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TICK SPECIES (ACARI: IXODOIDEA) DISTRIBUTION, SEASONALITY AND HOST ASSOCIATIONS IN ROMANIA

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Abstract. By integrating the literature data with those derived from personal investigations, the authors present the distribution of the 27 tick species (25 ixodids and 2 argasids) identified up to now in Romania, as well as some aspects regarding their abundance, seasonality and host associations. Altogether, 1439 tick records (of which 256, covering 25 counties, belong to the authors themselves) were georeferenced using EpiMap (an ArcView®-compatible GIS) from CDC's EpiInfo™ software package (v. 3.5.1), on a level 2 LAU (Local Administrative Units) shapefile. The resultant distribution maps and the data on seasonality and host associations may prove to be a useful reference system for subsequent studies on different tick species' distribution, ecology and biology, as well as a predictive tool for human and veterinary medicine, bearing in mind the vectorial role that ticks play in some dangerous diseases for man and livestock.

Résumé. En intégrant les données de la littérature avec les résultats d'enquêtes personnelles, les auteurs présentent la distribution des 27 espèces de tiques (25 ixodides et deux argasides) identifiées en Roumanie à ce jour, et quelques données sur l'abondance, la saisonnalité et l'association avec l'hôte. Tous les 1439 enregistrements (dont 256 de 25 comtés, appartiennent aux auteurs) ont été cartographiés, à l'aide de EpiMap (un système d'information géographique compatible avec ArcView®) du logiciel EpiInfo™ (v. 3.5.1) lancée par CDC, sur un fichier vectoriel niveau LAU2 (Unités Administratives Locales). Les cartes de distribution résultées, les données de saisonnalité et celles de l'associaton avec l'hôte, peuvent alors être utiles en tant que système de référence pour des futures études sur la répartition, l'écologie et biologie des différentes espèces de tiques, ainsi que comme outils de prévision pour la médecine humaine et vétérinaire, compte tenu du rôle des tiques dans la transmission des maladies dangereuses pour l'homme et les animaux d'intérêt économique.

Key words: Ixodidae, Argasidae, distribution, tick hosts, tick seasonality, Romania.

INTRODUCTION

Romania is located between 43º37'07" and 48º15'06" Latitude North and 20º15'44" and 29º41'24" Longitude East. It is divided into 41 counties (with 2685 communes) plus the capital of Bucureşti (Bucharest).

Out of the 357 habitat types (comprising 7 classes and 24 subclasses of the Palaearctic habitats classification system) described in Romania (Doniţă et al., 2005) those that are suitable for tick development make up ~ 50 % of the country's surface (29 % forest and woodland and 21 % permanent pastures). Furthermore, the main forest types in Romania are the broad-leaved ones with *Quercus pubescens, Q. frainetto and Q. cerris in the plains from the southern part of the country*; *Quercus* sp., *Carpinus* sp., *Fraxinus* sp. and *Tilia* sp. in plains from other parts of the country;

Q. petraea in hilly areas; and *Fagus* sp. and *Pinus* sp. in the mountains. Deciduous forests with oak-tree are known to sustain higher densities of ticks (Estrada-Peña, 2001) through the agency of the numerous vertebrate hosts they shelter (Ostfeld, 1997).

As a result of increased anthropogenic changes in the natural habitats of ticks, the humans tend to come into contact with these arthropods more often and thus, the risk of contracting tick-borne diseases increases also. Under these conditions tick distribution maps could prove to be useful tools in preventing and predicting major tick infestations and outbreaks of tick-borne diseases.

MATERIAL AND METHODS

Source of historical data

Historical tick data were collected from scientific papers, dating back as far as 1890. Most of the papers indicated only the presence of a particular tick species in one site, without any further investigations on the population dynamics. All records have been computerized and digital maps produced.

Tick collection

In authors' investigations, ticks were collected monthly from vegetation, by dragging technique, and from animal hosts (mostly domestic animals), between 2004 and 2008. The sites were randomly selected and represented forested and ecotone areas, from 25 of the 41 counties. Ticks were preserved in alcohol or RNAlater® (Ambion®, Applied Biosystems) solution until identification.

Mapping the distribution

The distribution of ticks was mapped using EpiMap software from EpiInfo 3.5.1 package using a LAU2 (Local Administrative Units) level shapefile (vector layer obtained from geo-spatial.org http://earth.unibuc.ro) in the Coordinate Reference System Dealul Piscului 1970 (Stereo 70).

