Exp Appl Acarol (2015) 65:243–248
DOI 10.1007/s10493-014-9867-y

Ixodes ricinus (Ixodidae), an occasional phoront on necrophagous and coprophagous beetles in Europe

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Received: 28 August 2014 / Accepted: 26 November 2014 / Published online: 10 December 2014

Abstract For ticks, phoretic behaviour using insects associated with vertebrates might offer an alternative strategy to host-seeking. Here we report for the first time the presence of immature stages of the most widespread tick species in Western Europe, *Ixodes ricinus* (Acari: Ixodidae), on three beetle species belonging to families Silphidae and Geotrupidae (Coleoptera). Specimens were collected while performing fieldwork surveys on insect diversity during the peak of tick's questing behaviour, in July and August of 2009 and 2010. The collections took place in two Natural Parks, the Aiako Harria, Guipúzcoa in Northern Spain and Wellington Country Park, Berkshire, in England. The silphid beetle *Nicrophorus vespilloides* and the geotrupid *Trypocopris pyrenaeus* were collected from pig-carcasses and both carried nymphs of *I. ricinus*; the geotrupid *Anoplotrupes stercorosus* was carrying a tick larva while feeding on red deer dung. These findings revealed an unnoticed but common relation of ticks not only with decomposed animals but also with insect scavengers. We discuss the rationale of this phenomenon.

Keywords Tick · *Ixodes ricinus* · Silphidae · Geotrupidae · Phoretic · Phoresy · Carcass

Introduction

Questing or wandering behaviour is a well-known mechanism used by hard ticks (Acari: Parasitiformes: Ixodidae) to locate a suitable host. After climbing aerial parts of plants to

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gain higher ground, a tick will extend its front legs (where Haller's sensory organs are located) and wait for a potential host passing close enough to allow it to hook onto fur, clothing or feathers using its claw-like ambulacra (Sonenshine 1993; Keirans 2009). While this behaviour is an established trait, other unusual ways of 'reaching' suitable hosts seem to appear and becoming more frequent during questing season peaks (Kurtenbach et al. 2006).

Hard ticks are more often found on and around animal remains during varied phases of decomposition in outdoor environments; the ticks quest either on the carcass/corpse or on the nearby vegetation (McNemee et al. 2003; Szabó et al. 2007). Animal carcasses attract scavengers, and many regular tick hosts; this is because they are in close proximity to remaining members of a herd or scavengers visiting the carcass. However, ticks might take full advantage of this necro-environment not only by clustering round the remains, but also by becoming phoretic on insects colonising carcasses.

Phoresy is the transport of one organism by another, whereby the host animal serves only as a vehicle for its passenger (Lesne 1896), enabling it to disperse to areas which are more suitable for development of itself or its offspring (Farish and Axtell 1971). Phoresy is widely spread across the Acari due to their limited capability for dispersion (lack of wings) (Athias-Binche 1994). A modified definition from Athias-Binche's (1994) eco-biological and eco-physiological phoretic categories allows the inclusion of extreme facultative, infrequent or occasional passengers such as ticks (Camerik 2010). Hence, ticks would engage in occasional or accidental phoresy with insects (Camerik 2010), particularly during their search for new hosts or while performing questing behaviour.

A few reports in the early 1990s documented phoretic ticks, mostly immature stages on flying insects, such as flies and beetles. In a study of phoretic mites on Diptera in South Yamal, larvae of the taiga tick *Ixodes persulcatus* Schulze were found on two specimens of Piophilidae (Petrova and Basikhin 1993). Additionally, the tropical horse tick *Anocentor nitens* Mohler was discovered to be phoretic on a Lampyridae beetle in Brazil (Flechtmann and Baggio 1993) and the deer tick *Ixodes ricinus* was also found to be phoretic on flies of the *Hydrotaea* genus (Mašán and Krištofík 1992).

Ixodes ricinus is the most widely distributed hard tick in Western Europe. It has a highly variable seasonal questing activity, which depends on regional climatic conditions (Dautel et al. 2008). While conducting two entomological surveys in two European countries we isolated *I. ricinus* nymphs and larvae from necrophagous and coprophagous beetle species. The occasional phoretics coincided with the tick's questing season peaks of summer (in either region). These are also the first reports of *I. ricinus* associated with carrion; previous records from North America included other Ixodidae species.

Materials and methods

Ticks were collected from beetles of forensic importance found in natural parks in Spain and UK. The two parks have a similar type of vegetation, predominantly deciduous forest.

