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ORIGINAL PAPER

Parasites and vector-borne diseases in client-owned dogs in Albania: infestation with arthropod ectoparasites

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Abstract To establish the diversity and seasonality of ectoparasite infestation in client-owned dogs in Albania, 602 dogs visiting four small animal clinics in Tirana from March 2010 to April 2011 inclusive were examined for ectoparasites by full body search and total body comb. In addition, ear swab specimens collected from all dogs and scrapings taken from skin lesions suspicious of mite infestation were examined for parasitic mites. Overall, 93 dogs (15.4 %, 95%CI 12.6–18.6) were demonstrated to be infested, and nine species of ectoparasites were identified: *Ixodes ricinus*, 0.8 %; *Rhipicephalus sanguineus* s. l., 8.1 %; *Demodex canis*, 0.2 %; *Sarcoptes scabiei*, 0.7 %; *Otodectes cynotis*, 2.8 %; *Ctenocephalides canis*, 4.8 %; *Ctenocephalides felis*, 3.0 %; *Pulex irritans*, 0.2 %; and *Trichodectes canis*, 0.2 %. Single and multiple infestations with up to four species of ectoparasites concurrently were recorded in 67 (11.1 %, 95%CI 8.7–13.9) and 26 dogs (4.3 %, 95%CI 2.8–6.3), respectively. On univariate analysis, the category of breed (pure breed dogs vs. mixed-breed dogs), the dog's purpose (pet, hunting dog, working dog), the housing environment (mainly indoors/indoors with regular outside walking vs. yard plus kennel/run), the history of ectoparasiticide treatment and the season of examination were identified as significant ($p < 0.05$) factors predisposing dogs to various ectoparasites, while the variables dog's age, gender, the dog's habitat (city, suburban, rural) and the presence/absence of other pets were not significant predictors. Multivariate logistic regression analysis for factors associated with overall ectoparasitism revealed that dogs treated with ectoparasiticides at least once per year (odds ratio [OR] = 0.24; $p < 0.001$) had a significantly lower risk of infestation compared with dogs not treated against ectoparasite infestation. Dogs examined during spring, summer and autumn (OR = 7.08, 7.43 and 2.48, respectively; all $p < 0.001$) had a significantly higher risk of infestation than dogs examined during winter. By providing basic data on the infestation with ectoparasites in client-owned, veterinary-cared-for dogs from Albania for the first time, the results of this survey should emphasize the need of an increase of attention to ectoparasites in dogs by both veterinarians and dog owners.

Keywords Dog · Ectoparasite infestation · Ticks · Fleas · Ear mites · Risk factors

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Introduction

The arthropod ectoparasites of greatest importance to dogs worldwide are usually hard ticks (Ixodidae) and fleas (Siphonaptera). However, there are many other species of insects (e.g. anopluran and mallophagan lice, biting flies, mosquitoes, dipteran myiasis larvae) and arachnids (e.g. scabies mites, ear mites, hair follicle mites, fur mites, chigger mites) which may infest dogs. These ectoparasites collectively can cause not only discomfort but are also capable to adversely affect the health and well-being of dogs through causing nuisance, feeding on blood, inducing dermatitis and hypersensitivity, introducing pathogens or damaging the dog's tissues during larval development. Apart from directly affecting the infested animal, some of the ectoparasites can also infest humans and are thus considered zoonotic. Ticks and mosquitoes are notorious as vectors of disease agents and may transmit pathogens like viruses, bacteria including rickettsiae, protozoans and/or filarial nematodes to other animals and humans. In addition, fleas can also transmit pathogens, such as the agents of flea-borne rickettsioses and *Bartonella* species, and can serve as intermediate hosts of some species of cestodes.

Geographical differences may influence the risk of arthropod-borne disease agents and parasite transmission, not only between animals but also between animals and humans, and they may have implications for the measures used to control these ectoparasites. The mild Mediterranean climate, which is characteristic to the western (lowland) parts of Albania bordering the Adriatic and the Ionnian seas including the capital Tirana (MoEFWA 2009; ENVSEC 2012), is favourable to the development of many arthropod species which are incriminated vectors of various pathogens (Otranto and Dantas-Torres 2010).