Seasonality data

Data regarding the seasonal distribution were derived both from historical data and personal investigations conducted monthly at 28 sites in 25 counties.

Host associations

Hosts were classified into several groups: human, companion animal, livestock, rodent, insectivore, chiropteran, lagomorph, mustelid, carnivore, cervid, avian and reptile.

RESULTS

Published records date back as far as the end of the 19th century (Leon, 1890). Many researches were made in the 20th century (Cernăianu, 1925; Leon, 1925; Ciurea & Stephănescu, 1929; Pârvulescu, 1940; Oprescu, 1950; Meţianu, 1951; Georgescu & Brătescu, 1953; Georgescu & Ciolca, 1953; Georgescu et al., 1955; Marcu, 1957; Feider, 1959, 1965 – the monograph "Acaromorpha, Suprafamilia

Ixodoidea (Căpuşe)"; Feider & Mironescu, 1958, 1961; Feider et al., 1958, 1964, 1968; Bădescu, 1966, 1967, 1968, 1969; Călinescu & Petrescu, 1972; Schirer, 1972; Voiculescu, 1972; Voiculescu et al., 1972; Ionescu et al,. 1991; Popa, 1992, 1997, 1998) and are continued in the 21st (Teodorescu & Popa, 2002; Ardeleanu, 2003; Ioniţă, 2003; Chiţimia, 2006; Coipan et al., 2006; Široky et al., 2006; Chiţimia et al., 2009).

In Romania, 27 tick species are known to occur, 25 of them belonging to Ixodidae family (*Dermacentor marginatus* Sulzer, 1776; *Dermacentor reticulatus* Fabricius, 1794; *Haemaphysalis concinna* Koch, 1844; *Haemaphysalis inermis* Birula, 1895; *Haemaphysalis parva* Neumann, 1897; *Haemaphysalis punctata* Canestrini & Fanzago, 1878; *Haemaphysalis sulcata* Canestrini & Fanzago, 1878; *Hyalomma aegyptium* (Linnaeus, 1758); *Hyalomma detritum scupense* Schulze, 1918; *Hyalomma marginatum marginatum* Koch, 1844; *Ixodes apronophorus* Schulze, 1924; *Ixodes arboricola* Schulze & Schlottke, 1930; *Ixodes crenulatus* Koch, 1844; *Ixodes hexagonus* Leach, 1815; *Ixodes laguri* Olenev, 1931; *Ixodes redikorzevi* Olenev, 1927; *Ixodes ricinus* Linnaeus, 1758; *Ixodes rugicollis* Schulze & Schlottke, 1930; *Ixodes simplex* Neumann, 1906; *Ixodes trianguliceps* Birula, 1895; *Ixodes vespertilionis* Koch, 1844; *Rhipicephalus annulatus* Say, 1821; *Rhipicephalus bursa* Canestrini & Fanzago, 1878; *Rhipicephalus rossicus* Yakimov & Kol-Yakimova, 1911; *Rhipicephalus sanguineus* Latreille, 1806) and only two to Argasidae family (*Argas persicus* (Oken, 1818) and *Argas reflexus* (Fabricius, 1794)).

Altogether, we collected 1439 records, covering 1278 communes from all over the country (all 41 counties plus Bucharest), of which 256 were personal records, covering 25 counties. The species with the highest number of records were *Ixodes ricinus* (543 records in 465 communes), *Haemaphysalis punctata* (187 records in 167 communes), *Hyalomma marginatum* (172 records in 149 communes), *Rhipicephalus bursa* (152 records in 139 communes) and *Dermacentor marginatus* (141 records in 123 communes). By mapping these records we obtained 13 maps, four for individual species (due to their high number of records; figs 3, 6, 8, and 12) and nine with species grouped by genus (figs 1, 2, 4, 5, 7, 9, 10, 11, and 13).

Regarding the distribution patterns, we can ascertain that most of the ticks are present throughout the country, while just few are restricted to the southern part, and these include *Hyalomma* species (which are known to occur in the drier and warmer regions of southern Europe), *Haemaphysalis parva*, *Ixodes simplex*, *Rhipicephalus annulatus* and *Rh. rossicus*.

Argas reflexus and *Ixodes crenulatus* were only collected in the North-Eastern part of the country.

For *Ixodes apronophorus*, *I. arboricola*, *I. hexagonus* and *I. rugicollis* we found only one record each and can not therefore envisage a distribution pattern.

