections, prevalence data from examination of faecal samples and case reports (Table 2) show that *A. abstrusus* is endemic in the cat population. The analyses of parasitological examination of faecal samples from all parts of Germany submitted for routine diagnosis indicate low infection rates varying between 0.5 % and 1.0 %. In contrast to this finding, post-mortem examination of stray cats in distinct regions such as Mecklenburg-Western Pomerania and Berlin (Hiepe et al. 1988) and the eastern part of Brandenburg (Schuster et al. 1997) has documented high prevalence rates of 15.3 and 10.0 %, respectively. Recent studies from Denmark and Germany have shown that prevalence rates of *A. abstrusus* in cats may have increased in recent years (Taubert et al. 2009). At any rate, the available data show that *A. abstrusus* is probably widespread in the feral cat population. However, there are no current data for the occurrence and regional distribution and prevalence of *A. abstrusus*. The aim of the

Table 1 Documented detection of *Aelurostrongylus abstrusus* in cats from different countries

Reference	Country	Region	Type of cat population	Prevalence (%)
Knaus et al. (2011)	Albania		Free roaming cats	50
Sommerfelt et al. (2006)	Argentina		Stray cats	2.6
Gregory and Munday (1976)	Australia	Tasmanian Midlands and King Island	Feral cats	39.2
Adams et al. (2008)	Australia	Christmas Island	Feral cats	25
Coman et al. (1981)	Australia	Victoria and New South Wales		14
Lacorcia et al. (2009)	Australia		Semiferal cats	13.8
Traversa et al. (2008)	Italy	Central and Southern Italy	Mixed cat population	17.3–18.5
Robben et al. (2004)	Netherlands		Shelter cats	2.6
Payo-Puente et al. (2008)	Portugal		Stray cats	17.4
Abu-Madi et al. (2007)	Qatar		Stray cats	7.5
Mircean et al. (2010)	Romania		Domestic cats	5.6
Miró et al. (2004)	Spain		Mixed cat population	1
Willard et al. (1988)	USA	Alabama	Stray cats	18.5
Lucio-Forster and Bowman (2011)	USA	New York	Shelter cats	6.2

present study was to assess the occurrence and regional geographical distribution of natural infections with *A. abstrusus* in domestic cats in Germany.

Materials and methods

Study population and faecal examination

Between December 2009 and November 2011, veterinary practitioners in Germany were asked to look for cats with a tentative diagnosis of lungworm infection with symptoms of respiratory disease, i.e. coughing, increased breathing frequency, dyspnoea, poor general condition and/or discharge from the eyes and nose. Only cats that had not been abroad within the last 3 months before developing clinical signs of a lungworm disease were included in the study. Faecal samples were collected on three consecutive days from 391 cats with respiratory problems. After collection, the faecal samples were sent directly to the private Veterinary Laboratory Freiburg and examined for lungworm larvae using a standard saturated salt solution flotation technique with zinc chloride and sodium chloride (specific gravity, 1.3) and a modified Baermann funnel technique as described previously (Barutzki and Schaper 2009). Any first-stage larvae (L1) that were collected were determined by distinctive morphological and morphometric characteristics as described by Traversa and Guglielmini (2008). L1 with a characteristic notched and S-shaped tip at the posterior end were determined as *A. abstrusus* (Figs. 1 and 2).

Table 2 Documented detection of *Aelurostrongylus abstrusus* in cats in Germany

Reference	Number of samples examined	Type of examination	Prevalence (%)
Hiepe et al. (1988)	170	Post mortem of feral cats	15.3
Epe et al. (1993)	1,147	Faecal samples, routine diagnosis of domestic cats	1.0
Schuster et al. (1997)	155	Post mortem of feral cats	10.0
Barutzki and Schaper (2003)	3,167	Faecal samples, routine diagnosis of domestic cats	0.7
Epe et al. (2004)	441	Faecal samples, routine diagnosis of domestic cats	0.7
Reinhardt et al. (2004)	1	Case report	
Dürr (2009)	2	Case report	
Taubert et al. (2009)	231	Faecal samples of cats with signs of respiratory disease	5.6
Becker et al. (2012)	837	Faecal samples of feral cats	1.0
Barutzki and Schaper (2011)	8,560	Faecal samples, routine diagnosis of domestic cats	0.5

Fig. 1 Light micrograph of the posterior end of the first-stage larva (L1) of *Aelurostrongylus abstrusus* immobilised by heat