Spain

Beetles were collected as part of a major research project on carrion-related arthropods that took place in the 'Aiako Harria' Natural Park (Errenteria, Guipúzcoa, Spain; UTM zone 30, E: 591454, N: 4788607) during the summer months of 2009 and 2010. Sampling was carried out in August 2009 13 days after first exposing the carcass, and in July and August 2010 3

and 5 days after first exposure. These two collection days coincided with *I. ricinus* seasonal peak of host seeking activity, particularly for immature stages (Kurtenbach et al. 2006). The landscape of the Natural Park is dominated by areas of dense forest with intermittent open areas of grazing pastures and crops (Sukia et al. 1996). The survey took place in the enclave 'Urdaburu-Añarbe', in an area previously used for the recuperation and conservation of wild boar populations. At present, cattle, deer (*Cervus elaphus* L.) and boar share open grassland, as well as scrubland and forested patches of the park. Fresh piglet carcasses (*Sus scrofa* L.), of 8–10 kg each, were located in unused locations with scarce tree cover and high density of shrubbery and ferns. Beetles were collected either manually using forceps, whilst inspecting the carcasses and their surrounded area. Each insect was independently preserved in alcohol to avoid mixing the phoretic fauna. The carcasses were checked daily to examine changes on the arthropod community throughout the decomposition process.

Guipúzcoa Foral Council issued official permissions for carcasses research in the Natural Park (Guipúzcoa Council certificate: 2009-2010/5951).

United Kingdom

In the UK, beetle sampling formed part of a survey on insect fauna in Wellington Country Park (Berkshire, UK; UTM zone 30, E: 0642466, N: 5691647) and was carried out on June 29, 2010; matching the peak of *I. ricinus* host-seeking activity [for larvae (Kurtenbach et al. 2006)]. The Park, offers dense areas of oak or beech trees combined with a variety of ground flora that keeps isolated patches of different invertebrate fauna. For zoologists, the main attractions of the park are the red and fallow deer herds [*C. elaphus* and *Dama dama* (L.)]. Insects and ticks were sampled mainly around the deer enclosures. Beetles were collected manually (using forceps) at early dusk, either directly from the ground or from incidental wildlife carcasses and dung. Insects were preserved in the same manner as in Spain.

Results and discussion

Ixodes ricinus were found to be phoretic on two beetle species surveyed in Spain (Table 1). Within Aiako Harria Natural Park, one specimen of the open-forest carrion beetle *Nicrophorus vespilloides* Herbst (Coleoptera: Silphidae) and two specimens of the heath dumble dor beetle *Trypocopris pyrenaeus* (Charpentier) (Coleoptera: Geotrupidae) harboured nymphs of *I. ricinus*.

Table 1 Sampling of beetles in Spain and UK and prevalence (%) of ticks on beetles

Date	Spain—Coleoptera			UK—Coleoptera			Beetle species	Tick stage
	Total	w/ticks	Prev. (%)	Total	w/ticks	Prev. (%)		
18/08/2009	3	1	33.3				*T. pyrenaeus*	Nymph
29/06/2010				5	1	20	*A. stercorosus*	Larvae
30/07/2010	5	1	20				*N. vespilloides*	Nymph
10/08/2010	8	1	12.5				*T. pyrenaeus*	Nymph

Nicrophorus vespilloides was collected from a bloated pig carcass on the 4th day of decomposition [being 1st day 0 (zero); 30/07/2010]. From the same carcass at day 15th of decomposition which had reached dry stage (10/08/2010), a *T. pyrenaeus* was collected transporting *I. ricinus*. A second specimen of *T. pyrenaeus* was collected from a different carcass at day 13th of decomposition, in bloated stage (18/08/2009).

In Wellington Country Park, United Kingdom, no silphids were found carrying ticks, instead, they were hosting their characteristic Parasitidae, Macrochelidae and Histiostomatidae mite fauna (Perotti and Braig 2009). However, a larva of *I. ricinus* was found on one out of five earth-boring dung beetles *Anoplotrupes stercorosus* (Scriba) (Coleoptera: Geotrupidae). These *A. stercorosus* specimens were feeding on red deer dung (*C. elaphus*). Figure 1 shows an in situ observation of a tick larva attached to the margin of the left elytron of *A. stercorosus*, in Wellington Park (UK).