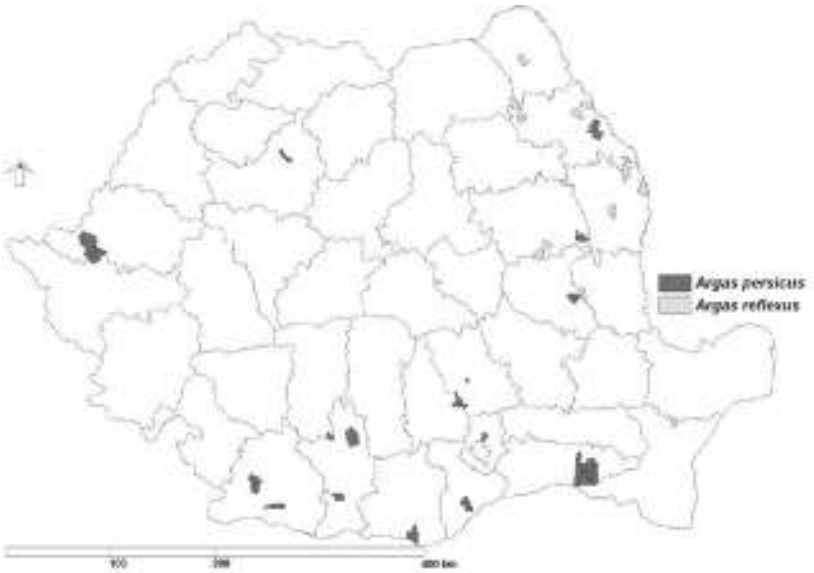

Fig. 1 - Distribution map for *Argas persicus* and *A. reflexus*.

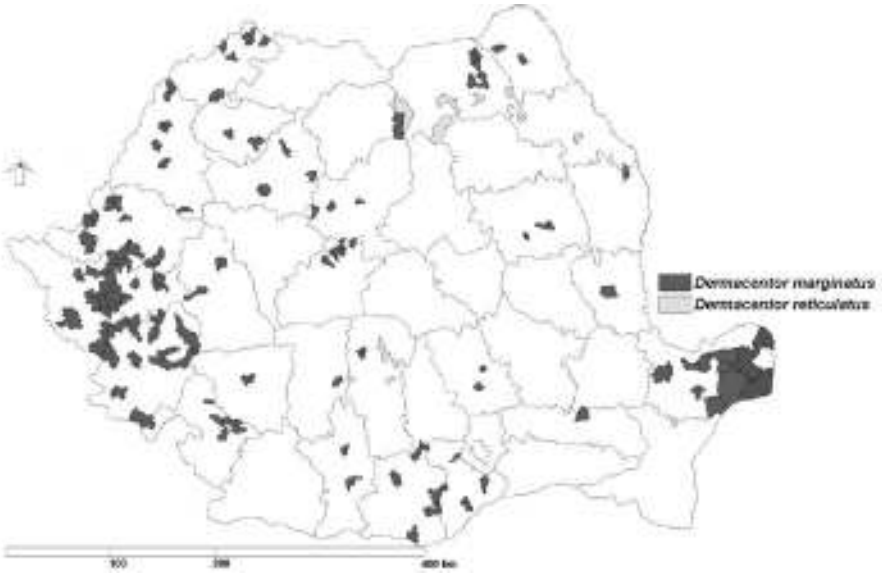

Fig. 2 - Distribution map for *Dermacentor marginatus* and *D. reticulatus*.

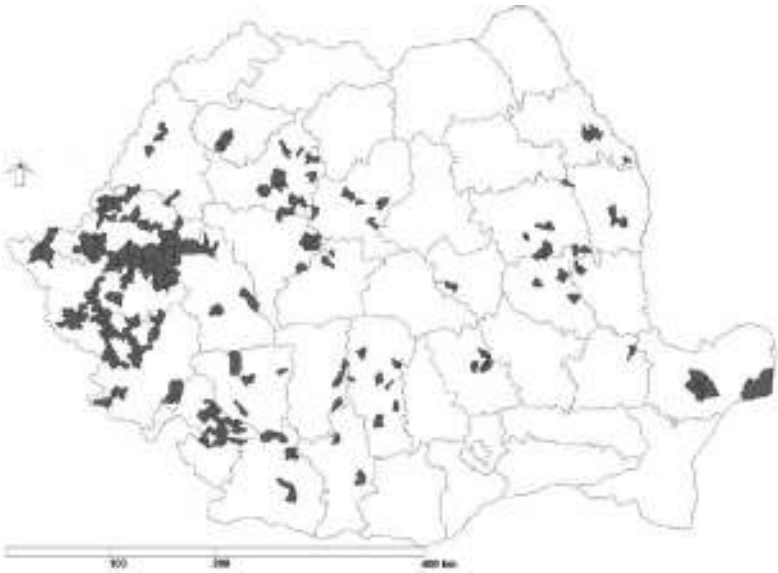

Fig. 3 - Distribution map for *Haemaphysalis punctate*.

