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Short communication

Ticks and the city: Ectoparasites of the Northern white-breasted hedgehog (*Erinaceus roumanicus*) in an urban park

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ABSTRACT

The European hedgehog (*Erinaceus europaeus*) is known to host several ectoparasites and also tick-borne pathogens, but there is scant information on its eastern relative, the Northern white-breasted hedgehog (*Erinaceus roumanicus*). We have studied an urban population of *E. roumanicus* in a city park of central Budapest, Hungary, for 2 years to investigate their tick and flea species. A total of 5063 ticks and 818 fleas were collected from 247 hedgehogs (including 46 recaptures). Ectoparasite prevalence and intensity differed significantly ($p < 0.001$) between the 2 study years attributable to the enhanced tick removal rate due to anaesthesia used in the second year. The most common tick species was *Ixodes ricinus* (93.7%) followed by unidentified *Ixodes* larvae (5%). Only 57 hedgehog ticks (*I. hexagonus*) were removed from 22 hedgehogs. One *I. acuminatus* and one *Hyalomma marginatum* nymph were also collected. Mean intensity of tick infestation was 26.5 (range: 0–155 ticks/host) and mean intensity of flea infestation was 6.6 (range: 0–78 fleas/host). Most fleas (99.4%) collected were hedgehog fleas (*Archaeopsylla erinacei*), dog fleas (*Ctenocephalides canis*) were found on 2 hedgehogs. *Hyalomma marginatum* has previously not been found in Hungary, and *I. acuminatus* was only reported sporadically before. The large number of ectoparasites and the 2 imported tick species may thus survive in close proximity to humans if hedgehogs are present. This calls attention to the risk of possible tick-borne human infections that urban hedgehogs can pose.

Introduction

Hedgehogs harbour many zoonotic pathogens, including a number which are transmitted by ticks (Riley and Chomel, 2005). Due to their active foraging behaviour in the undergrowth and their lack of effective grooming, hedgehogs are ideal hosts for ectoparasites. The most common tick species on the European hedgehog (*Erinaceus europaeus*) are the exophilic *Ixodes ricinus* and the endophilic *I. hexagonus* (Gern et al., 1997). Both of these ticks are known vectors of *Borrelia burgdorferi* sensu lato (s.l.) and tick-borne encephalitis virus (TBEV). The European hedgehog has been shown to host at least 4 species of Lyme spirochaetes, *B. burgdorferi* sensu stricto, *B. afzelii*, *B. garinii*, and *B. spielmanii* (Gray et al., 1994; Gern et al., 1997; Skuballa et al., 2007). A recent study suggests that they also have a role in the maintenance of *Anaplasma phagocytophilum* (Skuballa et al., 2010). Northern white-breasted (or Eastern) hedgehogs (*Erinaceus roumanicus*) are able to maintain TBEV during hibernation and might act as reservoirs during epidemic and interepidemic periods (Kožuch et al., 1963). They were shown to have higher antibody titers against TBEV then rodents in Slovakia (Kožuch et al., 1967). However, transmission experiments would be needed to demonstrate whether hedgehogs could also infect ticks over long time periods as a result of systemic infection or whether they mainly play a role in co-feeding transmission of the virus among ticks as in case of rodents (Süss, 2011).

Hedgehogs are commonly parasitized by various flea species (Visser et al., 2001), but mainly by the hedgehog flea (*Archaeopsylla erinacei*). Concerning their zoonotic risk, a recent study showed that hedgehog fleas in Germany can be infected with *Rickettsia felis* which causes a murine typhus-like disease in humans (Gilles et al., 2008).

Hedgehogs are commonly found within cities. They can even reach higher densities in urban/suburban environments than in rural habitats (Reeve, 1994). Based on the large number of ectoparasites and their closeness to humans, hedgehogs can play a special

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Table 1
Tick species and developmental stages collected from hedgehogs in 2009 and 2010.

	Ixodes ricinus			*Ixodes hexagonus*		*Ixodes larva*	*Ixodes acuminatus* nymph	*Hyalomma marginatum* nymph	Total
	Female	Male	Nymph	Female	Nymph				
2009	206	91	160	0	0	12	1	1	471
2010	1496	749	2044	4	53	246	0	0	4592
Total	1702	840	2204	4	53	258	1	1	5063

role in the epidemiology of tick-borne pathogens. Previous studies examined the ectoparasites and possible public health concerns of mainly *E. europaeus*, but similar information is missing on its eastern relative, *E. roumanicus*. The aim of this study was to investigate which ectoparasite species are present on an urban Northern white-breasted hedgehog population in the centre of Budapest, Hungary.