Data regarding the prevalence and species of ectoparasites of dogs in Albania is scarce. In the past, scattered information on the occurrence of ectoparasites infesting dogs in Albania was documented in the format of faunistic studies targeting certain types of parasites in domestic and non-domestic animals (e.g. ticks, fleas, bloodsucking dipterans) which included the opportunistic sampling of small numbers of not well characterized dogs (Danielova 1960; Rosický and Gjini 1960; Rosický et al. 1960; Luli 1963; Gina 1973; Gina and Kastrati 1974; Kero and Gina 1974; Gina et al. 1975). Only recently, the first systematic survey on the ectoparasites infesting dogs from Tirana, Albania, has been conducted (Xhaxhiu et al. 2009). Results of this survey were further supported with data derived from the identification of ticks and fleas which were collected from 68 dogs and examined for arthropod-transmitted pathogens (Silaghi et al. 2013).

Because keeping dogs as companion animals has recently increased in Albania, interest in the parasitological status of these animals has also increased. As there are no published data describing the status of parasite infections in this category of dogs in the country, a survey was prospectively conducted in the years 2010 and 2011 to assess the status of client-owned, veterinary-cared-for dogs in Albania including the assessment of history and demographic factors which may play a role in the epidemiology of these parasite infections.

This paper presents data on the diversity, prevalence and intensity of infestation with ectoparasites, while the results of the examination of the dogs for endoparasite infections and blood pathogens and seroprevalence of selected parasitic and infectious diseases are reported separately (Hamel et al. 2016; Shukullari et al. 2015).

Material and methods

Sample collection

As detailed previously (Shukullari et al. 2015), dogs presented to four small animal clinics in Tirana, Albania, during the period from March 2010 to April 2011 inclusive were included in the survey.

Apart from the reason for admission of the dogs to the clinics and the date of sampling, information on the dog's breed, age, gender, dog's purpose (main use), habitat and environment, presence of other dogs or cats in the household, type of food and history of parasite control were collected from a survey only (Shukullari et al. 2015).

Examination for ectoparasite infestation

All dogs were examined for ectoparasite infestation by a full body search, and the whole body was combed with a stainless steel fine-toothed flea comb (Zakson et al. 1995). Ticks were manually removed and collected together with any fleas and lice in the comb. The ticks, fleas and lice removed from the dogs were stored in 70 % ethanol until they were identified and counted to determine the intensity of infestation (ectoparasite load). In eight dogs, lesions suspicious of mite infestation (characterized by scaling, scores, dermal encrustations and hair loss) were observed during the body search and scrapings were taken from the altered skin. In addition, deep ear swab specimens were obtained from both ears from all dogs.

Ticks, fleas and lice were identified with a dissection microscope. Skin scrapings and ear swabs were placed in 10 % caustic potash and gently heated to macerate scales, crusts and hair or aural material. Thereafter, the material was centrifuged, and the digest's sediment was examined with a compound microscope under ×100 and ×400 magnification.

For speciation of ectoparasites, existing descriptions and/or keys were used (Jancke 1938; Babos 1964; Lohse et al. 2002; Estrada-Peña et al. 2004). Brown dog ticks of the *Rhipicephalus sanguineus* group or complex (Dantas-Torres et al. 2013; Gray et al. 2013) were recorded as *R. sanguineus* s. l.

Statistical analysis

Statistical analyses were performed using software package R, version 2.13.1 (R Development Core Team 2010). The prevalence was calculated with the 95 % Clopper-Pearson confidence intervals (95%CI). Associations between positivity for parasitism and variables representing reasons for admission to the clinics, host demographic and management factors and season of examination were assessed univariately using contingency tables and the chi-squared test or the Fisher exact test, as appropriate. Variables with a p value of less than 0.2 for the association with the outcome variable in the single variable analysis and potential factors (breed [pure breed vs. mixed breed], gender, age, dog's purpose, dog's habitat, dog's environment, presence of other pets, ectoparasiticide treatment, season of examination) were included into a multivariate logistic regression model to evaluate the adjusted effects of the associated factors. Level of significance for all analyses was set at $p < 0.05$.