Hitherto, only three reports document tick phoresy, just one of which mentions phoretic *I. ricinus* in Europe (Mašán and Krištofík 1992; Flechtmann and Baggio 1993; Petrova and Basikhin 1993). Our new records suggest that phoresy in *I. ricinus* may be more wide spread than previously understood and that this co-occurrence of ticks and necro-phagous/philous insects might be due to the close relation of the insects with the tick's vertebrate hosts. The finding of phoretic ticks at the peak of *I. ricinus* questing behaviour [for immature stages (Kurtenbach et al. 2006)] underlines the advantages of phoresy. Restricting the phoretic interaction to the environmental conditions offered by carcass or decomposition, the high prevalence of ticks on Spanish beetles might imply a transitional stage from occasional to facultative phoresy (Camerik 2010). Furthermore, ticks at immature stages are lighter than adults, this characteristic may make them more suited to become phoretic on other flying arthropod hosts.

On Silphidae, ticks can be transported long distances, as these beetles cover a large area in search of carrion (Bedick et al. 1999), making it more likely for the tick to encounter a host or enter an area of higher host density. Silphidae beetles are sometimes phoretic on small rodents (Lesne 1896), thus ticks may be directly transported to a host or its nest. Mejlon and Jaenson (1997) indicated that tick larvae are more commonly found at ground level, likely increasing their opportunity of encountering an animal or insect host.

The presence of trees considerably increases tick abundance (Dobson et al. 2011), therefore, the two parks seemed to have offered an optimal environment with abundance of

Fig. 1 Phoretic larval stage of *Ixodes ricinus* attached to the left elytron of *Anoplotrupes stercorosus*. Wellington Country Park, Berkshire, England, UK (June 9th, 2010). Photo taken by J. Sumner as part of a survey on tick diversity

hosts, trees and carcasses. By associating with coprophagous beetles ticks are more likely to be transported to areas of higher host density as these beetles are attracted to fresh dung of the tick's potential vertebrate hosts. Geotrupids such as *A. stercorosus* are dominant species in beech forests populated by deer and well known colonisers of carcasses (Schotsmans et al. 2012). Thus, phoresy on necrophagous and coprophagous/necrophilous beetles might facilitate ticks in their search for hosts. It is possible that phoresy and questing might even be synchronised to some extent, or represent different host-acquisition strategies during different seasons or life stages of the tick.

Ixodes ricinus is the most numerous and widespread tick in the Basque Country, being active even during the winter (Barandika et al. 2008; Dautel et al. 2008). *I. ricinus* in Northern Spain harbour numerous zoonotic diseases while in the South of Wales and England they are major vectors of Lyme disease and ehrlichiosis (Guy and Stanek 1991; Guy et al. 1998; Dumler et al. 2001; Barandika et al. 2008). Ultimately, the risk of contact with ticks harbouring disease should be considered when collecting and observing insects during research (and forensic investigations) or recreation.

Our findings detail the first cases of *I. ricinus* phoresy on flying insects in the Basque Country (Spain) and England (UK), bringing to light an overlooked interaction between beetles and insects of forensic importance. More research on phoretic behaviour of ticks is essential to ascertain the significance of tick phoresy, and whether carcass-insect phoresy is a successful behaviour that might facilitate the acquisition of a vertebrate host.

Acknowledgments Thanks to Nigel Burnett, General Manager of Wellington Country Park for permitting access to the park and enabling us to collect samples. B.D.M. thanks the Basque Government, Department of Education, Language Policy and Culture, for supporting her research.

References

Athias-Binche F (1994) La phorésie chez les acariens. Aspects adaptatifs et evolutifs. Castillet Publishing, Perpignan

Barandika JF, Hurtado A, García-Sanmartín J, Juste RA, Anda P, García-Pérez AL (2008) Prevalence of tick-borne zoonotic bacteria in questing adult ticks from Northern Spain. Vector Borne Zoonotic Dis 8:829–836

Bedick JC, Ratcliffe BC, Hoback WW, Higley LG (1999) Distribution, ecology, and population dynamics of the American burying beetle (*Nicrophorus americanus* Olivier (Coleoptera, Silphidae)) in south-central Nebraska, USA. J Insect Conserv 3:171–181

Camerik AM (2010) Phoresy revisited. In: Sabelis MW, Bruin J (eds). Trends in acarology: Proceedings of the 12th International Congress of Acarology. Springer, Amsterdam

