Infestation of the Northern white-breasted hedgehog (*Erinaceus roumanicus*) with *Ixodes* ticks in urban ecosystems of the city of Poznań

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Abstract

Between April and November 2009, infestation by *Ixodes hexagonus* and *I. ricinus* ticks on the northern white-breasted hedgehog, *Erinaceus roumanicus*, was investigated in urban environments of the city of Poznań. In total, 49 hedgehogs were trapped, 36 (73.5%) of which hosted 1,519 ixodid ticks, with a mean intensity of 42.2 ticks per infested animal. The most abundant tick species, *I. hexagonus*, constituted 67% (1,019) of all ticks recorded and infested 71.4% of the hosts. *I. ricinus* accounted for 33% (500) of all ticks recorded, and was identified on 51% of the hedgehogs. Mean intensities of ticks were higher for *I. hexagonus* than for *I. ricinus* (29.1 and 20.0, respectively). The proportion of the two tick species differed by life stage. *I. hexagonus* larvae (n = 744) strongly dominated over nymphs (n = 204) and females (n = 71). In contrast, similar proportions of three stages of *I. ricinus* were recorded (168 larvae, 194 nymphs, 138 females). Both tick species parasitizing hedgehogs showed seasonal differences in tick burdens and prevalences. The data obtained in this survey demonstrate that *E. roumanicus* hedgehogs hosting all developmental stages of *Ixodes*, contribute to the local amplifying and maintenance of tick populations within urban environments.

Introduction

Western Poland is localized within the central European contact zone of two hedgehog species: the western hedgehog, *Erinaceus europaeus* Linnaeus, 1758 and the northern white-breasted hedgehog, *E. roumanicus* Barret-Hamilton, 1900. The former is widespread in western and central Europe, South Scandinavia, Estonia, and in the northern and central regions of European Russia. The latter inhabits central and eastern

Europe and has its eastern range's limit in Trancaucasia and Asia Minor. *E. roumanicus* has been reported in Poland, Slovakia, Austria, Balkan Peninsula, Ukraine, and the central and south regions of European Russia and the northern Caucasus. In south-eastern Europe, *E. roumanicus* coexist with the Southern white-breasted hedgehog, *E. concolor* Martin, 1838 from which it has been excluded as a separate species based on biochemical and molecular studies (Filippucci and Simson 1996, Santucci et al. 1998, Seddon et al. 2002).

As a result of human-induced landscape alterations associated mainly with urbanization, deforestation and habitat fragmentation observed in Europe over the last 50 years, the hedgehog has become a synanthropic species. Apart from its natural habitats, such as open deciduous/mixed forests, it willingly colonizes suburban and urban ecosystems including private gardens (Egli 2004, Riber 2006). Hedgehogs, as ground-foraging mammals seeking for invertebrates and small vertebrates, are naturally exposed to haematophagous ectoparasites including ixodid ticks. The western hedgehog is commonly parasitized by all developmental stages of two ecologically different ixodid tick species: *Ixodes ricinus*, an exophilous generalist species that seeks hosts on vegetation in various open habitats, and *I. hexagonus*, an endophilous burrow/nest-dwelling tick largely specific to the hedgehog (Smith 1968, Siuda 1993). It should be noted, that hedgehogs occurring in suburban and urban environments may also enhance tick exposure to companion animals such as dogs and cats which may bring ticks into dwellings of their owners. To date, most published data concerning infestation parameters of ixodid ticks feeding on hedgehogs are limited to *E. europaeus*. Despite widespread distribution of *E. roumanicus*, its role as a host for *Ixodes* ticks has not been systematically evaluated and remains almost unknown, except for one survey conducted in the Czech Republic (Kožuch et al. 1967).

In this paper, we present preliminary results of a 1-yr study concerning the prevalence and abundance of two tick species: *I. hexagonus* and *I. ricinus* on the northern white-breasted hedgehog examined in urban ecosystems of the city of Poznań. This is the first such survey conducted in Poland.