Data and statistical analysis

The collected data were analyzed by a GIS using the program RegioGraph 10 (GfK GeoMarketing, Bruchsal) to visualise the regional distribution of *A. abstrusus*. Based on the five-digit postcodes as points of reference, the locations of the owners of lungworm-positive cats were displayed on maps with administrative and postcode boundaries. The data were supplied in electronic form for statistical analysis. The analysis was performed with the validated program Testimate Version 6.5 from IDV Gauting (validation of software, hardware and user according to FDA 21 CFR Part 11). All evaluation steps were documented in full. The group differences for cats with respect to age and season (months) were tested with Rx2 frequency tables. The null hypothesis was that of no differences H_0: p1=p2=…=pk (the so-called homogeneity hypothesis). The classical *P* values were computed using Pearson's correlation coefficient without continuity correction; Fisher's exact *P* values (two-sided, alpha=0.05) were used only for smaller samples. If the result was significant, two-group comparison for each age group vs all animals was performed with the Fligner–Wolfe test without any alpha correction for multiple testing. The predefined two-sided alpha-level was 0.05. The data were summarised in two categories for analysis by season: summer (April–September) and winter (October–March). The variable 'season' (with these two categories) and the variable 'gender' (male/female) were tested with 2× 2 frequency tables. The null hypothesis was that of no differences H_0: p1=p2. The exact *P* values were computed using the Röhmel–Mansmann procedure.

Fig. 2 Light micrograph of a dehydrated, damaged and morphologically altered first-stage larva (L1) of *Aelurostrongylus abstrusus* after flotation using a concentrated salt solution with zinc chloride and sodium chloride (specific gravity, 1.3)

Results

A total of 391 cats with a tentative diagnosis of lungworm infection underwent faecal examination between December 2009 and November 2011. The gender of 378 cats was known, of which 186 (49.2 %) were male and 192 (50.8 %) were female. The age of 361 cats was known. Based on the Baermann method, the standard saturated salt solution flotation technique with zinc chloride and sodium chloride (specific gravity, 1.3) followed by microscopic examination revealed infections with *A. abstrusus* in 26 (6.6 %) of the 391 cats examined. The most densely populated age group and the highest percentage of *A. abstrusus*-positive cats were found in the category up to 1 year of age (Table 3). However,

Table 3 Age structure of cats examined and found to be *Aelurostrongylus abstrusus*-positive in Germany

Age of cats (years)	Number of cats examined	*Aelurostrongylus abstrusus*-positive cats	
	(*n*)	(*n*)	(%)
≤1	86	14	16.3
>1–2	58	6	10.3
>2–3	24	1	4.2
>3–4	33	1	3.0
>4–5	16	1	6.3
>5–6	12	0	0.0
>6–7	8	0	0.0
>7–8	18	0	0.0
>8–9	16	1	6.3
>9–10	21	0	0.0
>10–11	11	0	0.0
>11–12	20	0	0.0
>12–13	12	0	0.0
>13–14	9	0	0.0
>14–15	9	0	0.0
>15–16	2	0	0.0
>16–17	5	0	0.0
>17–18	1	0	0.0
Total	361	24	6.6

the so-called homogeneity hypothesis can be significantly rejected for age (P=0.0435). The Fligner–Wolfe test shows that only cats over 7 years of age were significantly less infected with lungworms than young cats. Sixteen of the 192 females and 7 of the 186 males examined were *A. abstrusus*-positive, but there were no significant differences with respect to the variable 'gender infection rate'. Most of the lungworm-positive cats (Table 4 and Fig. 3) were found in January (eight), followed by February (five), March and December (three), September and October (two) and June, July and November (one). Comparison between the winter and summer seasons shows significantly higher infection rates in winter between October and March (P=0.0027). The majority of infected cats manifested severe clinical symptoms characterised by coughing (12) and dyspnoea (12), followed by increased breathing rate (7), weight loss (6), bronchopneumonia (4), generally poor condition (4), sneezing (3) and nasal discharge (2). Most of the positive cats (12) were located in Baden-Wuerttemberg, 4 in Lower Saxony, 2 each in Bremen and North Rhine-Westphalia (Table 3). In Bavaria, Hesse, Mecklenburg-Western Pomerania, Saarland, Saxony and Schleswig-Holstein, only one cat with *A. abstrusus* was detected in each case. A microgeographic analysis based on postcodes using the program RegioGraph 10 gives a detailed profile of the regional geographical distribution of natural infections with lungworms in cats in Germany. The area

Table 4 Demonstrated infection with *Aelurostrongylus abstrusus* in cats in federal states of Germany

Federal state of Germany	Examined cats	*Aelurostrongylus abstrusus*-positive cats	
	(n)	(n)	(%)
Baden-Wuerttemberg	131	12	9.2
Bavaria	40	1	2.5
Berlin	5	0	0
Brandenburg	5	0	0
Bremen	17	2	12
Hamburg	8	0	0
Hesse	25	1	4
Mecklenburg-Western Pomerania	2	1	50
Lower Saxony	43	4	9
North Rhine-Westphalia	63	2	3.2
Rhineland-Palatinate	18	0	0
Saarland	7	1	14.3
Saxony	6	1	16.7
Saxony-Anhalt	2	0	0
Schleswig-Holstein	18	1	6
Thuringia	1	0	0
Total	391	26	6.6