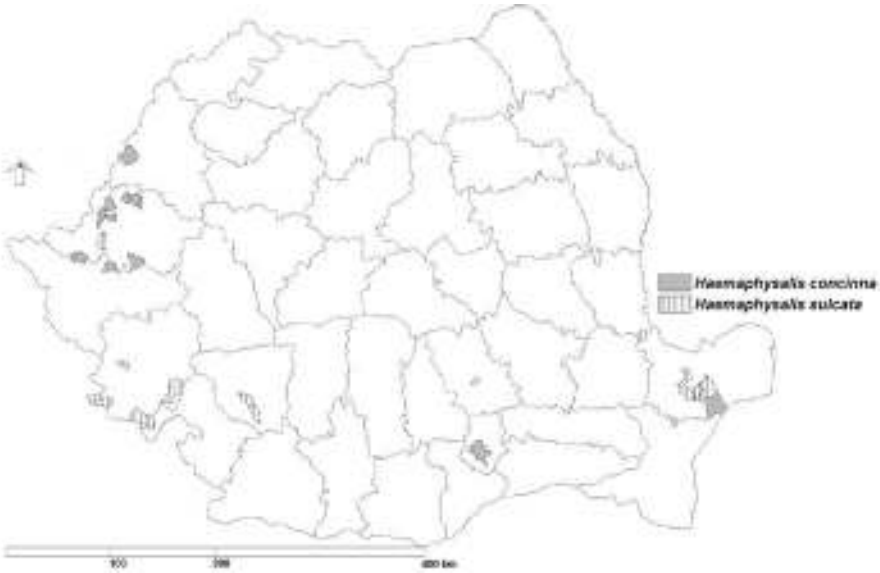

Fig. 4 - Distribution map for *Haemaphysalis concinna* and *H. sulcata*.

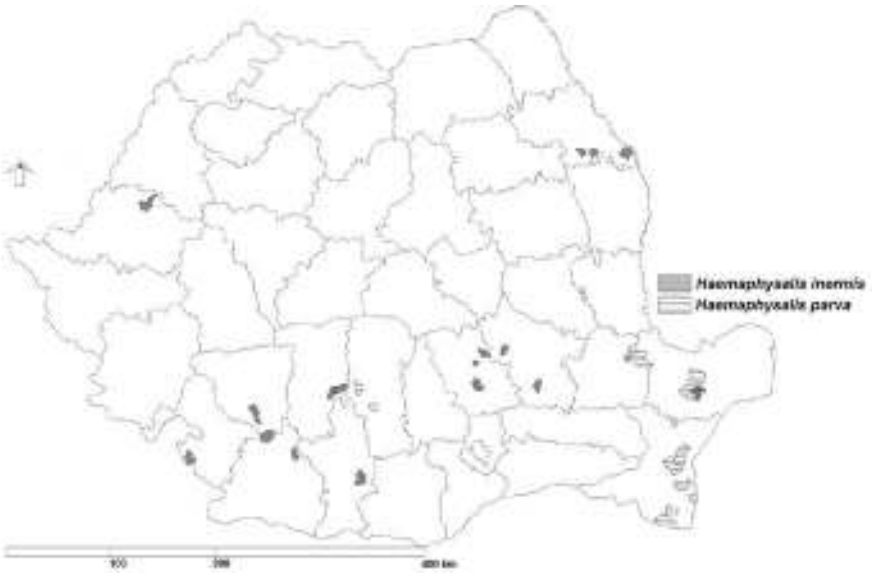

Fig. 5 - Distribution map for *Haemaphysalis inermis* and *H. parva*.

