

# TICKS AND TICK-BORNE DISEASES

GEOGRAPHICAL DISTRIBUTION AND CONTROL  
STRATEGIES IN THE EURO-ASIA REGION

EDITED BY  
MO SALMAN AND  
JORDI TARRÉS-CALL



# Ticks and Tick-borne Diseases

## Geographical Distribution and Control Strategies in the Euro-Asia Region

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*Edited by*

**Mo Salman and Jordi Tarrés-Call**

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Frank Koenen, Maxime Madder, Ilaria Pascucci, Mo Salman,  
Rita de Sousa and Alan R. Walker**



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<sup>1</sup> The editor Jordi Tarrés-Call is employed by the European Food Safety Authority (EFSA). The positions and opinions presented in this monograph are those of the authors and editors alone and are not intended to represent the views or scientific works of EFSA.

# Foreword

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Ticks are the most important ectoparasites worldwide in veterinary science, both as parasites in their own right and also as vectors of many different pathogens that cause diseases in livestock and companion animals – such as anaplasmosis, babesiosis, cowdriosis, ehrlichiosis and theileriosis. Although few tick species are adapted to parasitize mankind, they are also of great significance in human medicine as vectors of zoonotic pathogens, notably in the temperate northern hemisphere, where Lyme borreliosis, caused by the spirochaete species complex, *Borrelia burgdorferi* sensu lato, is now acknowledged as the most prevalent vector-borne disease. Despite long-standing knowledge of the subject, relatively few books have been devoted to ticks and tick-borne diseases, with the two-volume 1992/3 publication *Biology of Ticks* by D.E. Sonenshine constituting the most important recent contribution, and a new multi-author version currently in preparation. Several other books such as A. Bowman and P. Nuttall's *Ticks: Biology, Disease and Control* and *Tick-borne Diseases of Humans* by J.L. Goodman *et al.* address current 'hot topics', and there are several published proceedings of conferences and, reflecting growing public interest, a plethora of popular books. However, none of these publications are concerned with the very important subject of the geographical distribution of tick-borne pathogens and their vectors. This topic has acquired special significance in light of the predicted effects of climate and environmental change brought about by global warming and other anthropogenic factors, especially in the context of remote sensing and risk mapping. For such information pertaining to Europe and the Mediterranean, tick biologists have had to rely in the past on texts such as *Ticks of North-west Europe* by P.D. Hillyard and *Ticks of the Domestic Animals in the Mediterranean Region* by A. Estrada-Peña *et al.*, though both are quite short publications and are primarily concerned with taxonomy and identification rather than distribution. Not since the outdated and relatively limited monographs compiled by the great Harry Hoogstraal and co-workers in the 1950s has such a comprehensive record of tick distribution been published as is presented in this monograph, and to my knowledge no such attempt to record the distribution of tick-borne diseases in these particular geographical regions has been attempted before.

This monograph comes in two parts: first is the main text with descriptions and accompanying maps, applying to both the ticks and to the diseases they transmit, and second is an appendix detailing the sources of the data and other reference material. The main text starts with an introduction that focuses on the significance of tick-borne diseases, the geographic scope of the work, the methods used for reviewing the literature and a brief account of tick

identification methods. Information on the literature was extracted from PubMed and the ISI Web of Knowledge using several databases including those of CABI, *Current Contents*, *Food Science and Technology Abstracts*, *Journal Citation Reports*, MedLine and Web of Science. This resulted in the citation of more than 1400 papers concerning the distribution of ticks and tick-borne diseases, with many others addressing other topics, and the vast majority published in English.

The first chapter consists of an account of the factors behind the emergence and re-emergence of tick-borne diseases, highlighting the theme of environmental and climatic change and also the renewed interest in ticks and the diseases they transmit, which has been stimulated by an increased awareness of tick-borne zoonoses. Chapter 2 describes the basic biology of a total of 25 important tick species endemic to part or all of the geographical region under consideration, and also includes short accounts of their life cycles, geographical distributions, and significance as vectors. It contains original photographs of examples of the vast majority of the tick species considered in the publication, some of which have evidently been collected from host animals. In addition there are comments on some non-endemic species such as *Amblyomma (Am.) variegatum* and *Am. hebraeum*, which are of immense significance south of the Sahara and whose distribution may change as a result of accidental introduction, as in the Caribbean. In Chapter 3 the factors responsible for the spread and distribution of ticks are considered, which include climate, land use, animal movement – both wild and domestic, and the importation of exotic vertebrates. Tick-borne infections are reviewed in Chapter 4, and within each section of this chapter topics as varied as molecular taxonomy, pathology and epidemiology are covered. Approximately 29 bacterial species, 12 protozoan and three viral species are considered at varying levels of detail depending on their significance, and these descriptions provide useful thumbnail sketches of the species biology to put alongside their distributions. The geographical distribution of tick-borne pathogens is the focus of Chapter 5, in the form of maps with accompanying qualifying and illustrative comments; Chapter 6 addresses the distributions of the vector ticks in the same way. In both cases, the longitude and latitude coordinates were utilized; if these were not available, the nomenclature of territorial units for statistics (NUTS) was used for EU countries, while for non-EU countries the name of the administrative area given in the publication was used. Chapter 7 addresses the surveillance and control of ticks and tick-borne diseases. It includes a brief description of tick sampling methods, an introduction to the principles of surveillance and monitoring, and control options for both ixodids and argasids.