Dautel H, Dippel C, Kämmer D, Werkhausen A, Kahl O (2008) Winter activity of *Ixodes ricinus* in a Berlin forest. Int J Med Microbiol 298(S1):50–54

Dobson AD, Taylor JL, Randolph SE (2011) Tick (*Ixodes ricinus*) abundance and seasonality at recreational sites in the UK: hazards in relation to fine-scale habitat type revealed by complementary sampling methods. Ticks Tick Borne Dis 2:67–74

Dumler JS, Barbet AF, Bekker CP, Dasch GA, Palmer GH, Ray SC, Rikihisa Y, Rurangirwa FR (2001) Reorganization of genera in the families *Rickettsiaceae* and *Anaplasmataceae* in the order *Rickettsiales*: unification of some species of *Ehrlichia* with *Anaplasma*, *Cowdria* with *Ehrlichia* and *Ehrlichia* with *Neorickettsia*, descriptions of six new species combinations and designation of *Ehrlichia equi* and 'HGE agent' as subjective synonyms of *Ehrlichia phagocytophila*. Int J Syst Evol Microbiol 51:2145–2165

Farish DJ, Axtell RC (1971) Phoresy redefined and examined in *Macrocheles muscaedomesticae* (Acarina: Macrochelidae). Acarologia 13:16–29

Flechtmann CHW, Baggio D (1993) On phoresy of hematophagous ectoparasitic Acari (Parasitiformes: Ixodidae and Dermanyssidae) on Coleoptera observed in Brazil. Int J Acarology 19:195–196

Guy EC, Stanek G (1991) Detection of *Borrelia burgdorferi* in patients with lyme disease by the polymerase chain reaction. J Clin Pathol 44:610–611

Guy E, Tasker S, Joynson DHM (1998) Detection of the agent of human granulocytic ehrlichiosis (HGE) in UK tick using polymerase chain reaction. Epidemiol Infect 121:681–683

Keirans JE (2009) Order Ixodida. In: Krantz GW, Walter DE (eds) A manual of acarology. Texas Tech University Press, Texas, pp 111–123

Kurtenbach K, Hanincová K, Tsao JI, Margos G, Fish D, Ogden NH (2006) Fundamental processes in the evolutionary ecology of Lyme borreliosis. Nat Rev Microbiol 4:660–669

Lesne P (1896) Moeurs du *Limosina sacra* Meig. Phénomènes de transport mutuel chez les animaux articulés. Origine du parasitisme chez les insectes diptères. Bull Soc Entomol Fr 1896:162–165

Mašán P, Krištofík J (1992) Phoresy of some Arachnids (Acarina and Pseudoscorpionidea) on synanthropic flies (Diptera) in the South Slovakia. Biologia 47:87–96

McNemee RB, Sames WJ, Maloney FA (2003) Occurrence of *Dermacentor variabilis* (Acari: Ixodidae) around a porcupine (Rodentia: Erthethizontidae) carcass at Camp Ripley, Minnesota. J Med Entomol 40:108–111

Mejlon HA, Jaenson TGT (1997) Questing behaviour of *Ixodes ricinus* ticks (Acari: Ixodidae). Exp Appl Acarol 21:747–754

Perotti MA, Braig HR (2009) Phoretic mites associated with animal and human decomposition. Exp Appl Acarol 49:85–124

Petrova AD, Basikhin PV (1993) The finding of larvae of the taiga tick *Ixodes persulcatus* (Parasitiformes: Ixodidae) on necrophagous piophilid flies (Diptera: Piophilidae) in the southern Yamal. Parasitology 27:427–429

Schotsmans EMJ, Denton J, Dekeirsschieter J, Ivaneanu T, Leentjes S, Janaway RC, Wilson AS (2012) Effects of hydrated lime and quicklime on the decay of buried human remains using pig cadavers as human body analogues. Forensic Sci Int 217:50–59

Sonenshine D (1993) Biology of ticks. Oxford University Press Inc, Oxford

Sukia XL, Serrano M, Rico MJL (1996) Catálogo abierto de espacios naturales relevantes de la Comunidad Autónoma del País Vasco. Servicio central de publicaciones del Gobierno Vasco, Vitoria-Gasteiz

Szabó MPJ, Castro MB, Ramos HGC (2007) Species diversity and seasonality of free-living ticks (Acari: Ixodidae) in the natural habitat of wild marsh deer (*Blastocerus dichotomus*) in Southeastern Brazil. Vet Parasitol 143:147–154