Results

Study population and characteristics

As detailed previously (Shukullari et al. 2015), dogs of the study population were examined continuously (31 to 49 dogs per month), and the ratio of dogs of the two age categories (dogs ≤1 year/dogs >1 year) was similar in the four seasons of examination (winter, 24/96; spring, 57/163; summer, 34/99; autumn, 23/106; $p = 0.2498$).

The query regarding the use of treatments for the control (treatment and/or prevention) of ectoparasite infestation identified only topical products which release their active ingredients from liquid formulations or polymers embedded in a plastic-like collar (non-systemic compounds which have repellent properties and/or kill the parasites through direct contact to the active ingredient after dispersal over the body surface; deltamethrin, permethrin, tetramethrin, imidacloprid, fipronil).

Prevalence of ectoparasite infestation, occurrence of multiple parasitism and intensity of infestation

Total prevalence and counts of ectoparasites (ticks and fleas only) obtained by full body search and total body comb and examination of ear swabs and scrapings taken from skin lesions suspicious of mite infestation are summarized in Table 1. Overall, 93 dogs (15.4 %, 95%CI 12.6–18.6) had evidence for ectoparasite infestation, with ticks, fleas and ear mites representing the most common types of ectoparasites. In total, nine species of ectoparasites were identified comprising two species of hard ticks (*Ixodes ricinus*, *R. sanguineus* s. l.), three species each of mites (*Demodex canis*, *Otodectes cynotis*, *Sarcoptes scabiei* var. *canis*) and fleas (*Ctenocephalides canis*, *Ctenocephalides felis*, *Pulex irritans*) and one species of mallophagan lice (*Trichodectes canis*).

Single and multiple infestations with up to four species of ectoparasites concurrently were recorded in 67 (11.1 %, 95%CI 8.7–13.9) and 26 dogs (4.3 %, 95%CI 2.8–6.3), respectively (Table 2). *R. sanguineus* s. l. ticks plus *C. canis* or *C. felis* fleas were the most frequently found combinations.

The most common parasites were ticks which were found attached to 52 dogs (8.6 %, 95%CI 6.5–11.2) with individual counts ranging from one to 61, and fleas which were recovered from 40 dogs (6.6 %, 95%CI 4.6–8.8) with individual flea counts ranging between one and 161. Stratifying the counts of ticks and fleas into three categories using the score established by Marchiondo et al. (2007), approximately 75 % of the tick-infested dogs carried low and moderate levels of infestation of up to three or four to ten ticks per animal; 75 % of the dogs carried a low level infestation of up to five fleas, and the infestation level was moderate (6–20 fleas/animal) or high (>20 fleas/animal) in 12.5 % each of the dogs (Fig. 1). While fleas (*C. canis* and *C. felis)* were recovered from the dogs in each season, *I. ricinus* were recorded in winter and spring and *R. sanguineus* s. l. in spring and summer only. Analysis of the prevalence of infestation with any of the three major types of ectoparasites (ticks, fleas, ear mites) revealed a significant association between infestation of ticks and of fleas: dogs infested with fleas were found significantly ($p = 0.0001$) more frequently among dogs infested with ticks (flea-positive/tick-positive: 22/52, 42.3 % vs. flea-positive/tick-negative: 18/550, 3.3 %).

Testing of prevalence of any ectoparasite vs. grouped reasons for admission of the dogs to the clinics (routine measures, dermatological conditions, other [surgery, gastrointestinal conditions including vomiting, cardiopulmonary and urinary conditions, general abnormal condition]; 12.4, 45.5 and 12.4 %) did reveal a significant association of overall ectoparasitism and dermatological conditions ($p < 0.0001$).

The query of the dog owners revealed that owners who treated their dogs with ectoparasiticides claimed to deworm the dogs significantly ($p < 0.0001$) more often (316/360, 87.8 %) than owners who did not use ectoparasiticides (110/242, 45.5 %).

