

Original article

A prospective study on the incidence of *Borrelia burgdorferi* sensu lato infection after a tick bite in Sweden and on the Åland Islands, Finland (2008–2009)



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ABSTRACT

Lyme borreliosis (LB) is a common and increasing tick-borne disease in Europe. The risk of acquiring a *Borrelia* infection after a tick bite is not fully known. Therefore, we investigated the incidence of *Borrelia* infection after a bite by a *Borrelia*-infected tick and if the *Borrelia* load and/or the duration of tick-feeding influenced the risk of infection. During 2008–2009, ticks and blood samples were collected from 1546 tick-bitten persons from Sweden and the Åland Islands, Finland. Follow-up blood samples were taken 3 months after the tick bite. The duration of tick feeding was microscopically estimated and *Borrelia* was detected and quantified in ticks by real-time PCR. Anti-*Borrelia* antibodies were detected in sera using ELISA tests and immunoblot.

Five percent (78/1546) of the study participants developed *Borrelia* infection (LB diagnosis and/or seroconversion) after a tick bite (45% bitten by *Borrelia*-infected ticks and 55% bitten by uninfected ticks). Of these, 33 developed LB (whereof 9 also seroconverted) while 45 participants seroconverted only. Experience of non-specific symptoms was more frequently reported by *Borrelia*-infected participants compared to uninfected participants. All who seroconverted removed “their” ticks significantly later than those who did not. The *Borrelia* load in the ticks did not explain the risk of seroconversion. Regional and sex differences in the *Borrelia* seroprevalence were found. The risk of developing a *Borrelia* infection after a bite by a *Borrelia*-infected tick is small but increases with the duration of tick feeding.

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1. Introduction

Lyme borreliosis (LB) is the most commonly diagnosed tick-borne disease in Europe, where some ten thousands of cases of LB are diagnosed annually (Hubálek, 2009). LB is caused by spirochetes belonging to the *Borrelia burgdorferi* sensu lato complex (*Borrelia*) (Stanek and Reiter, 2011). In Europe these borrelial species

are transmitted to humans by *Ixodes (I.) ricinus* ticks. Notably, an increase of LB has been reported from several European countries and has been suggested to be associated with larger abundance of ticks (Hofhuis et al., 2006; Mehnert and Krause, 2005). In most cases, an early symptom of a *Borrelia* infection is the localized skin manifestation erythema migrans (EM), which usually appears at the site of the tick bite and expands within days to weeks after infection. Disseminated *Borrelia* infections may involve neurologic, joint and/or skin manifestations and occur weeks to months after the primary infection (Stanek et al., 2011). However, we and others have earlier shown that most people infected seem to remain asymptomatic (Fryland et al., 2011; Huegli et al., 2011).

In Sweden, the distribution of *I. ricinus* covers the southern and central parts of the country, as well as the coastal area of northern Sweden. On the Åland Islands, Finland, located between the mainlands of Sweden and Finland, *I. ricinus* is abundant and tick bites are commonly reported by the inhabitants (Wahlberg, 1990). The population of *I. ricinus* is believed to have increased and its habitat to have expanded northwards, possibly due to climate change, and this may have resulted in an increased risk of tick bites for humans and consequently an increased risk of LB (Mannelli et al., 2012). At present, Sweden and the Åland Islands lack a mandatory LB notification system and thus, the annual incidence of LB is associated with high uncertainty. In a study conducted several years ago in southernmost Sweden an incidence of 69 annual cases per 100,000 inhabitants was estimated (Berglund et al., 1995). Extrapolation of this incidence to the whole Swedish population suggests that there could be approximately 6600 cases of LB in Sweden annually. In contrast, the hyper-endemic Åland Islands have an incidence of 993–1912/100,000 inhabitants (years 2000–2012) (Finnish Ministry of Social Affairs and Health, 2013). Since the incidence of LB is believed to have increased, updated surveillance data on this disease is needed. A larger prospective investigation of the serological and clinical outcome for tick-bitten individuals and investigation of the *Borrelia* content in the ticks is needed in order to reveal the importance of different LB risk factors.