Materials and methods

Fieldwork was carried out for about 5 h after sunset once every month between May and October 2009 and March and November 2010 at Margaret Island, Budapest. This is a 2.5-km-long and 500-m-wide island (0.965 km^2 in area) in the middle of the Danube in central Budapest, Hungary. The island is mostly covered by landscape parks and is a popular recreational area.

Hedgehogs were captured by hand systematically using the lights of head torches after the sunset, walking randomly on the island (Tóth et al., in preparation). The animals' weight was measured and ectoparasites were removed and stored in tubes containing 70% ethanol. Hedgehogs were ear-tagged before release. Ticks and fleas were counted and identified under a stereo microscope using standard keys (Hillyard, 1996). Tick larvae were only identified to genus. To enhance the effectiveness of ectoparasite removal, anaesthesia was performed during 2010 with a combination of ketamine (5 mg/kg body weight) and dexmedetomidine (50 μg/kg body weight) given intramuscularly. The induction time was 5–10 min. During the entire anaesthesia and procedures including the awakening-period, animals were kept at room temperature, and their respiration rate was monitored. Thirty minutes after induction, atipamezole (0.5 mg/kg body weight) was administered as an antidote for dexmedetomidine. There was no emergency situation or fatality during anaesthesia.

For data analysis, the R-environment (R Development Core Team, 2010) and the programme Quantitative Parasitology 3.0 (Rózsa et al., 2000) were used. Tick abundance data were evaluated statistically using generalized linear regression. Prevalence data were analysed with logistic regression and intensities with quasi-Poisson regression. A value of $p < 0.05$ was considered significant.

Results

A total of 5063 ticks and 818 fleas were collected during the 2 years (Table 1). From the 247 hedgehogs examined, 46 were recaptured animals. There was no significant difference between tick prevalence of first captures and recaptures. Tick prevalence and intensity differed significantly ($p < 0.001$) between the 2 study years mainly attributable to the enhanced tick removal due to anaesthesia in 2010 (Table 2). The most common tick species was *I. ricinus* (93.7%) followed by unidentified *Ixodes* larvae (5%). Only 57 *I. hexagonus* ticks were removed from 22 hedgehogs. One *I. acuminatus* and one *Hyalomma marginatum* nymph were also collected during 2009. The mean intensity of tick infestation was 26.5 (range: 0–155 ticks/host), and the mean intensity of flea infestation was 6.6 (range: 0–78 fleas/host) during the two-year study. Flea prevalence and intensity also differed significantly ($p < 0.001$) between the 2 years: 31/118 hedgehogs were infested in the first study year (prevalence: 26.3%, mean intensity: 2.52) and 93/128 (prevalence: 72.1%, mean intensity: 7.61) in the second. Most fleas (99.4%) collected belonged to the species *Archaeopsylla erinacei*. One and 5 dog fleas (*Ctenocephalides canis*) were found on 2 hedgehogs, respectively.

No significant difference was found between abundance, prevalence, and intensity data when analysed according to weight or sex of hedgehogs. Collection dates could not be statistically compared because the number of people collecting hedgehogs varied between months.

Discussion

We examined the ectoparasites of an urban Northern white-breasted hedgehog population for the first time. We found a statistically significant difference between prevalence and intensity of infestation in the 2 study years. This can be attributed to the more efficient collecting method in the second year. In 2009, only a portion of the ticks and fleas could be removed because non-anaesthesized hedgehogs are difficult to handle due to their rolling up behaviour and their spiny body surface. In 2010, an effective and safe anaesthesia was applied, and we could examine each hedgehog for a longer time. This led to an about tenfold increase in the number of ectoparasites recovered in the second year and in case of the small larvae, a 20-fold increase was seen in 2010. However, even with the more efficient screening for ectoparasites during anaesthesia, we calculate with an underestimation of prevalence in both years. Especially for the larval stage, ectoparasites are often undetected and will not be removed. A very effective alternative method to anaesthesia and manual removal is the tick collecting box (Pfäffle et al., 2009, 2011). This box has a grid of holes in its base and collects replete ticks in a water-filled tray. It can collect 100% of ticks feeding on an individual; however, hedgehogs have to be kept in such a box for at least 5–6 days until every tick specimen finishes feeding. In case of fleas, we assume an even smaller efficacy of removal since these ectoparasites are masters of hiding. We experienced that fleas on the anaesthetised hedgehogs “disappeared” quickly to the dense spiny back area where they are very hard to find. To

Table 2
Prevalence and intensity of tick infestation on hedgehogs in 2009 and 2010.

	Hedgehogs examined/infested	Prevalence (%)	Mean intensity	Median intensity
2009	118/75	63.6	6.3	2
2010	129/116	89.9	39.6	31
Total	247/191	77.3	26.5	12

maximize the efficiency of flea collection, the application of a suitable repellent or insecticide can be recommended as used by Egli (2004) and Pfäffle et al. (2009).

