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Short communication

First record of *Ixodes simplex* found on a human host, with a review of cases of human infestation by bat tick species occurring in Europe

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ABSTRACT

Ixodes simplex is a bat tick species, a common parasite of the Schreibers' bent-winged bat, *Miniopterus schreibersii*. Its distribution is linked to the range of its host, free stages occurring exclusively inside the underground bat shelters. Here we present the first case of human infestation with *I. simplex*. An adult female tick was found attached to the upper limb after a visit to the underground shelter of a large bat colony. This unusual host selection is a likely consequence of the reduction of suitable hosts, as the number of bats was much lower at the time of the visit than in previous years. Bat ticks rarely feed on humans, with soft ticks (Argasidae) being more commonly involved. In the light of the potential vectorial capacity of *I. simplex*, the incidence and potential future risks are discussed.

1. Introduction

Ticks (Acari: Ixodida) are important blood-feeding ectoparasites of terrestrial vertebrates. They show wide geographic distribution, likely being the most widely distributed ectoparasites on the Globe (Guglielmone et al., 2014). They are not only resource-depleting ectoparasites, but play an important role in transmission of vector-borne diseases caused by numerous viral, bacterial and protozoan pathogens. Their importance is exceptionally high in temperate regions, where they are responsible for the most important vector-borne diseases affecting humans (Parola and Raoult, 2001). Taxonomically the order Ixodida is grouped into three families (Ixodidae, Argasidae and Nutalliellidae), with more than 900 known species (Burger et al., 2014). Hard ticks (Ixodidae) are the more speciose group, although only five hard tick species (all *Ixodes*) are known as exclusive parasites of bats globally (Chiroptera) (Hornok et al., 2016a, 2014; Kolonin, 2007). In contrast Argasidae (soft ticks) are more diverse in subtropical and tropical areas, with more than 70 species (35 %) as bat-specialists (Guglielmone et al., 2010). Three members of the genus *Ixodes* are known to parasitize bats in Europe (*I. ariadnae, I. simplex* and *I. vespertilionis*), with most European bats already recorded as hosts for these species (Sándor et al., 2019). All three species are exclusively bat-specialists, endophilous ticks, attaching to their hosts inside their underground roosts. While *I. ariadnae* and *I. vespertilionis* are more generalists in their bat-host selection (Hornok, 2017a, 2017b), *I. simplex* is found primarily on a single highly social bat species, the Schreibers' bent-winged bat, *Miniopterus schreibersii* (Hornok, 2017c; Sándor et al., 2019). The distribution of *I. simplex* is also mirrored by its main host's distribution, being a species with a southern European range (Hornok, 2017c). Two different soft ticks (Argasidae) are known to regularly occur on European bats: *Carios vespertilionis* is the most wide-spread, while *Secretargas transgariepinus* is known only from a relatively small number of locations in the central and western part of the Mediterranean Basin. Both these species are known to feed on a large number of bat species (Petney et al., 2017a, 2017b; Sándor et al., 2019).

Bats are important reservoirs for a number of emerging zoonotic viruses, bacteria and piroplasms (Brook et al., 2015), so their ticks were also targets for several studies in order to evaluate their vector role in the transmission of a number of know pathogens causing such diseases. As

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such, ticks of European bats were successfully screened for the presence of *Bartonella, Borrelia* or *Rickettsia* spp. (Hornok et al., 2012; Leulmi et al., 2016; Lv et al., 2018; Michalik et al., 2020; Socolovschi et al., 2012), while a number of known and suspected zoonotic piroplasms are known to be present in these ectoparasites (Hornok et al., 2016b; Lv et al., 2018). Thus, ixodid and argasid ticks of bats may have vector role for the above pathogens and as such may represent risk for pathogen transfer if feeding on humans. Here we report the first European case of *I. simplex* found attached to a human, with a review of human-related cases induced by bat-associated tick species known to occur on European bats.