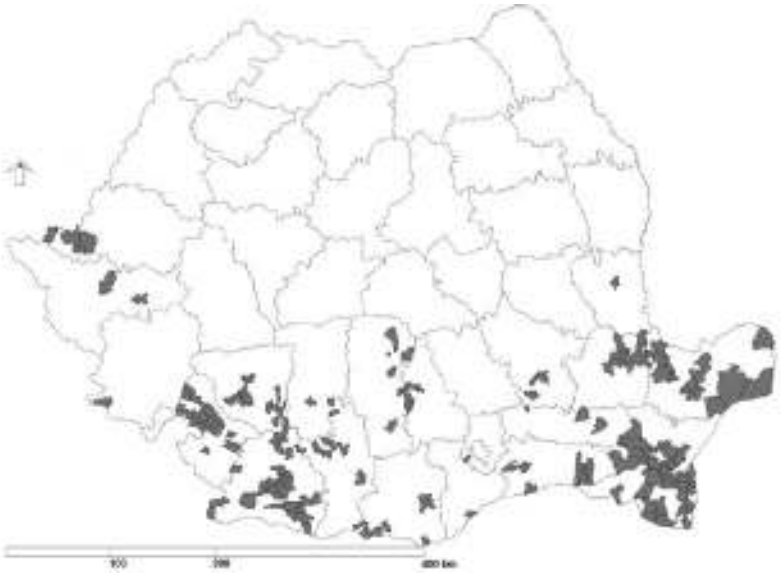

Fig. 6 - Distribution map for *Hyalomma marginatum*.

Fig. 7 - Distribution map for *Hyalomma aegyptium* and *H. detritum scupense*.

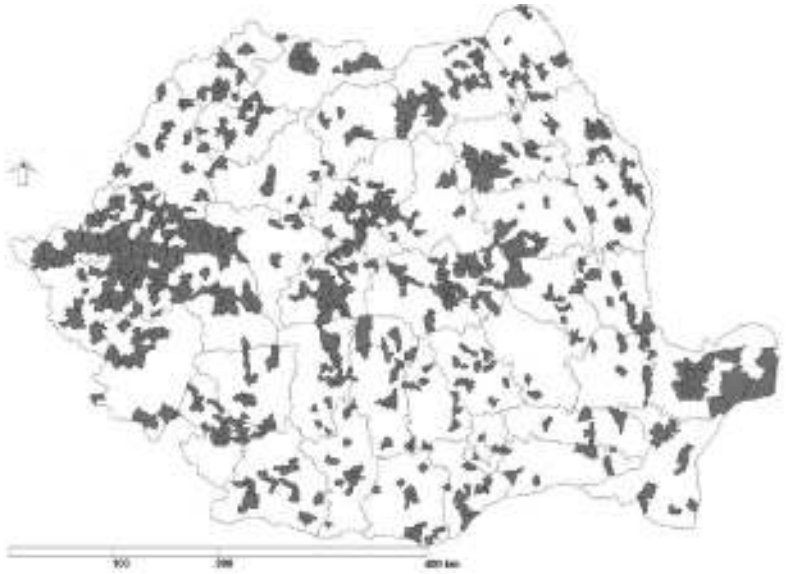

Fig. 8 - Distribution map for *Ixodes ricinus*.

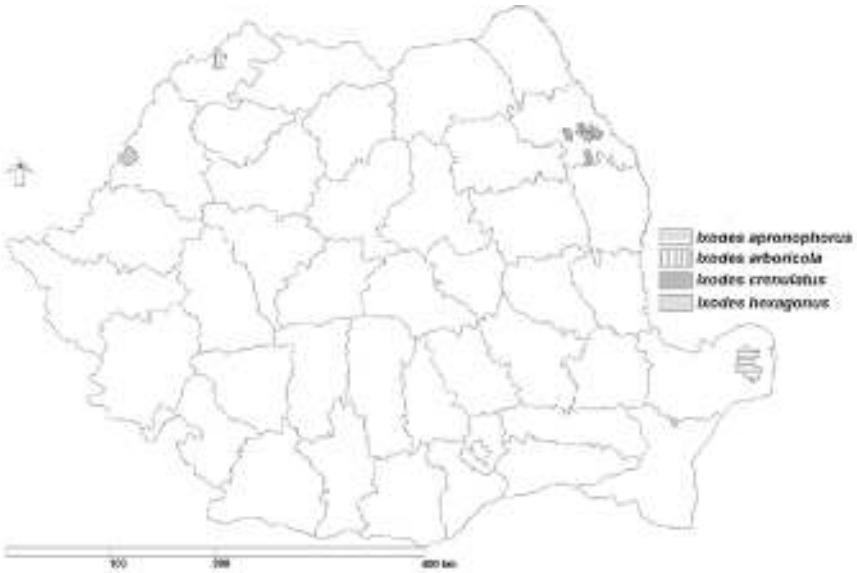

Fig. 9 - Distribution map for *Ixodes apronophorus*, *I. arboricola*, *I. crenulatus,* and *I. hexagonus*.

