Ticks and Tick-borne Diseases 3 (2012) 232–239

Contents lists available at SciVerse ScienceDirect

Ticks and Tick-borne Diseases

journal homepage: www.elsevier.com/locate/ttbdis

Original article

Dynamics of tick infestations in foxes in Thuringia, Germany

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ARTICLE INFO

Article history:
Received 10 October 2011
Received in revised form 24 April 2012
Accepted 11 May 2012

Keywords:
Ixodes ricinus
Ixodes hexagonus
Ixodes canisuga
Dermacentor reticulatus
Red fox

ABSTRACT

This study aimed to provide up-to-date information on the dynamics of tick infestations on foxes in Thuringia, as the most recent information available was published in 1997. Fox carcasses that had been sent to the Thuringian State Authority for Food Safety and Consumer Protection (Thüringer Landesamt für Lebensmittelsicherheit und Verbraucherschutz – TLLV), between January 1st and December 31st, 2009, were examined for the presence of ticks. All ticks collected were stored at −20 °C before being identified and classified according to their developmental stage and sex. Out of a total of 1286 foxes examined, 989 (76.9%) were infested with ticks. A total of 13,227 ticks were collected from the foxes. The stage most frequently found was the larva (48.1%), followed by the adult (34.1%), and the nymphal stage (17.8%). Regarding the adult stage, *Ixodes ricinus* was the most frequent tick species detected (82.2%), followed by *I. canisuga* (10.8%) and *I. hexagonus* (6.7%). *Dermacentor reticulatus* ticks were very rare (0.3%). With regard to nymphs, *I. canisuga* and *I. hexagonus* were the most frequent tick species found, and this was also assumed for the larval stage. The results indicate the occurrence of tick infestations in foxes throughout the year, mainly by *I. ricinus*, *I. canisuga*, and *I. hexagonus*, with seasonal variations. Foxes were infested by *I. ricinus* ticks significantly more frequently from April to September. This applied to all tick developmental stages, but especially to adults. In contrast to *I. ricinus*, the infestation of foxes with *I. canisuga* and *I. hexagonus* was significantly higher from January to March and from October to December, especially with the immature developmental stages.

Introduction

Among wild animals, the red fox (*Vulpes vulpes*) is the most common predator in Europe. As well as playing an important role in the transmission of several animal diseases and zoonoses, the red fox is one amongst many tick hosts in the environment. As in other European countries, interest in tick-borne diseases has been steadily growing in recent years in Germany (Süss et al., 2008).

The most recent information on tick populations on foxes in Thuringia dates back to 1997 (Liebisch et al., 1997). According to the State Forestry Administration of Thuringia, the number of foxes in Thuringia has not risen in the past 15 years, but the fox stock calculation does not consider foxes that live in cities and suburban areas. The number of urban foxes in Thuringia (Kalla, 2010) as well as in other European regions (Gloor et al., 2006) has been increasing continuously and thus the possibility of direct and indirect contact with domestic animals and humans has also increased.

Ticks infesting foxes belong to the family Ixodidae, represented in Central Europe mainly by the genera *Ixodes* and *Dermacentor* (Arthur, 1963; Hillyard, 1996). In Germany, *I. ricinus*, *I. hexagonus*, and *I. canisuga* have been recorded on foxes (Cornely and Schultz, 1992; Heidrich, 2000; Liebisch et al., 1997; Liebisch and Walter, 1986; Schöffel et al., 1991). *Dermacentor reticulatus* and *Haemaphysalis concinna* were occasionally found (Liebisch et al., 1997).

I. ricinus is the most common and widespread tick species in Europe. It has a very wide range of hosts, including humans, mammals, birds, and reptiles (Hillyard, 1996), and it is the most important vector of tick-borne diseases in Europe (Süss et al., 2008). The seasonal activity of these ticks depends on weather conditions. Temperatures of 7 °C are sufficient for their activation (Gray, 1984).

I. hexagonus (the hedgehog tick) and *I. canisuga* (the fox tick) have a narrower range of hosts. Most of the hosts are residents of caves and burrows, such as hedgehogs, foxes, polecats, and badgers, but also other Mustelidae, rodents (Arthur, 1963; Hillyard, 1996), and occasionally dogs and cats serve as hosts (Földvári and Farkas, 2005; Gothe et al., 1977; Odgen et al., 2000). These ticks spend

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http://dx.doi.org/10.1016/j.ttbdis.2012.05.004

Table 1
Tick load on foxes examined from January to December 2009 in Thuringia, Germany.