Material and Methods

The study was conducted in the city of Poznan (52°17'34"N, 16°44'08"E), in west-central Poland. Between April and November 2009, hedgehogs were searched by foot, with the aid of powerful torchlight, on four housing estates situated within the Winogrady district. They all consisted of blocks of flats and non-sealed areas occurring around residential buildings and in parks. Every site was visited once per week between 8 pm - 11 pm in the spring and the autumn, and between 10 pm - 1 am in the summer. Additionally, hedgehogs were collected from drainage ditches which spread out for 5 kilometers along tram line of Poznan's Fast Tram. Inspections of ditches were carried out during morning trapping sessions, twice per week. Animals were captured by hand and taken to a laboratory where they were maintained in plastic boxes in a darkened room for at least one night. Animals were supplied with commercial cat food and water ad libitum. Each individual was visually inspected for feeding ticks which were removed with tweezers and stored in plastic vials containing 75% ethanol. Examinations lasted from 10 to 60 minutes. In the case of several individuals hosting a large number of larval ticks (above 100 larvae per host), a maximum of 50 larvae were collected, whereas the rest was remained, and counted. Moreover, each box in which an animal was kept, was thoroughly checked for detached ticks. After the examination, animals were returned to their sites of capture and released.

Infestation indices calculated for each tick species collected from hedgehogs were: prevalence (percentage of hosts carrying at least one tick), abundance (mean number of ticks per host) and mean intensity (average number of ticks per tick-infested host).

Results

Forty-nine white-breasted hedgehogs were captured, 36 (73.5%) of which were found to be infested with 1,519 ixodid ticks, with a mean intensity of 42.2 ticks per infested animal (range, 1-261). Of these ticks, 60% (912) were larvae, 26% (398) were nymphs and 14% (209) were females. Overall, five (10.2%) of the 49 animals hosted over 100 *Ixodes* ticks. The most abundant tick species, *I. hexagonus*, accounted for 67% (1,019) of all ticks recorded and infested 71.4% of the hosts. *I. ricinus* constituted 33% (500) of all ticks recorded, and was identified on 51% of the hedgehogs (Tab. 1). Mean intensities of ticks were higher for *I. hexagonus* than for *I. ricinus* (29.1 and 20.0 respectively; Mann-Whitney U-Test, $p<0.05$). All feeding instars of both tick species were identified. Double infestations with both tick species were observed on 23 (64%) of the infested hosts.

Table 1. Prevalence and abundance of *I. hexagonus* and *I. ricinus* ticks on 49 *E. roumanicus* hedgehogs in west-central Poland, between April and November 2009.

Tick species by stage	No. ticks collected (%)	No. hosts infested (%)	No. per host ± SD	Mean intensity (range)
Ixodes hexagonus				
Larvae	744 (73.0)	16 (32.7)	15.2 ± 45.9	46.5 (1-233)
Nymphs	204 (20.0)	29 (59.2)	4.2 ± 8.8	7.0 (1-43)
Females	71 (7.0)	20 (40.8)	1.4 ± 3.2	3.6 (1–18)
Total	1019	35 (71.4)	20.8 ± 50.2	29.1 (1–247)
Ixodes Ricinus				
Larvae	168 (33.6)	12 (24.5)	3.4 ± 18.1	14.0 (1–126)
Nymphs	194 (38.8)	12 (24.5)	4.0 ± 17.6	16.2 (1–121)
Females	138 (27.6)	18 (36.7)	2.8 ± 5.8	7.7 (1–26)
Total	500	25 (51.0)	10.2 ± 37.2	20.0 (1–260)
Total	1519	36 (73.5)	31.0 ± 60.9	42.2 (1-261)

I. hexagonus larvae (744, 73%) strongly predominated over nymphs (204, 20%) and females (71, 7%), and were found on 16 (32.7%) hedgehogs. Prevalences of nymphs and females on hosts were relatively comparable (41% and 59%, respectively). Mean abundance for larvae was significantly higher than for nymphs and females (15.2 versus 4.2 and 1.4, respectively; Mann-Whitney U-Test, $p<0.001$). This larval predominance over nymphs and females was more pronounced in mean intensities (46.5 versus 7.0 and 3.6 per infested animal, respectively). Infestation analysis of *I. ricinus*

showed that all feeding stages infested approximately equal proportion of hosts (range: 24.5–36.7%) and that mean abundances for each stage were similar ranging from 2.8 to 4.0 ticks per animal (Tab. 1).