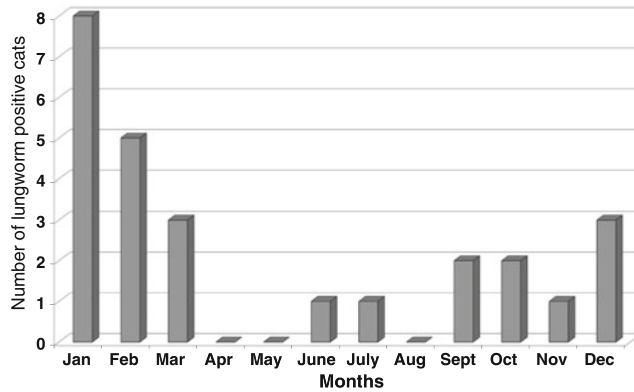

Fig. 3 Seasonal distribution of *Aelurostrongylus abstrusus*-positive feline faecal samples (n=26) in Germany

analyses show most of the infections with *A. abstrusus* in the southern parts of Germany with extensive clusters in Baden-Wuerttemberg and in the northern federal states Lower Saxony, Bremen and Schleswig-Holstein (Fig. 4).

Discussion

Assessment of parasite prevalence in a population depends on the selection criteria applied to the patients included. Published data for prevalence of *A. abstrusus* in cats in Germany have been gained in different populations as shown in Table 2. When stray and feral cats were investigated by necropsy, robust data were obtained for the prevalence of the parasite in this subpopulation, although such studies are usually limited in terms of the number of patients included and in their regional coverage. In contrast, analysis of the results of routine faecal examinations from diagnostic laboratories usually covers a wide regional scope, but may be limited in terms of realistic assessment of the prevalence due to the lifestyle of the cats included. These samples are usually collected from cats used to depositing their faeces in places known to the owner, e.g. in cat litter boxes or close to the home. These cats with a lifestyle more connected to the home of the owner may be less at risk of infection with infective larvae of *A. abstrusus* in snails or intermediate hosts such as mice, birds or reptiles. In contrast, cats with a more remote lifestyle and in the habit of roaming and hunting often defecate and discard their faeces in places not known to the owner, which limits the availability of faecal samples for routine faecal analysis. Therefore, data gained in such studies are biased towards well-cared-for cats and neglect outdoor cats with a higher risk of exposure to lungworms and thus underestimate the prevalence. The approach chosen in this study of investigating a broader regional population of cats with respiratory symptoms increases the likelihood of identifying patients in whom the disease symptoms may have been caused by a lungworm infection. The