Fig. 10 - Distribution map for *Ixodes laguri*, *I. rugicollis*, and *I. simplex*.

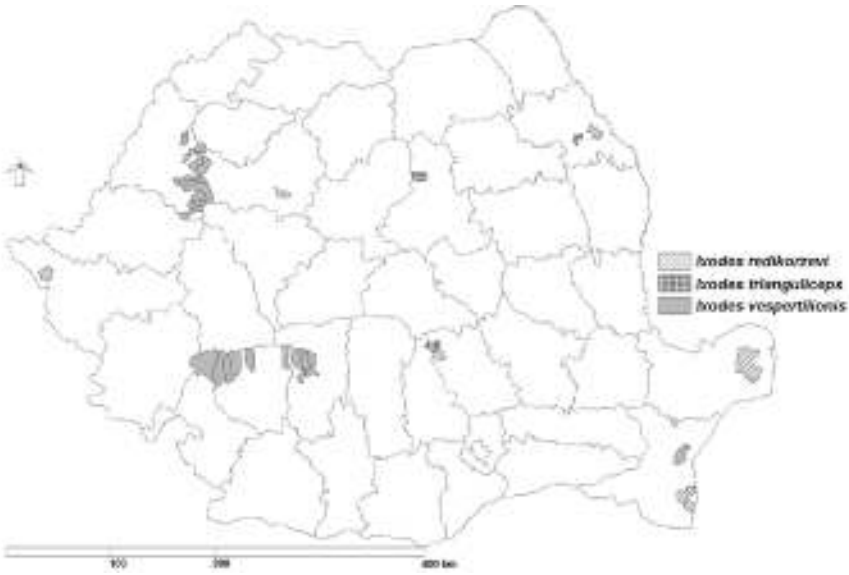

Fig. 11 - Distribution map for *Ixodes redikorzevi*, *I. trianguliceps*, and *I. vespertilionis*.

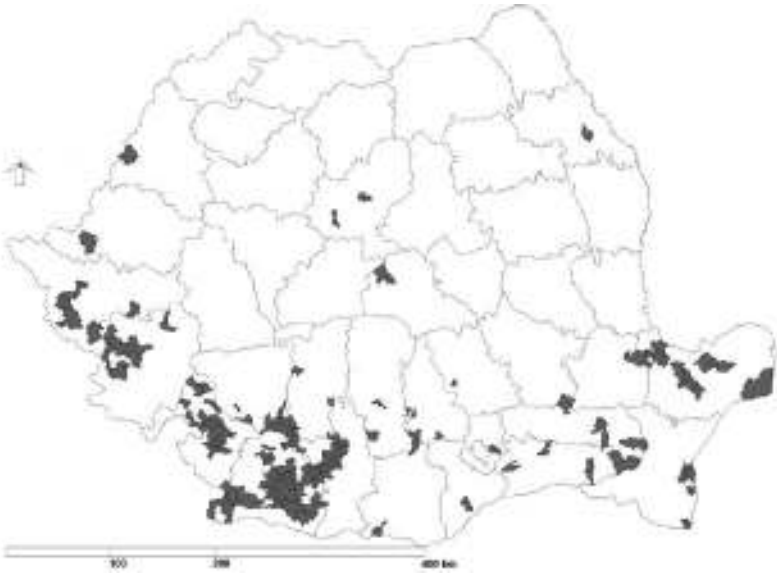

Fig. 12 - Distribution map for *Rhipicephalus bursa*.