Experimental studies have shown that efficient transmission of *Borrelia* and risk of infection increase with increased duration of tick attachment (Kahl et al., 1998; Meiners et al., 2006; Piesman et al., 1987). The *Borrelia* load in a feeding tick could also be a factor that influences the risk of developing a *Borrelia* infection. To investigate how different variables influence the risk of developing tick-borne infections, the Tick-Borne Diseases (TBD) STING-study was initiated 2007 in the county of Östergötland, Sweden (Fryland et al., 2011; Wilhelmsson et al., 2010). The aims of the present study were to investigate (i) the incidences of LB and seroconversions after a tick bite, (ii) possible symptoms and clinical manifestations suggestive of LB after a tick bite, (iii) if the *Borrelia* load in the tick and/or the duration of tick feeding influences the risk of seroconversion in tick-bitten persons, and (iv) if there are any age or sex as well as regional differences regarding *Borrelia* seroprevalence and medical history of LB in tick-bitten persons. In the study presented here we analyze and discuss the clinical and serological outcomes of 1546 persons that were bitten by ticks in Sweden and in the Åland Islands in 2008 and 2009.

2. Materials and methods

2.1. Ethics

The study was approved by the Regional Ethical Review Board, Linköping University (M132-06), and by the Ethics Committee of the Åland Health Care, 2008-05-23.

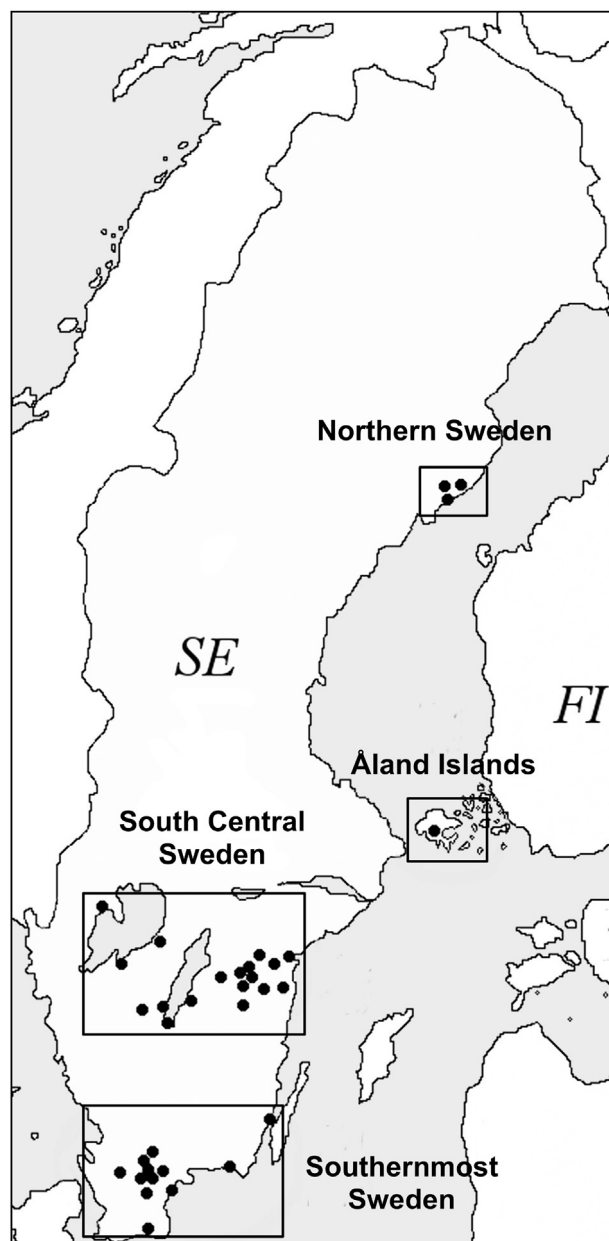


Fig. 1. Map showing the four regions where the 34 primary health care (PHC) centres are located. Southernmost Sweden (12 PHC centres), south central Sweden (18 PHC centres), northern Sweden (3 PHC centres), and Åland Islands (1 PHC centre). SE, Sweden, FI, Finland.

2.2. Study design

This part of the TBD STING-study was initiated in February of 2008 by advertisements in local public media. Persons (≥ 18 years) bitten by tick(s) were asked to bring the tick(s) after detachment to one of 34 Primary Health Care (PHC) Centres located in the regions of southernmost, south central, and northern Sweden, and on the Åland Islands (Fig. 1). These regions were selected based on expected differences in LB incidences. The southernmost Sweden and the Åland Islands are known to be highly endemic for *Borrelia* infection (Berglund et al., 1995; Finnish Ministry of Social Affairs and Health, 2013), while the incidences in south central Sweden and northern Sweden have, to our knowledge, never been estimated. However, we previously reported a *Borrelia* IgG seroprevalence of 11% among 341 tick-bitten persons in the eastern part

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