The text of the book is supported by an extremely extensive appendix. Nearly all of this (as Appendix 1) consists of tables of geographic data for individual tick-borne diseases and tick species that have been derived from the very numerous bibliographic records (Appendices 2 and 3; available at <http://www.cabi.org/vetmedresource/>) from which the distribution data were extracted. Finally, Appendix 4 presents illustrated identification keys for the genera and species of ticks in the Mediterranean basin. Most of the focus is on identification to genus level but there are notes on selected species accompanying the illustrations. All the important tick species that occur in northern Europe and that are mentioned in the main text are also included here, with the exception of *Ixodes persulcatus*, which is primarily a tick of temperate Asia.

There is no question that this publication will prove to be extremely useful for all those working with ticks and tick-borne diseases in Europe and around the shores of the Mediterranean. It fills an obvious gap in the tick literature and will complement the more specialized content of other recent publications, including the forthcoming new edition of *Biology of Ticks*. It will be a useful addition to the library of every European university with a biology department, and it should also find a place in all institutions in this geographical region that are concerned with the surveillance and monitoring of vector-borne diseases, which are likely to become increasingly relevant to those concerned with the determination of public health policies and the implementation of control measures.

# Acknowledgements

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The authors acknowledge the valuable assistance of Drs Milen Georgiev and Sofie Dhollander (Scientific Officers of the Animal Health and Animal Welfare Unit of EFSA); and of Dr Nely Sánchez (Veterinary Parasitologist of the Department of Animal Pathology – Parasitology – of the University of Zaragoza) during the systematic literature review.

Thomas Jaenson's contributions were related to his research on ticks and tick-borne infections which is funded by Carl Trygger's Stiftelse (Norwegian Foundation) and Magnus Bergvall's Stiftelse.

The data set produced for this monograph was a joint effort made possible in part by the International Consortium of Ticks and Tick-Borne Diseases, funded by the European Union and led by Frans Jongejan (University of Utrecht, The Netherlands), and EFSA.

Parts of the data set were compiled with records curated in the collection of the Institute of Parasitology of the Czech Republic, with the help of František Dusbábek and the support of the European Concerted Action on Lyme Borreliosis.

We express our thanks to the people in these concerted actions who contributed with expert assistance to the compilation: Danielle de Meneghi, Peter Zemman and Milan Daniel. We also express our thanks to Ali Bouattour, Laurence Vial, Miguel A. Habela, Ramón Juste, Ana García-Pérez, Joaquim Castellà, Margarida Santos Silva and Sofia Núncio for providing advice and lists of records in the collections of ticks under their charge. Byron Papadopoulos contributed with records in Macedonia. Lise Gern contributed with much help on data on tick distribution in Switzerland. John Scharlemann provided a list with records of *Ixodes ricinus* in the UK. Zati Vatasever compiled unreported reports of ticks in Turkey and produced the list of species for the country as included in the final data set. Jean-Louis Camicas and Ali Bouattour examined earlier maps of the species reported in the Mediterranean region. We want to extend our gratitude to collectors and systematists who made the creation of this data set possible.

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# Abbreviations

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A.: *Anaplasma*  
AF: Astrakhan fever  
Am.: *Amblyomma*  
Ar.: *Argas*  
ASF(V): African swine fever (virus)  
B.: *Borrelia* or *Babesia*  
Bo.: *Boophilus*  
CCHF(V): Crimean-Congo haemorrhagic fever (virus)  
D.: *Dermacentor*  
DEBONEL: *Dermacentor*-borne necrosis erythema lymphadenopathy  
DEET: diethyl toluamide  
E.: *Ehrlichia*  
EPNs: Entomopathogenic nematodes  
H.: *Hepatozoon*  
Ha.: *Haemaphysalis*  
Hy.: *Hyalomma*  
I.: *Ixodes*  
ISF: Israeli spotted fever  
ICTTD: Integrated Consortium on Ticks and Tick-borne Diseases (European project)  
LAR: Lymphangitis-associated rickettsiosis  
LI(V): Louping ill (virus)  
MSF: Mediterranean spotted fever  
NUTS: Nomenclature for territorial units for statistics  
O.: *Ornithodoros*  
R.: *Rickettsia*  
RF: Russian Federation  
Rh.: *Rhipicephalus*  
T.: *Theileria*  
TBD: Tick-borne disease  
TBE(V): Tick-borne encephalitis (virus)  
TCC: Transcaucasian Countries  
TIBOLA: Tick-borne lymphadenopathy