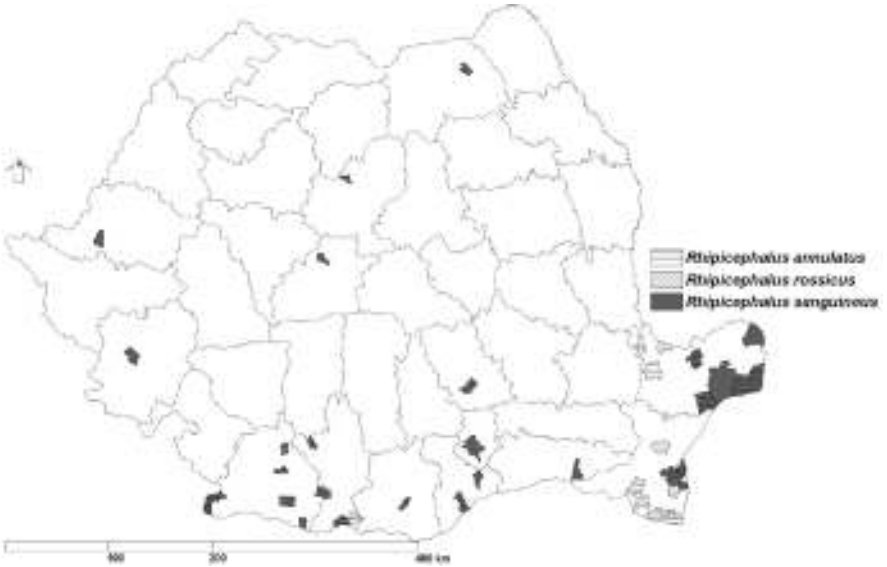

Fig. 13 - Distribution map for *Rhipicephalus annulatus*, *Rh. rossicus* and *Rh. sanguineus*.

Seasonality data from literature and personal field investigations is presented as monthly presence (+) and maximum activity (++), and refers to all tick stages indiscriminantly. Most of the tick species begin their questing activity in March-April and remain active throughout the warm season, until late October or November (Tab. 1). The species that are active during the cold season months are *Argas persicus*, which overwinters in bird nests or poultry shelters, *Hyalomma detritum scupense* and *Hyalomma marginatum marginatum*, for which it was documented that immature stages feed during winter (Kolonin, 2009; Horak & MacIvor, 1987).

Information on *host associations* of Romanian ticks was available for most of the historical records and was supplemented with personal results (Tab. 2 presents information on host associations for all three tick stages). Most of collections were from livestock hosts, rodents, insectivores and birds. *Ovis aries* was the most common livestock host, followed by *Bos primigenius taurus* and *Capra aegagrus hircus*. Three tick species (*Argas persicus*, *Haemaphysalis inermis* and *Rhipicephalus annulatus*) were collected exclusively from livestock, but no *Ixodes* species (except for *I. ricinus*), *Hyalomma aegyptium* and *Rhipicephalus rossicus* were ever encountered on livestock. All the hard ticks genera were found on various rodent species, of which *Spermophilus citellus*, *Apodemus sylvaticus* and *Microtus arvalis* were the preferred ones, hosting ticks belonging to four genera (*Ixodes*, *Haemaphysalis*, *Rhipicephalus* and *Hyalomma*). From the insectivorous hosts

Table 1

Seasonality of tick species in Romania.

Species	Month											
	J	F	M	A	M	J	J	A	S	O	N	D
Argas persicus	+	+	+	+	+	+	+	+	+	+	+	+
Argas reflexus								+	+	+	+	
Dermacentor marginatus		+	+	++	+	+	+	+	+	++	+	
Dermacentor reticulatus		+	+	+								
Haemaphysalis concinna				+	+	+	++	+	+	+		
Haemaphysalis inermis				++	+	+	+	+	+	+	++	
Haemaphysalis parva				++	+	+	+	+	+	++		
Haemaphysalis punctata			+	++	+	+	+	+	+	++	+	
Haemaphysalis sulcata			+	++	+	+	+	+	+	+		
Hyalomma aegyptium				++	+	+	++	++	+			
Hyalomma detritum scupense	+						+	+	+	+	+	+
Hyalomma marginatum marginatum	+	+	+	+	+	++	+	+	++	+	+	
Ixodes apronophorus			+	+	++	+	+	+	+	+		
Ixodes arboricola					+	+						
Ixodes crenulatus						++	++	+	+	+		
Ixodes hexagonus						+						
Ixodes laguri				++	+	+	+	++	+			
Ixodes redikorzevi				++	+	+	+	+	+	++		
Ixodes ricinus			+	+	++	+	+	+	+	++	+	
Ixodes rugicollis						+						
Ixodes simplex				+	+	+	+	+	+	++		
Ixodes trianguliceps				+	+				+	+	+	
Ixodes vespertilionis			+	+	++	+	+	+	+	++	+	
Rhipicephalus annulatus				+	++	+	+	+	+	++		
Rhipicephalus bursa			+	+	++	+	+	+	+	+		
Rhipicephalus rossicus					+	+	+					
Rhipicephalus sanguineus				+	+	++	+	+	+	+	+	

Erinaceus roumanicus, *Sorex araneus*, *Sorex alpinus* and *Talpa europaea* were parasitized by ticks and *I. ricinus* and *Rhipicephalus bursa* were the most frequent parasites.