Tick species	Number of specimens	Percentage	Males	Females	Male/female ratio (%)
Adults					
I. ricinus	3711	82.23	766	2,945	20.6/79.4
I. canisuga	486	10.77	1	485	0.2/99.8
I. hexagonus	303	6.71	4	299	1.3/98.7
D. reticulatus	13	0.29	6	7	46.2/53.8
Nymphs					
I. ricinus	196	8.31			
I. canisuga	1162	49.28			
I. hexagonus	839	35.58			
Ixodes spp.	161	6.83			
Larvae					
Ixodes spp.	6356				
Total	13,227				

the time between their blood meals in the burrows of their hosts, regardless of outside weather conditions. Due to the microclimate of the nest, they are active throughout the year (Arthur, 1963). In comparison to *I. ricinus*, they have seldom been examined for tick-borne disease agents.

In the previous study from 1997 (Liebisch et al., 1997), *I. ricinus*, *I. hexagonus*, and *I. canisuga* ticks were collected from hunted foxes in Thuringia. Although *D. reticulatus* was not found on foxes in Thuringia at that time, it is known to be endemic in Germany (Heile et al., 2006). It is present in several European countries, and it has become more widespread in recent years (Dautel et al., 2006; Heile et al., 2006; Silaghi et al., 2011), being the second most common tick species infesting dogs (Dautel et al., 2006). As for *I. ricinus*, the adults of this tick must stay on the vegetation and are therefore dependent on weather conditions (Heile et al., 2006).

As the most recent data on ticks of foxes in Thuringia dates back to nearly 15 years ago (Liebisch et al., 1997), the aim of this study was to provide new information about the tick populations infesting foxes in Thuringia and their dynamics over a whole year.

Materials and methods

Fox carcasses sent to the Thuringian State Authority for Food Safety and Consumer Protection (TLLV) by official veterinarians and hunters in Thuringia between 1st January and 31st December 2009 were examined for tick infestation within the scope of the rabies and fox tapeworm monitoring programmes.

Foxes can be hunted in Germany all year round, except for some restrictions during the breeding season (March 1st to June 15th). Autumn and especially winter are the preferred seasons for fox hunting.

Number and origin of foxes

During the experimental period, a total of 1286 foxes were examined, however, the monthly number of submitted fox carcasses was strongly influenced by the hunting season. The highest number of foxes was submitted in January (299 foxes) and the lowest in May (26 foxes). About 3 quarters of the foxes were submitted during the colder months (January to March and October to December) and one quarter during the warmer months (April to September).

Carcasses were packed in individual plastic bags and had an official identification form, detailing the place and date of death by hunting or accident. Carcasses that could not be dispatched to the laboratory at short notice were kept frozen until examination.

Data on the gender, age range, nutritional condition and special remarks were determined and recorded in individual files. The age range was estimated by tooth wear (Wagenknecht, 1984), and the foxes were divided into 5 age groups: puppies, young foxes, 1–2, 2–3 and >3 years old. The nutritional condition was estimated mainly by considering the subcutaneous fat deposition that covers the bony prominences on carcasses (especially ribs, pelvis, backbone, and shoulder). Foxes with unobservable, moderately visible, or pronounced bony prominences were accordingly classified into the 3 groups good, normal, and poor body condition.

Since the objective of the study focused on tick populations of foxes, clinically manifest scabies was registered only as a special remark, without further details or additional investigation. However, a few carcasses were examined in more detail, and sarcoptic mange was the only type of mite infestation detected.

Collection and examination of samples

After removal from the bag, each carcass was briefly immersed in a container of water in order to prevent the inhalation of pathogenic dust during the examination and the removal of ticks. The body areas preferred by ticks (head, ears, neck, and shoulders), were examined carefully and all attached ticks were removed using tweezers, placed into identifiable tubes and stored at −20 °C.

Ticks were classified according to their developmental stage and, except for larvae, the tick species was identified using several identification keys (Arthur, 1963; Morel and Perez, 1973).

Statistical analysis

For statistical analysis, R version 2.10.1 (R Development Core Team R, 2009) and R version 2.13.0 (R Development Core Team R, 2011) were used.

A generalised linear model with binominal distribution and logit link (logistic regression) was used to evaluate the effects of several covariates on the infestation prevalence. For the analysis of the infestation intensity, a generalised linear model with quasi-poisson distribution, which accounts for overdispersion, and log link was used. In order to obtain valid p values, no model selection was performed (Hurvich and Tsai, 1990). Instead, we included all collected variables in the evaluation which could conceivably have influenced the target values (Tables 3 and 4). No explanatory variables have been removed from the model afterwards.

Boxplots were performed to display the monthly infestation intensity of each tick species. For seasonal evaluation, infestations during the warm months (April to September) and the cold months (January to March, October to December) were considered. Infestation with *D. reticulatus* was not analysed due to the low infestation prevalence.