Both tick species parasitizing hedgehogs showed distinct seasonal differences in tick burdens and prevalences (Fig. 1). Mean numbers of *I. ricinus* peaked in spring (21.8 ticks per animal) when 70% of hosts carried this tick species, and strongly decreased in summer and autumn (3.5 and 1 tick per host, respectively). *I. hexagonus* ticks were most abundant in summer (48.1 ticks per host) compared to spring and autumn (6.1 and 12.6 ticks per host, respectively), exhibiting similar prevalences during three consecutive seasons (range: 67-75%). Moreover, seasonal variations in abundance by tick stage were observed for both ticks species (Fig. 2). *I. hexagonus* larvae were most abundant in summer and autumn (42.6 and 7.3 ticks per host, respectively) with an extremely low density in spring (0.2 tick per host). In summer, larvae accounted for 88% (n = 639) of *I. hexagonus* ticks recorded. Mean abundances of nymphs feeding on hedgehogs were comparable throughout the study season (range: 3.2 – 4.9 nymphs per host), whereas females, similarly as larvae, prevailed in spring. The highest numbers of immature as well as female *I. ricinus* was recorded in spring, with extremely low densities recorded in summer/autumn. Mean abundances for each stage in spring were comparable ranging from 6.5 (females or larvae) to 8.8 (nymphs) ticks per host.

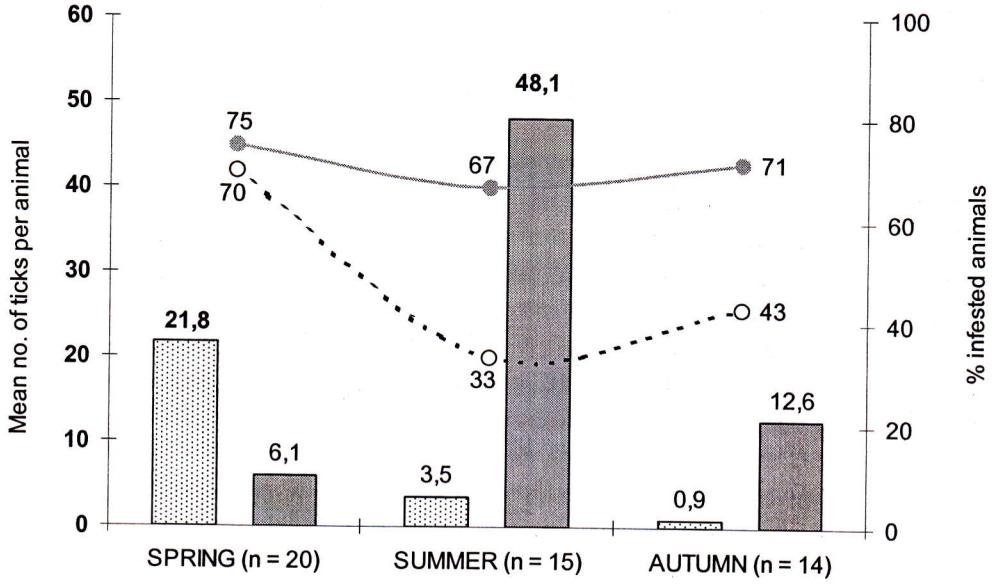

Figure. 1. Seasonal prevalence (%) and abundance (no. ticks per host) of *I. ricinus* (dotted line and bars) and *I. hexagonus* (solid line and grey bars) on *E. concolor* (n = 49), in west-central Poland, April and November 2009. Numbers in parentheses denote numbers of hedgehogs sampled.