Risk factors

On univariate analysis, the breed (pure breed dogs vs. mixed-breed dogs), the dog's purpose, the dog's environment, the history of ectoparasiticide treatment and the season of examination were identified as significant ($p < 0.05$) factors predisposing dogs to various ectoparasite infestations.

Compared to pure breed dogs, mixed-breed dogs were infested more frequently with overall ectoparasites (13.2 vs. 28.7 %) and ticks and/or fleas (9.7 vs. 24.1 %). Pet dogs were more often infested with ticks and/or fleas than hunting/working dogs (14.6 vs. 6.2 %).

Dogs kept mainly indoors/indoors with regular outside walking harboured less frequently overall ectoparasites and ticks and/or fleas (12.4 and 8.5 %, respectively) than dogs which were kept in yards/were kennelled (17.7 and 14.2 %, respectively). Analysis of general ectoparasiticide use (yes/

Table 1 Prevalence and intensity of ectoparasite infestation on 602 client-owned dogs from Albania with either single or multiple-species infestation

	Prevalence			Intensity
	Number of infested dogs	%	95%CI[a]	AM[b] (range)
Ixodes ricinus	5	0.8	0.3–2.0	1.6 (1–4)
Rhipicephalus sanguineus s. l.	49	8.1	6.1–10.7	9.2 (1–61)
Total ticks	52	8.6	6.5–11.2	8.9 (1–61)
Otodectes cynotis	18	3.0	1.8–4.7	–
Sarcoptes scabiei	4	0.7	0.2–1.8	–
Demodex canis	1	0.2	0.01–1.1	–
Ctenocephalides canis	29	4.8	3.3–6.9	4.5 (1–22)
Ctenocephalides felis	18	3.0	1.8–4.7	20.1 (1–163)
Pulex irritans	1	0.2	0.01–1.1	1 (1)
Total fleas	40	6.6	4.6–8.8	12.3 (1–163)
Trichodectes canis	1	0.2	0.01–1.1	–
Total ectoparasites	93	15.4	12.6–18.6	–

95%CI 95 % confidence interval, *AM* arithmetic mean

[a] Yates continuity correction performed

[b] Infested animals

no) vs. prevalence of ectoparasitism showed that dogs of owners who used ectoparasiticides in their animals tested significantly less frequently ectoparasite-positive than dogs whose owners did not administer ectoparasiticides for overall ectoparasites (10.8 vs. 31.5 %), *C. canis* (1.7 vs. 10.5 %), *C. felis* (1.1 vs. 5.8 %) and *R. sanguineus* s. l. (4.2 vs. 14.0 %). However, among the subpopulation of dogs which were administered ectoparasiticides, there was no association of the prevalence of any type of ectoparasitism to the annual frequency of use. Dogs examined during the winter had less evidence of ectoparasite infestation than had the dogs tested in spring, summer and autumn for overall ectoparasites (5.0, 19.1, 22.6 and 11.6 %), *O. cynotis* (0, 4.1, 0.8 and 6.2 %), fleas (2.5, 6.4, 16.7 and 3.9 %), and *R. sanguineus* s. l. (0, 11.4, 18.0 and 0 %). Figure 2 plots the seasonal percentage prevalence of infestation of the dogs with overall ectoparasites, *R. sanguineus* s. l. ticks and fleas.

Table 2 Occurrence of single and multiple ectoparasite infestations in 602 client-owned dogs from Albania

	Prevalence, total (%)
Single ectoparasite infestations	67 (11.1)
Ixodes ricinus	2 (0.3)
Rhipicephalus sanguineus s. l.	28 (4.7)
Otodectes cynotis	18 (3.0)
Sarcoptes scabiei var. canis	3 (0.5)
Demodex canis	1 (0.2)
Ctenocephalides canis	12 (2.0)
Ctenocephalides felis	3 (0.5)
Mixed ectoparasite infestations	26 (4.3)
I. ricinus + *R. sanguineus* s. l.	1 (0.2)
I. ricinus + *C. canis*	1 (0.2)
R. sanguineus s. l. + *C. canis*	7 (1.2)
R. sanguineus s. l. + *C. felis*	8 (1.3)
S. scabiei var. canis + *C. canis*	1 (0.2)
C. canis + *C. felis*	3 (0.5)
I. ricinus + *R. sanguineus* s. l. + *C. canis*	1 (0.2)
R. sanguineus s. l. + *C. canis* + *C. felis*	2 (0.3)
R. sanguineus s. l. + *C. canis* + *C. felis* + *Pulex irritans*	1 (0.2)
R. sanguineus s. l. + *C. canis* + *C. felis* + *Trichodectes canis*	1 (0.2)