The finding of large numbers of adult *I. ricinus* is significant in relation to both maintenance of tick populations and also of pathogens such as *B. burgdorferi* s.l. *E. europaeus* was shown to be a reservoir of these spirochaetes, and *E. roumanicus* seems to be also infected with a high prevalence (Földvári et al., unpublished). Thus, the Northern white-breasted hedgehog is a key host species which feeds every developmental stage of *I. ricinus* and probably also serves as a reservoir for *B. burgdorferi* at the same time. There are very few zoonotic pathogens for which a single host species serves both purposes (Tälleklint and Jaenson, 1993). The large number of males found on these hedgehogs confirms that female ticks were not only accidentally feeding on this host, but they also reproduced. This unique double function of hedgehogs in the epidemiology of *B. burgdorferi* has implications on the relative proportion of infected nymphs and adults and possibly also on transovarial transmission of spirochaetes which will be subject of our future studies.

We collected a rather small amount (1.1%) of *I. hexagonus* on the hedgehogs of Margaret Island. Previous studies reported that 87%, 58.5%, 44%, or 18% of the examined hedgehog ticks belonged to *I. hexagonus* (Beichel et al., 1996; Egli, 2004; Gern et al., 1997; Pfäffle et al., 2009). Some studies suggested a relative increase of *I. hexagonus* from rural to urban habitats (Gern et al., 1997; Egli, 2004). Pfäffle et al. (2011) showed that high population densitiy of hedgehogs in a semi-natural environment yielded higher numbers of *I. ricinus* than *I. hexagonus*. We assume that the hedgehog density on the Margaret Island is higher than in rural or suburban areas (Pfäffle et al., 2011). The availability of hedgehogs and the relatively high humidity of the island provide ideal conditions for the generalist *I. ricinus*. Our finding might be explained by the competitive advantages (more available hosts, higher reproduction rate) of *I. ricinus* against *I. hexagonus*. In addition, the island with its high groundwater is probably not ideal for *I. hexagonus* which might prefer shelters of hedgehogs more underground.

The single *Hyalomma marginatum* specimen was most probably imported from southern countries by birds to Margaret Island. This species has not been reported from Hungary before. The original geographical range of *H. marginatum* is Africa, Asia Minor, and southern Europe. However, it has been imported to other parts of Europe. This tick species is an important vector of zoonotic pathogens, e.g. Crimean-Congo haemorrhagic fever virus, and recently Rumer et al. (2011) reported that a migratory bird in Germany carried *H. marginatum* infected with *Rickettsia aeschlimanni*. The other unusual finding was an *I. acuminatus* nymph. This species is able to bite humans and occurs throughout Europe, but also in parts of Africa and Asia (Hillyard, 1996). It was found before in Hungary on hedgehogs (Babos, 1965), dogs (Földvári et al., 2007), and recently on hamsters (Rigó et al., in press). Continuation of this survey will clarify if hedgehogs on the island are able to maintain a population of these 2 tick species in the long run.

As co-feeding haematophagous insects, fleas might play a vector role for some tick-transmitted pathogens (e.g. *Rickettsia* spp.). The most common flea species found in the present study was *Archaeopsylla erinacei* as expected. This flea is very common on hedgehogs and can also bite dogs, cats (Visser et al., 2001), and rarely humans (Pomykal, 1985). Six dog fleas (*Ctenocephalides canis*) were also collected which has already been found to feed on hedgehogs (Visser et al., 2001). Hedgehog fleas can be infected with *Rickettsia felis* (Gilles et al., 2008), and dog fleas can carry the causative agent of cat scratch disease, *Bartonella henselae* (Márquez et al., 2009), but further studies are needed to understand their role as pathogen vectors.

Pfäffle et al. (2009) showed that tick infestation may lead to anaemia and can have a pathological effect in hedgehogs, especially before the hibernation period. However, healthy hedgehogs are often heavily infested by ticks and fleas without any clinical symptoms. More importantly, they serve as key hosts for the blood-feeding ectoparasites themselves and provide sufficient resources for them to survive in a given habitat. With urbanization of hedgehogs, their ability to maintain huge number of ectoparasites brings fleas and ticks closer to humans. Several thousand visitors come to Margaret Island every week for recreational purposes. Thus, the presence of high numbers of both hedgehogs and humans results in a direct risk of infestation with ticks and an indirect risk of acquiring tick-borne pathogens. The next step in our studies is to scan tick and hedgehog samples for the presence of *B. burgdorferi* s.l. and other pathogens to shed light on the role of these urban hedgehogs in the epidemiology of tick-borne diseases.

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