2. Materials and methods

One adult female *I. simplex* was found attached to one of the authors, after a visit to a large maternity colony of *M. schreibersii*, located in southeastern Romania. The colony site (close to Băneasa, 44.075727 N, 27.643677E) holding approximatively 2000 bats, was visited on the night of 27 May 2019 (1.30–2.30 a.m., after the bats left for foraging) in order to collect feces and parasites below the roost. The tick was found attached to the left elbow bend of one of the visitors, after visiting the mine-shaft (ca. 5 h after the visit). It was easily detached and kept in 70 % ethanol until identification. The tick was identified using morphological keys (Estrada-Peña et al., 2018). The picture in Fig. 1 was made with a VHX-5000 (Keyence Co., Osaka, Japan) digital microscope.

3. Results

The collected tick was identified as a female *I. simplex* (Fig. 1). The identification was supported by the combination of the following characters: an *Ixodes* species (showing preanal groove), with relatively small size (in comparison to unfed adult females of *I. vespertilionis* or *I. ariadnae*), short legs, with especially short tarsi, short and blunt palps with indistinct joints between segments II and III, short hypostome and dense hair on idiosoma, while no spur on coxa I. The individual was not showing signs of engorgement, however skin scraps from the attachment site are visible on the hypostome (Fig. 1). The attachment site showed a small red punctuation and superficial swelling, which disappeared after two days.

4. Discussion

This is the first record of human infestation with *I. simplex*, a bat tick species found primarily on Schreibers' bent-winged bats (Hornok, 2017c; Sándor et al., 2019). *Ixodes simplex* is not listed among the tick species reported to feed on humans (Estrada-Peña and Jongejan, 1999; Guglielmone and Robbins, 2018). It is a bat tick, with a wide geographical distribution from southeastern Asia to western Europe and from Morocco and Egypt to Southern Africa, wherever its host species (bats belonging to the Miniopteridae family) occur (Arthur, 1956; Hornok, 2017c). In Europe it is mainly found in countries of the Mediterranean Basin, sporadically reported from Central (Hungary, Slovakia) and southeastern Europe (countries of the Balkan Peninsula), exclusively in areas where Schreibers' bent-winged bats are regularly present (Hornok, 2017c). It is a three host tick species, with most records (99.8 %) collected from Schreibers' bent-winged bats (Sándor et al., 2019), with a few odd reports from other cave dwelling bat species roosting together with its main host (Beaucournu, 1966). It shows a prominent seasonality of its occurrence on hosts (higher prevalence in spring in nursing colonies, abundance continuously decreasing towards the autumn), with adult females showing no seasonal preference for feeding (Lourenço and Palmeirim, 2008; Sándor et al., 2019). Ticks stay hidden while off-host, with large numbers of different stage individuals grouped together in cracks or behind loose rocks close to the host's roosting sites (distances of 20–180 cm from the roosting sites, Sándor AD unpublished). This secretive behavior may also be the cause for the reduced encounter rate (Beaucournu, 1966; Sándor et al., 2018) and the lack of human-cases. The Schreibers' bent-winged bat colony from the abandoned mine shaft at Băneasa (range 4100-7500 in the period 2016–2018, with ca. 2800 individuals present in 2019, Sándor A. unpublished) showed seasonally high prevalence of tick parasitism in most years in spring (ranging between 39–51 % in the period 2016–2018: Sándor et al., 2019), thus ticks were present at the colony most of the time. However, the tick prevalence was extremely high in May 2019, with a 80.0 % prevalence (n = 27 hosts) and mean intensity of 5.1 ticks infesting bats. This was also coupled with an exceptional level of adult female ticks on bats. The prevalence of adult females was 17.9 %, and the intensity was 22.1, range 1–31, in contrast to a mean adult female prevalence <1%, and mean intensity 1.02, in the period 2016–2018 (Sándor et al., 2019). This unusual high abundance of ticks coupled with an apparent reduction in the number of adult bats present at the colony, likely caused a scarcity in available hosts, most probably determining adult female ticks to actively engage in host-seeking and resulting in the attack of an unusual host.

Hard ticks of bats from Europe are rarely reported from humans, with only one incidence of human attack is known for *I. vespertilionis* (Piksa et al., 2013). However, soft ticks of bats are more commonly involved in human cases, with at least 20 instances known for *C. vespertilionis* and 4 for *S. transgariepinus* (out of these, seven recorded in Europe, see details in Table 1, references therein).