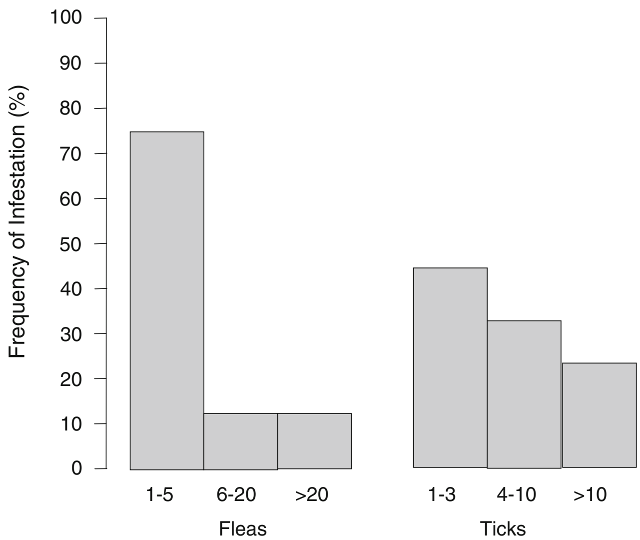


Fig. 1 Infestation with fleas (*Ctenocephalides* spp. and *P. irritans*) and ticks (*I. ricinus* and *R. sanguineus* s. l.) of 40 and 52 client-owned dogs from Albania, respectively, grouped according to the score of Marchiondo et al. (2007) corresponding to low, moderate and high levels of infestation

The factors dog's age, gender, the dog's habitat and the presence/absence of other dogs and/or cats were not found to be significant risk factors for ectoparasitism for the examined population of dogs in the univariate analysis.

The final multivariate logistic regression models for risk factors associated with overall ectoparasitism developed on the basis of the results of the examination of the dogs by full body search and total body comb, and examination of ear swabs and scrapings taken from skin lesions suspicious of mite infestation showed that only general ectoparasiticide use and season of examination were the significant predictors (Table 3).

Table 3 Multivariate analysis for risk factors associated with overall ectoparasitism in 602 client-owned dogs from Albania

Factor and group	Odds ratio	95%CI	*p* value
Overall ectoparasitism			
Ectoparasiticide use			
No	Reference	NA	NA
Yes	0.24	0.12–0.46	<0.001
Season of examination			
Winter	Reference	NA	NA
Spring	7.08	2.78–18.02	<0.001
Summer	7.43	2.84–19.46	<0.001
Autumn	2.48	0.88–7.00	<0.001