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# Introduction

**Mo Salman<sup>1</sup> and Jordi Tarrés-Call<sup>2</sup>**

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## Significance of Tick-borne Diseases

The aim of this monograph is to provide a general overview of the geographical distribution of various tick species which have proven their involvement in the transmission of the pathogens causing animal diseases and zoonoses in Europe, the Middle East and the Mediterranean basin. As blood-feeding parasites, ticks are able to transmit to their hosts a wide variety of pathogens which may cause tick-borne infections and tick-borne diseases (TBDs) that affect wild and domestic animals, including companion animals. The transmission of pathogens among ticks may occur transovarially, i.e. the pathogen is transmitted via the eggs from females to their offspring, trans-stadially from larva to nymph and/or from nymph to adult, and venereally during copulation from male to female tick. Vectorial competence is the overall ability of a vector tick species to transmit a pathogen to a range of receptive vertebrate hosts in a given location at a specific time. The TBDs usually are geographically distributed within the range of their vectors. Some of these infections/diseases can give clinical signs which can be severe (in the acute phase) but can also present as subclinical forms (mainly in endemic areas) in animals or humans. Furthermore, co-infection with different pathogens can occur in the same vertebrate animal when the same tick species transmits more than one pathogen (e.g. *Hepatozoon canis*, *Ehrlichia canis* and *Anaplasma platys* transmitted by *Rhipicephalus sanguineus*), or when two or more tick species infest an animal or human at the same time (Belongia, 2002; Stańczak *et al.*, 2002; Bremer *et al.*, 2005; Halos *et al.*, 2005; Swanson *et al.*, 2006). TBD co-infections by ticks are frequent in companion animals living in endemic areas and this may often impair an appropriate aetiological diagnosis (EFSA, 2007).

Several recent reports have indicated the wider spread of specific tick species as vectors in geographic areas that were not considered previously infested with these tick species (e.g. Jääskeläinen *et al.*, 2006, for *Ixodes persulcatus*; Nijhof *et al.*, 2007, for *Dermacentor reticulatus*; Gray *et al.*, 2009, Jaenson *et al.*, 2012, for *I. ricinus* and *D. reticulatus*). Furthermore, other reports have shown that the host range of some tick species was wider than previously known. There are limited data on vector competence for many tick species and a lack of information on the effect of environmental factors, including climatic factors, on the transmission of pathogens.

The taxonomy of tick-borne pathogens is also evolving and subject to change. Based on recent molecular studies, the taxonomy of certain tick species has been adapted accordingly. This monograph uses the taxonomy proposed by Uilenberg (2006).

## Geographic Scope

The list of countries that are covered in this monograph includes the European countries (Albania, Andorra, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Faroe Islands, Finland (including Åland Islands), France, Germany, Greece, Hungary, Ireland, Italy, Kosovo, Latvia, Liechtenstein, Lithuania, Luxembourg, Macedonia, Malta, Montenegro, The Netherlands, Norway, Poland, Portugal, Romania, San Marino, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, the UK). In addition, the following countries are also included: Algeria, Egypt, Israel, Jordan, Lebanon, Libya, Morocco, Syria, Tunisia and Turkey, and the geographic areas covering Palestine and the Western Sahara. These neighbouring countries were included owing to their proximity to Europe and the potential for the spread of ticks from them. The eastern border of Europe (Armenia, Belarus, Georgia, Moldova and Ukraine, and a buffer zone of some 600 km in European Russia) is also included to account for the important tick species recorded in that area which are of potential interest for Europe under future scenarios.

## Methods Used for the Systematic Review of the Literature

A systematic literature review was carried out based on the general principles of the systematic review methodology (CRD, 2009; Higgins and Green, 2009) with the aim of gathering information about the geographical distribution of tick species and tick-borne pathogens. The literature review was based on scientific papers published from January 2000 to March 2010 (some of the most recent data published or generated after this monograph was initiated are not present in the maps). These papers were retrieved from the citation indexing service of ISI Web of Knowledge<sup>SM</sup> (Thomson Reuters) and from PubMed (US National Library of Medicine).