This record of adult female *I. simplex* attaching and apparently initiating its feeding on a human raises some concerns. Ticks in general are known to be vectors for a number of vector-borne diseases (de la Fuente et al., 2008). While the proven vectorial capacity of *I. simplex* for zoonotic pathogens is unknown, DNA of several vector-borne pathogens was identified in ticks. Results of molecular analyses of *I. simplex* ticks (all stages) showed the presence of piroplasms of the genera *Theileria* (*T. capreoli, T. orientalis*) and *Babesia* (*B. canis, B. crassa*) and other uncharacterized *Theileria* and *Babesia* species (Hornok et al., 2016b). DNA of several Lyme-borreliosis causing *Borrelia burgdorferi* s.l. species (Michalik et al., 2020) and also other human pathogenic bacteria (*Anaplasma phagocytophilum*, *Candidatus* Bartonella hemsundetiensis and *Mycoplasma* spp.) were identified in *I. simplex* ticks primarily from Romania, too (Hornok et al., 2019). Thus, *I. simplex* may be suspected to possess vector potential for some of these microbial pathogens. Although the occurrence of this tick species (and other cave-dwelling bat ticks) on humans is merely accidental (together with its associated potential zoonotic risk), we are not able to rule out potential future cases with the continuous increase in cave-tourism and associated human activities (Cigna and Forti, 2013) in close proximity of bat colonies.

Fig. 1. Adult female *Ixodes simplex*, collected from a human on 27.05.2019, Băneasa, Romania (arrow indicates host skin tissue remnants on the mouthparts).

Table 1
Records of human infestation involving bat specialist ticks occurring in Europe (Argasidae: *Secretargas transgariepinus, Carios vespertilionis* and Ixodidae: *Ixodes simplex, I. vespertilionis*).

Tick species	Country	Reference
Secretargas transgariepinus	Italy	Berlese (1913)
	Egypt	Hoogstraal (1957)
	Italy	Starkoff (1957)
	Italy	Principato (2002)
	South Africa	Howard (1908)
	Mozambique	Gedoelst (1911)
	South Africa	Bedford (1920)
	Mozambique	Brumpt (1922)
	Sudan	Hoogstraal (1956)
	Kazakhstan	Galuzo (1957)
	Italy	Starkoff (1958)
	Japan	Kamo et al. (1962)
	Kazakhstan	Belashova (1966)
Carios vespertilionis	Japan	Yamaguti et al. (1971)
	Japan	Kamimura and Kondo (1977)
	Japan	Takada et al. (1978)
	Iraq	Keirans (1984)
	India	Keirans (1984)
	Sweden	Jaenson et al. (1994)
	Spain	Estrada-Peña and Jongejan (1999)
	Turkey	Bursali et al. (2012)
	France	Socolovschi et al. (2012)
	Turkey	Keskin et al. (2016)
Ixodes simplex	**Romania**	**this study**
Ixodes vespertilionis	Poland	Piksa et al. (2012)

Ethics approval and consent to participate

Permission for bat capture was provided by the Underground Heritage Commission and the local protected area management authorities. Bat banding license number is 103/2019. Bats were handled according to the current law of animal welfare regulation (Law 206/2004), and the Research Bioethics Commission of USAMV CN approved the used methodology of bat handling. Permission from the Institutional Animal Care and Use Committee (IACUC) was not necessary, because bats were released in the field after tick removal (none taken to participating institutes). No live bat was harmed for this study.

Consent for publication

Not applicable.

Availability of data and materials

Data supporting the conclusions of this article are included in Additional file 1.

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Authors' contributions

ÁP and ADS initiated the study, did part of the sample collection and wrote the manuscript. LB, and AC participated in the fieldwork and data collection. ÁP and SH identified the ticks. SH and ADM organized part of the sample collection and contributed to the study design and manuscript preparation. All authors read and approved the final manuscript.

Declaration of Competing Interest

The authors declare that they have no competing interests.

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