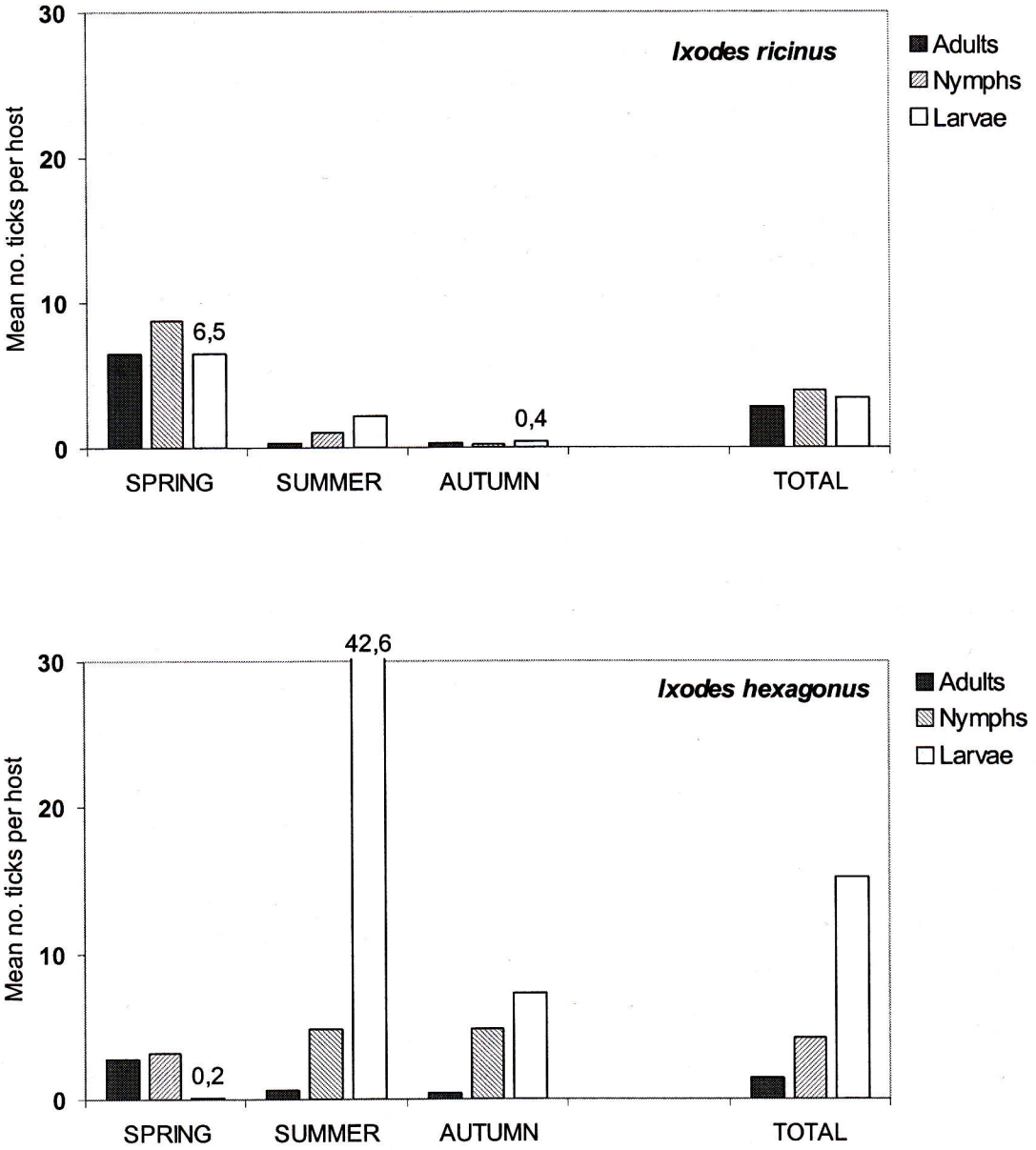

Figure 2. Seasonal abundance (no. ticks per host) of *I. hexagonus* and *I. ricinus* ticks by life stage recorded on *E. roumanicus* (n = 49), west-central Poland, April and November 2009. Numbers above bars denote maximal and minimal densities of larval ticks.

