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Geographical distribution, climate adaptation and vector competence of the Eurasian hard tick *Haemaphysalis concinna*

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Abstract

The ixodid tick *Haemaphysalis concinna* Koch, 1844 is a proven vector of tick-borne encephalitis (TBE) virus and *Francisella tularensis*, the causative agent of tularaemia. In the present study, up-to-date maps depicting the geographical distribution and climate adaptation of *H. concinna* are presented. A dataset was compiled, resulting in 656 georeferenced locations in Eurasia. The distribution of *H. concinna* ranges from the Spanish Atlantic coast to Kamchatka, Russia, within the belt of 28–64° N latitude. *Haemaphysalis concinna* is the second most abundant tick species after *Ixodes ricinus* collected from birds, and third most abundant tick species flagged from vegetation in Central Europe. To investigate the climate adaptation of *H. concinna*, the georeferenced locations were superimposed on a high-resolution map of the Köppen-Geiger climate classification. A frequency distribution of the *H. concinna* occurrence under different climates shows three peaks related to the following climates: warm temperate with precipitation all year round, boreal with precipitation all year round and boreal, winter dry. Almost 87.3 % of all *H. concinna* locations collected are related to these climates. Thus, *H. concinna* prefers climates with a warm and moist summer. The remaining tick locations were characterized as cold steppes (6.2 %), cold deserts (0.8 %), Mediterranean climates (2.7 %) or warm temperate climates with dry winter (2.9 %). In those latter climates *H. concinna* occurs only sporadically, provided the microclimate is favourable. Beyond proven vector competence pathogen findings in questing *H. concinna* are compiled from the literature.

Keywords: Ixodid tick, Distribution map, Georeferenced locations, Tick-borne diseases, Köppen-Geiger climate classification

1. Introduction

Haemaphysalis concinna Koch, 1844, the Relict tick (Acari, Ixodidae), is a proven or incriminated vector of various tick-borne pathogens causing human and animal disease. It is endemic in wide areas of Europe and Asia. Fig. 1 depicts the geographical distribution of the tick species as published by Kolonin (2009). It has been the best distribution map for *H. concinna* presented so far, although it does not include some findings in Europe (e.g. Belarus, Germany, Italy) and other recently documented findings in Asia (e.g. China). Note that the online tick atlas of Kolonin (2009) is unfortunately no longer available. Other distribution maps are restricted to national territories such as the *H. concinna* maps of the former Soviet Union (Lebedeva and Korenberg, 1981) and China (Sun et al., 2017). Thus, *H. concinna* is much wider distributed than depicted in Fig. 1. It colonizes deciduous and mixed forests in the warm temperate climate zone of Eurasia, particularly moist habitats like shores of lakes and banks of rivers (Nosek, 1971a). Typical habitats were found in the largest connected water landscape in Central Europe, the Mecklenburg lake district in the north-east of Germany, and alongside the rivers Danube and Morava. The latter are located on the borders of Czech Republic, Slovakia, Austria, and Hungary (Fig. 2b). In these regions, *H. concinna* is the third most abundant tick species after *Ixodes ricinus* and *Dermacentor reticulatus* (Kahl et al., 1992; Rubel et al., 2014). Further *H. concinna* habitats comprise forest steppes and wet steppe habitats, mainly in Asia. In some Asian regions, for example in the Shaanxi province of China, *H. concinna* has been the most abundant tick species collected from domestic animals (Tian et al., 2017).

Haemaphysalis concinna is an exophilic three-host tick. The adults have mainly been found on red deer (Ruiz-Fons et al., 2006) and roe deer (Walter et al., 1986) and the immatures as catholic feeders on reptiles (Hassl, 2003), birds (Choi et al., 2014; Hornok et al., 2016), small mammals (Sakiyev et al., 2013; Radulović et al., 2017), and particularly roe deer (Hornok et al., 2012). Other frequently confirmed hosts are farm animals such as cattle, goats and sheep (Meng et al., 2016; Tian et al., 2017). Humans are attacked by nymphs and adult ticks (Nosek, 1971a). In Central Europe, adult *H. concinna* are mainly active from May to July with maximum activity in June (Széll et al., 2006), nymphs from mid-April to mid-October and larvae from late May to mid-October (Nosek, 1971a). As demonstrated by Belozerov (1969), the seasonal development of the engorged immatures is regulated by photoperiod. Developmental diapause of engorged larvae and nymphs as well

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