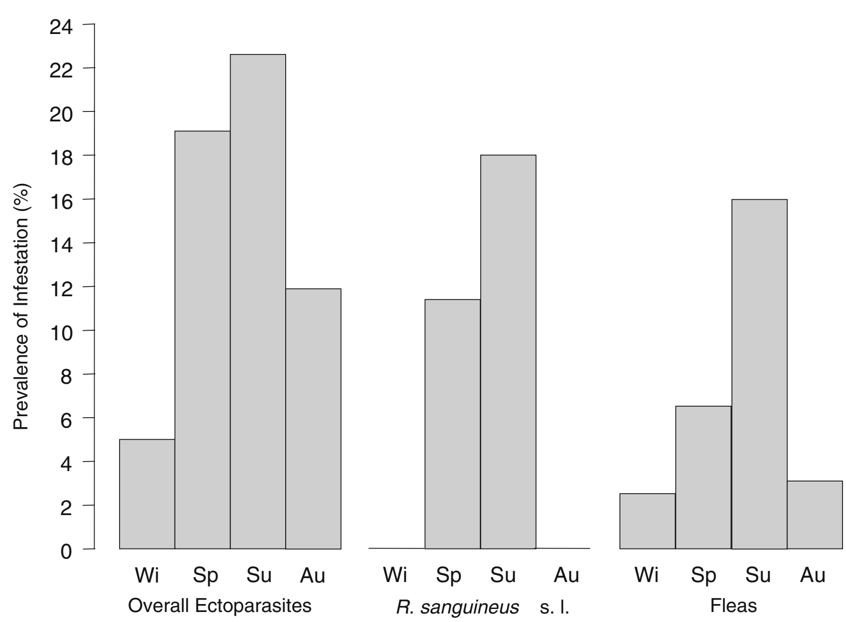
NA not applicable

Discussion

Ectoparasite spectrum

The nine species of arthropod ectoparasites recorded in the client-owned dogs presented in four small animal clinics in Tirana are considered as common canine ectoparasites with worldwide occurrence, but prevalence and importance of infestation vary related to geographical region and category of dogs. Canine infestations with tick and flea species have been documented in Albania in prior studies (Rosický and Gjini 1960; Rosický et al. 1960; Luli 1963; Gina 1973; Gina and Kastrati 1974; Kero and Gina 1974; Gina et al. 1975). However, the occurrence of all nine species of ectoparasites, including three species of mites and one mallophagan, has been recorded in a recently conducted survey only (Xhaxhiu et al. 2009). All species have been recorded in other countries

Fig. 2 Seasonal prevalence of infestation of client-owned dogs from Albania with overall ectoparasites (ticks, mites, fleas and *T. canis*), *Rhipicephalus sanguineus* s. l. and fleas (*Ctenocephalides* spp. and *P. irritans*) (*Wi* winter, *Sp* spring, *Su* summer, *Au* autumn)



on the Balkans as discussed exhaustively before (Xhaxhiu et al. 2009) and supported through additional recent work from the geographic region (Omeragic 2011; Pavlović et al. 2011; Kirkova et al. 2013; Krčmer et al. 2014). Further to the ectoparasite spectrum recorded in this study, the anecdotal collection of a ked (*Hippobosca equina*) from a dog was reported in 1960 (Danielova 1960), and in a tick survey conducted in the early 1970s, *Haemaphysalis inermis* and *Haemaphysalis punctata* ticks were found attached to dogs in Albania (Gina et al. 1975; Gina 1977). Although not specifically studied as parasites of dogs but testified through the endemicity of zoonotic canine leishmaniosis and dirofilariosis (e.g. Cani et al. 2001; Lazri et al. 2008; Rapti and Rehbein 2010; Xhaxhiu et al. 2011; Bizhga et al. 2013; Hamel et al. 2016), dogs in Albania must be attacked for blood-feeding by the incriminated flying vectors of the agents of the two diseases. Phlebotomine sandflies or mosquitoes of the Culicidae family that are competent vectors of *Leishmania infantum* and *Dirofilaria immitis*, respectively, are abundant in the country (e.g. Adhami 1997, 2000; Adhami and Reiter 1998; Velo et al. 2003, 2005, 2010; Rogozi et al. 2012).