Discussion

This is the first Polish study on the infestation of *E. roumanicus* hedgehogs with *Ixodes* ticks surveyed in urban environments. These hosts were investigated during the period of their seasonal activity, between April and November 2009. *E. roumanicus* populations revealed to act as very important hosts for all developmental stages of ixodid ticks, with the overall prevalence of 73% and the mean intensity of 42.2 ticks.

These wild-living hedgehog populations from Poznan, were found to be more abundantly parasitized by *I. hexagonus* than *I. ricinus* ticks (29.1 and 20.0 ticks per infested animal, respectively). Similar patterns of *Ixodes* infestation by both tick species were observed on the western hedgehog from urban ecosystems in Switzerland and

Germany. In a Swiss study by Gern et al. (1997), *E. europaeus* hedgehogs sampled in private gardens in Neuchâtel, exhibited mono-infestation with *I. hexagonus*, whereas animals derived from a suburban area were co-infested with *I. ricinus*. Egli (2004) demonstrated a distinct increase in prevalence and intensity of *I. hexagonus* infesting *E. europaeus* from rural to urban habitats of the city of Bern. In rural areas, 37% of hedgehogs harboured on average 1.5 ticks, whereas animals trapped in urban habitats hosted on average 14 ticks, with a 75% prevalence. Recently, the influence of landscape structure on tick burdens of *E. europaeus* in urban environments was demonstrated in a German study by Thamm et al. (2010). Overall prevalences of ticks assessed for both species were comparable with those from our study and reached 65% for *I. hexagonus* and 35% for *I. ricinus*. According to these authors, tick infestation levels respond to small-scale differences in landscape structure and therefore ticks could be used as markers of habitat use in hedgehogs.

This quantitative dominance of *I. hexagonus* on hedgehogs inhabiting suburban-urban environments can be mainly explained by environmental factors that in such habitats seem to favour this nidicolous species. Since its reproduction cycle is completely restricted to burrows or nests of its hosts, it is less dependent on micro-climatic conditions than the exophilous *I. ricinus*. The latter is extremely susceptible to desiccation and as a typically hygrophilous species may survive only where relative humidity is above 80%. Therefore, it prefers mainly deciduous/mixed forests covered with a thick litter layer, contrary to *I. hexagonus*, that is more likely to occur in urban environments such as private or public parks and various forested green spaces neighbouring sport and recreation areas (Ogden et al. 2000).

Both tick species showed also differences in seasonal patterns of infestation on the *E. roumanicus* hedgehogs. The prevalence of *I. ricinus* assessed for all feeding stages, decreased from spring (70%) to summer (33%) and autumn (43%), whereas, *I. hexagonus* infested the hosts with similar prevalences throughout the study (Fig. 1). The numerous predominance of *I. hexagonus* larvae in summer distinctly demonstrates differences in the reproduction cycles of both tick species co-infesting the host species.

It should be noted, that in Europe, *I. hexagonus* may parasitize at least 15 mammal species, especially Canidae and Mustelidae including also cats and humans (Liebisch and Walter 1986, Siuda 1993). Therefore, active transfer of these ticks may occur from hedgehogs which enter residential properties. Since these two tick species have been recognized as competent vectors for Lyme disease spirochetes, *Borrelia burgdorferi* s.l. (Gern et al. 1997, Liebisch et al. 1998), *E. roumanicus* populations seem to influence not only density of tick populations but potentially may establish and maintain local foci of tick-borne diseases in the close proximity of human settlings. Recently, 10% of 150 *I. hexagonus* ticks collected from hedgehogs in the Netherlands, were found to harbor *Anaplasma phagocytopilum* DNA, the causal agent of human granulocytic anaplasmosis (Nijhof et al. 2007). Therefore, extensive and long-term monitoring of tick burdens on these synanthropic mammals is essential to assess their role in the ecology of tick-borne zoonotic pathogens circulating within local human environments.

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