The active databases during the search in the ISI Web of Knowledge were:

- Web of Science<sup>®</sup>
- Current Contents Connect<sup>®</sup>
- CAB Direct
- Food Science and Technology Abstracts<sup>™</sup>
- MEDLINE<sup>®</sup>
- Journal Citation Reports<sup>®</sup>

Additional publications within which the topics were considered relevant to the review, were submitted by the other contributors to this monograph. Two different sets of search strings were used – one for ticks and another for tick-borne pathogens. These strings were applied to the title and the abstract (Table I.1) of the publications. No language restrictions were set. The geographical limitation was applied as per the rustication to countries and regions listed above. Published validated data from the European Union Project Integrated Consortium on Ticks and Tick-borne Diseases (ICTTD-3), collected by one of the contributors to this monograph, were also considered. All data derived from these sources were collated in a relational database (using FileMaker software, see <http://www.filemaker.com>), from which the maps were created.

Duplicate references were deleted automatically by means of a reference management system<sup>1</sup>. References were then checked manually and duplicates removed. The search in ISI Web of Knowledge and in PubMed produced a list of 2197 references.

The title and abstract of each reference were screened following the criteria listed in Table I.2.

After the first screening, 1222 references were considered relevant, 309 doubtful, and 666 non-relevant. The doubtful references (title and abstract) were further revised by two contributors to this monograph who still found ten relevant references. By checking the full text,

**Table I.1.** The search strings for publications on ticks and tick-borne pathogens.

Search terms related either to ticks or tick-borne pathogens	AND	AND (search terms related to the geographic region)
Tick	<i>Argas</i> OR <i>Ornithodoros</i> OR <i>Dermacentor</i> OR <i>Haemaphysalis</i> OR <i>Hyalomma</i> OR <i>Ixodes</i> OR <i>Rhipicephalus</i> OR <i>Boophilus</i>	Aland OR Albania OR Andorra OR Austria OR Belgium OR Bosnia and Herzegovina OR Bulgaria OR Croatia OR Cyprus OR Czech Republic OR Denmark OR Germany OR Spain OR Estonia OR Faroe Islands OR Finland OR France OR Greece OR Hungary OR Ireland OR Italy OR Kosovo OR Latvia OR Liechtenstein OR Lithuania OR Luxembourg OR Macedonia OR Malta OR Montenegro OR The Netherlands OR Norway OR Poland OR Portugal OR Romania OR San Marino OR Serbia OR Slovakia OR Slovenia OR Switzerland OR Sweden OR United Kingdom OR Algeria OR Egypt OR Israel OR Jordan OR Lebanon OR Libya OR Morocco OR Syria OR Tunisia OR Turkey OR Palestine OR Western Sahara OR Armenia OR Belarus OR Georgia OR Moldova OR Ukraine OR Russia OR USSR
Tick-borne pathogen	African Swine Fever virus OR ASF virus OR ASFV OR <i>Anaplasma</i> OR <i>A phagocytophilum</i> OR <i>Ehrlichia phagocytophila</i> OR <i>Babesia</i> OR Crimean Congo Haemorrhagic Fever virus OR CCHF virus OR CCHFV OR Hepatozoon OR Lyme disease agent OR <i>Borrelia</i> OR <i>B burgdorferi</i> OR <i>B garinii</i> OR <i>B spielmanii</i> OR <i>B lusitaniae</i> OR <i>Rickettsia</i> OR <i>R conorii</i> OR <i>Ehrlichia canis</i> OR <i>Borrelia</i> <i>hispanica</i> OR <i>B hispanica</i> OR <i>Theileria</i> OR <i>T parva</i> OR <i>T hirci</i> OR <i>T ovis</i> OR <i>T lestoquardi</i> OR Tick borne encephalitis virus OR Louping ill virus OR TBE virus OR TBEV OR tick borne flavivirus OR TBEF OR TBEFV OR TBE group OR <i>Francisella</i> OR <i>F tularensis</i> OR <i>Bartonella</i> OR Q fever OR <i>Coxiella</i> OR African horse sickness virus OR AHSV OR tick borne orbivirus	Distribution OR presence OR occurrence OR reported

**Table I.2.** Criteria used in the first screening for relevance of the selected references.

Criterion	Included	Excluded
Concerns occurrence of a tick species or a tick-borne pathogen in the area considered	Yes	No
Concerns a tick species with proven involvement in transmitting pathogens of animal diseases or zoonoses	Yes	No
Contains geographic information on the distribution of the tick species or the tick-borne pathogen	Yes	No

43 other initially doubtful references were considered as relevant. This produced a total of 1275 relevant references and 822 non-relevant references. The full articles of the relevant references were then retrieved, but some could not be found. There were 125 scientific articles (six in English language and 119 in other languages) that were missed.

The second screening of articles was performed in parallel with the data extraction by two experienced veterinary parasitologists of the Veterinary School of the University of Zaragoza (Spain), one of whom is a contributor to this monograph. All contributors were