Prevalence and intensity of ectoparasitism

Of the four species of ticks described attaching to dogs in Albania, ticks of the two species *I. ricinus* and *R. sanguineus* s. l. were recorded on the client-owned dogs with the latter outnumbering the former for both prevalence and intensity of infestation. Thus, results of the current study are in agreement with recently conducted studies in dogs from suburban areas of Tirana (Xhaxhiu et al. 2009; Silaghi et al. 2013), and similar results revealed the examination of dogs admitted to veterinary clinics in the city and county of Thessaloniki, Greece (Papazahariadou et al. 2003). Apart from the aspect that *R. sanguineus* is a characteristic representative of the Mediterranean tick fauna which primarily parasitizes dogs while *I. ricinus* ticks are opportunistic feeders infesting virtually all land vertebrates, the predominance of *R. sanguineus* is likely explained through the different habitat preferences of the two species of ticks in relation to the habitats, the dogs originated from. More than 80 % of the dogs were from urban and suburban habitats which constitute a suitable environment for the endophilous *R. sanguineus* that can infest houses and can reach pest proportions in animal shelters (Dantas-Torres 2008, 2010; Lorusso et al. 2010; Otranto et al. 2012). *I. ricinus* with its very limited tolerance to desiccation, in contrast, has a typical exophilous behaviour and is commonly found in habitats like less maintained meadows, bushy areas and deciduous and mixed forests (Bowman and Nuttall 2008). Although the Mediterranean Basin constitutes the southern edge of the range of distribution of *I. ricinus* in Europe, ticks of this species can develop well in the region in natural habitats which provide the specific microclimatic conditions and may complete its life cycle in approximately 1 year (Dantas-Torres and Otranto 2013). This is apparently applicable to Albania, where *I. ricinus* was shown to have a wide geographical distribution (Luli 1963) like in the neighbouring Kosovo, former Yugoslav Macedonia and Greece (Papadopoulos et al. 1996; Milutinović et al. 1997; Pavlidou et al. 2008; Pavlović et al. 2014).

While infestation with *I. ricinus* was of a very low level in both the client-owned dogs and dogs with limited or no veterinary care from suburban areas of Tirana (Xhaxhiu et al. 2009), prevalence of *R. sanguineus* s. l. in the client-owned dogs was just one third of the one observed in dogs from suburban areas of Tirana (8.1 vs. 23.8 %, $p < 0.0001$). Mean level of infestation of the tick-infested client-owned dogs was only slightly lower (~9 ticks per dog) than that of the infested dogs with limited or no veterinary care (~11 ticks per dog) (Xhaxhiu et al. 2009). The relevance of *R. sanguineus* infestation is underlined through the range of pathogens identified in the client-owned dogs enrolled in this survey (Hamel et al. 2016) which are confirmed (*Babesia vogeli*, *Ehrlichia canis*, *Hepatozoon canis*, *Mycoplasma haemocanis*) or suggested (*Anaplasma platys*) to be transmitted by this species of ticks (Senevira et al. 1973; Otranto and Dantas-Torres 2010).

Similar to the infestation with ticks but much more pronounced, overall infestation with fleas of the client-owned dogs in this study was lower than that of less well-cared-for dogs from suburban areas of Tirana (Xhaxhiu et al. 2009). As with ticks, prevalence of infestation was distinctly different ($p < 0.0001$) with 6.6 and 75.7 %, respectively, while the mean total flea load per infested dog was apparently similar (12.3 vs. 12.0). However, the arithmetic mean flea count of the infested client-owned dogs does not adequately reflect that 75 % of the dogs harboured no more than five fleas but it is biased by high counts of single animals. Although *C. canis* was the most prevalent species of flea in both client-owned, veterinary-cared-for dogs (4.8 %) and less well-cared-for dogs in Albania (75.7 %, Xhaxhiu et al. 2009), proportions of infested dogs harbouring *C. canis*, *C. felis* and *P. irritans*, suggest a shift from a *C. canis*-predominated flea population in the dogs with limited or no veterinary care towards a population with a substantial higher percentage of *C. felis* in the client-owned dogs (100, 6.5 and 10.9 %, respectively, vs. 72.5, 45.0 and 2.5 %, respectively). The findings in the client-owned dogs from Albania resemble the results of a survey conducted in the early 1990s with dogs presented to the veterinary teaching hospital of Thessaloniki, Greece (Koutinas et al. 1995), where infestation with *C. canis*, *C. felis*, *P. irritans* and *Xenopsylla cheopis* was recorded in 71.3, 40.3, 0.8 and 0.8 % of the flea-infested dogs, respectively. Globally, *C. felis* is the most prevalent species of flea recorded in domestic dogs (Dobler and Pfeffer 2011). Higher proportions of *C. canis* are found usually in dogs inhabiting rural settings, living in kennels or being kept outdoors, in contrast to dogs from residential habitats which harbour predominately *C. felis* (Xhaxhiu et al.

2009). Based on the findings of this study, further surveys should be conducted to follow-up potential changes in the flea population of client-owned dogs in Albania.