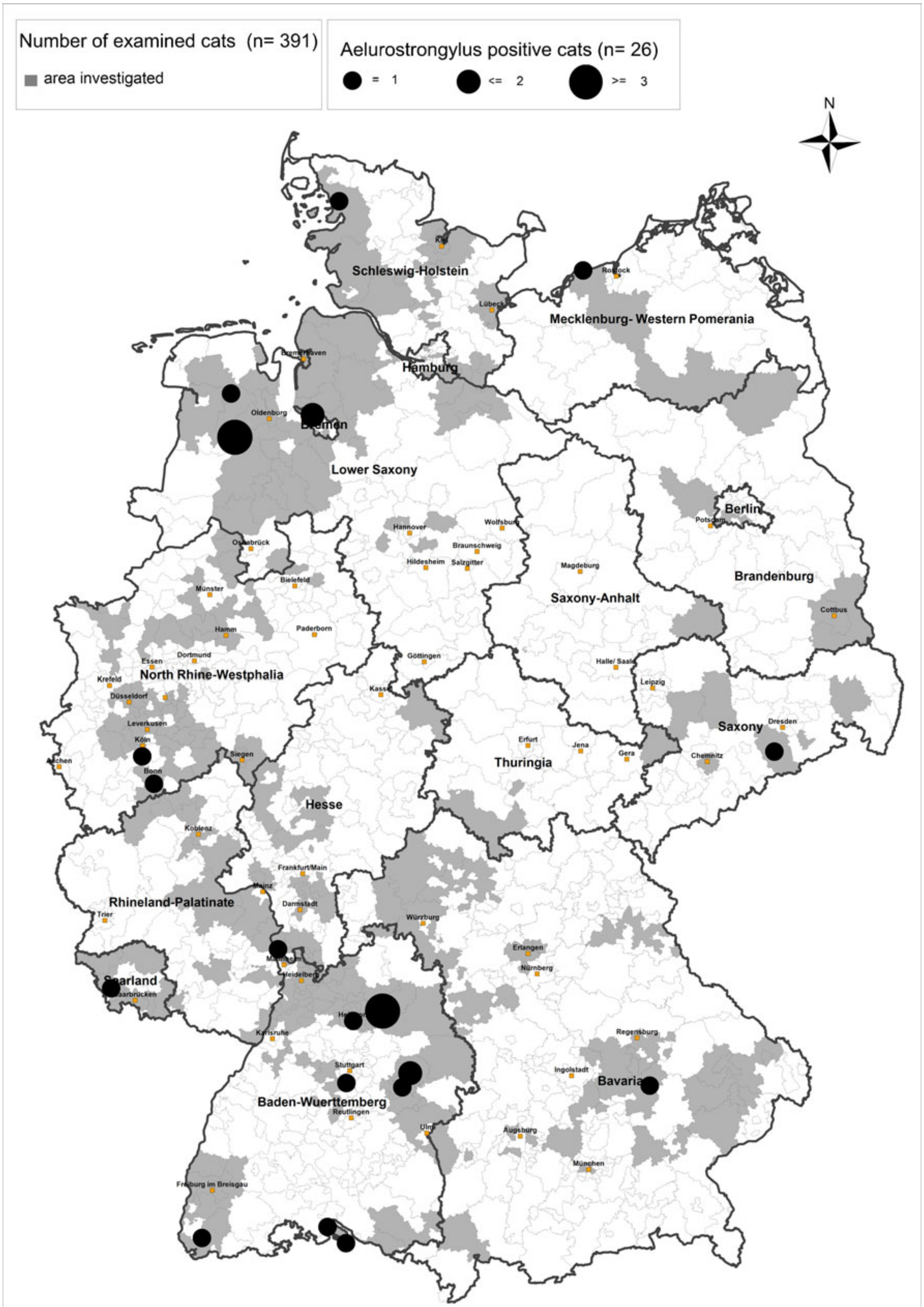

Fig. 4 Regional geographical distribution of *Aelurostrongylus abstrusus* in cats in Germany

prevalence of 6.6 % in cats with respiratory signs found in this study is of the same magnitude as the 5.6 % found by Taubert et al. (2009) and supports the finding that lungworm infection is a frequent cause in cats with respiratory signs. Georeferencing of the cases shows that *A. abstrusus* is widespread across Germany and is not limited to specific areas, although the data basis is limited at this point in time, and as yet, there are no data for the whole of Germany.

Any feline patient presenting in a veterinary clinic with respiratory distress should therefore undergo testing for lungworm infection. The gold standard for diagnosis is still the Baermann procedure, ideally performed with faecal samples collected over three consecutive days. Alternative methods such as bronchoaleaolar lavage are laborious and require anesthesia, but it may be a good tool for differential diagnosis in cats presenting with respiratory symptoms. Serological diagnostic tools such as ELISA or PCR could be a potential tool for mass screening but are currently not commercially available.

Treatment of *A. abstrusus* infections

Currently, there is no licenced drug available in Germany for the treatment of aelurostrongylosis. There is published evidence of successful treatment of the infection with a number of different anthelmintics. Roberson and Burke (1980) demonstrated partial efficacy of fenbendazole when administered orally over three consecutive days at 50 mg/kg bw against adult parasites and transitory effects on larval shedding in experimentally infected cats. Hamilton et al. (1984) reported successful treatment of aelurostrongylosis in cats with fenbendazole given at 50 mg/kg bw over more than three consecutive days.

Schmid and Duewel (1990) and Barrs et al. (1999) confirmed the efficacy of fenbendazole at 50 mg/kg bw if administered over three consecutive days. An 18.75 % fenbendazole paste formulation administered at that dose and treatment interval is licensed in the UK for this indication.

Macrocyclic lactones (ivermectin and selamectin) have been evaluated in natural *A. abstrusus* infection in various doses and treatment regimens in a few reports, although they were not considered to be completely satisfactory due to only partial efficacy or the need for repeated administration (Kirkpatrick and Megella 1987; Blagburn et al. 1987; Grandi et al. 2005).

More recently, Traversa et al. (2009a, b) published data from a comparative study involving the 18.75 % fenbendazole paste (Panacur® MSD) administered at 50 mg/kg bw over three consecutive days, moxidectin (Advocate® Bayer) administered at 1 mg/kg bw moxidectin/10 mg imidacloprid given once as a spot-on treatment, and emodepside (Profender® Bayer) administered at 3 mg/kg bw emodepside/12 mg/kg bw praziquantel given once as a spot-on treatment. All products successfully eliminated larval shedding in naturally infected cats. Treatment of indocile and feral cats that may more often be infected with the parasite is difficult, especially when oral administration over a longer period is required. Application of a spot-on formulation, in contrast, is easier, will achieve a higher compliance rate and offers a worthwhile alternative to orally administered products.

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