As discussed previously (Xhaxhiu et al. 2009), canine parasitism caused by ectoparasites other than ticks and fleas (e.g. mites and lice) does usually not receive much attention in cross-sectional type of studies and information regarding the prevalence of these parasites is largely lacking, especially in veterinary-cared-for dogs. Examination of the 602 client-owned dogs revealed significantly ($p < 0.01$) lower prevalence of infestation with *S. scabiei* var. *canis* mites and *T. canis* lice than the examination of 181 dogs with limited or no veterinary care from suburban areas of Tirana (0.7 % and 0.2 %, respectively, vs. 4.4 % and 6.6 %, respectively). However, prevalence of infestation with *O. cynotis* and *D. canis* mites was not different (3.0 % and 0.2 %, respectively, vs. 6.7 % and 0.6 %, respectively; $p > 0.2$).

Risk factors associated with ectoparasitism

In contrast to endoparasitism (Shukullari et al. 2015), there are relatively few studies which evaluated risk factors associated to ectoparasitism and attempted to associate variation in prevalence and/or intensity (ectoparasite load) to certain epidemiological factors.

Although univariate analyses identified several risk factors for various types of ectoparasite infestation in the population of client-owned dogs (e.g. mixed-breed dogs, pet dogs, dogs kept in yards and kennel/runs, lack of ectoparasiticide use, warm seasons) only history of ectoparasiticide use and season of examination were identified as strongest predictors for ectoparasitism.

Despite that *R. sanguineus* may infest dogs in the Mediterranean region throughout the year as recently shown in a study conducted in a heavily infested animal shelter in southern Italy (Lorusso et al. 2010), infestation with *R. sanguineus* in the client-owned dogs from Albania was observed in the spring and summer months only. A similar seasonal pattern with *R. sanguineus* found attached to dogs in spring, summer and autumn has been previously recorded in less well-cared-for dogs from suburban areas in Tirana (Xhaxhiu et al. 2009; Silaghi et al. 2013) and was reported from central Italy (Stella et al. 1988; Principato et al. 1989). As found in the client-owned dogs from Albania, field studies conducted in central Europe demonstrated that ticks (mainly *Ixodes* spp. and *Dermacentor reticulatus*) attached less frequently to dogs treated with acaricides than to untreated dogs (Duscher et al. 2013; Beck et al. 2014).

In agreement with other studies from Europe including prior studies conducted in Albania (Koutinas et al. 1995; Beck et al. 2006; Rinaldi et al. 2007; Gracia et al. 2008; Xhaxhiu et al. 2009; Silaghi et al. 2013), infestation of dogs with both *C. canis* and *C. felis* fleas was demonstrated year round with the peak of prevalence seen in summer. In contrast to a study conducted in the south of Italy (Rinaldi et al. 2007), housing with other dogs and/or cats was not identified as risk factor in the client-owned dogs from Albania. Interestingly, while hunting and guard dogs from southern Italy had a higher risk of flea infestation than pet dogs (Rinaldi et al. 2007), examination of the client-owned dogs from Albania revealed the contrary. However, the controversial findings of the two surveys result from univariate analyses only. For the client-owned dogs from Albania, multivariate analyses accounting for several additional factors including use of ectoparasiticides did not provide evidence for the dog's purpose to be considered as a significant predictor for ectoparasitism. The relevance of considering potential confounding factors in this regard was discussed by Rinaldi et al. (2007).

Conclusion

This study is the first which evaluated the ectoparasite status of client-owned, veterinary-cared-for dogs from Albania in a systematic approach and included more dogs than any other prior survey that provided information on the infestation with ectoparasites of dogs in the country. Results of the study demonstrated a range of ectoparasites but prevalence rates were substantially lower than rates of infestation estimated in dogs with limited or no veterinary care in Albania. Local veterinary practitioners and dog owners should be aware of the endemic ectoparasites of dogs and risk factors associated with infestation because of the potential direct and indirect impact of infestation on the dogs but also on humans. The present study indicates that veterinarians and dog owners should increase their efforts to reduce the prevalence of ecto-parasite infestation in the dogs and thus lower the risk of the transmission of vector-borne agents.

Compliance with ethical standards

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