Birds belonging to the order Passeriformes were most frequently mentioned as hosts, with 15 bird species bearing 5 tick species (four of them having quite a wide area of distribution and a large number of collections: *Dermacentor marginatus*, *Hyalomma marginatum marginatum*, *I. ricinus* and *Rhipicephalus bursa*). *I. ricinus*, which leads the field for collections, is also the most versatile tick species in terms of host range, with 36 host species covering all the groups (2 species of companion animals, 4 of livestock, 8 of rodents, one insectivore, one lagomorph, one mustelid, one carnivore, one cervid, 13 of birds and 4 of reptiles), except for bats.

Table 2

Hosts of tick species in Romania.

Species	Hosts											
	H.	C.a.	Ls.	Ro.	I.	Ch.	Lg.	M.	C.	Cv.	A.	Re.
Argas persicus											+	
Argas reflexus											+	
Dermacentor marginatus	+	+	+	+							+	
Dermacentor reticulatus			+						+			
Haemaphysalis concinna		+	+	+				+				
Haemaphysalis inermis			+	+					+	+		+
Haemaphysalis parva			+				+				+	+
Haemaphysalis punctata		+	+	+								
Haemaphysalis sulcata			+									+
Hyalomma aegyptium					+							+
Hyalomma detritum scupense			+							+		
Hyalomma marginatum marginatum	+		+	+			+				+	
Ixodes apronophorus				+								
Ixodes arboricola											+	
Ixodes crenulatus								+				
Ixodes hexagonus								+	+			
Ixodes laguri				+								
Ixodes redikorzevi				+	+				+		+	+
Ixodes ricinus	+	+	+	+	+		+	+	+	+	+	+
Ixodes rugicollis								+				
Ixodes simplex						+						
Ixodes trianguliceps				+	+							
Ixodes vespertilionis						+						
Rhipicephalus annulatus			+									
Rhipicephalus bursa		+	+		+			+				
Rhipicephalus rossicus				+	+							
Rhipicephalus sanguineus	+	+	+	+								

H.-Human; C.a.-Companion animals; Ls.-Livestocks; Ro.-Rodents; I.-Insectivores; Ch.-Chiropterans; Lg.-Lagomorphs; M.-Mustelids; C.-Carnivorous; Cv.-Cervids; A.-Avian; Re.-Reptiles

DISCUSSIONS

Our updated distribution maps of ticks are necessary, because many of the ticks in the Romanian fauna are important vectors for different pathogens and parasites of medical and veterinary importance.

In Romania, ticks and tick-borne diseases have been documented ever since the end of the 19th century. Cases of human infection with tick-borne encephalitis virus (Molnar et al., 2001; Ungureanu et al., 2001), Crimean-Congo virus (Heyman et al., 2008), *Francisella tularensis* (Pencea et al., 1974 b), *Rickettsia conorii* (Rugină, 2008), *Coxiella burnetti* (Bacalbaşa et al., 1967; Crăcea et al., 1988), *Borrelia burgdorferi* (Căruntu et al., 1988; Pop et al., 1995), have already been reported in România. Some of these pathogens have also been detected in ticks: *Borrelia burgdorferi* s.l. (Coipan & Vladimirescu, 2010) and *Francisella tularensis* (Pencea et al., 1974 a).

As the population ecology of ticks is fundamental to the spatial and temporal variation in the risk of infection by tick-borne pathogens (Randolph, 2004), knowing the distribution and seasonality of ticks is a step forward in the study of ticks and tick-borne diseases. Currently, a large number of new, emerging and re-emerging diseases are zoonotic and many of them are transmitted by arthropod vectors, including ticks. Under these conditions acknowledging host associations of ticks is useful in identifying the different bridging hosts (Kahl et al., 2001), which may form a link between distinct enzootic cycles of infection in particular regions, as well as those hosts that pose a threat to human health by their mere vicinity to human habitations.The distribution maps may be biased due to pre-selection of sampling sites by collectors, or be representative of locations at which collectors reside or work. Also, regarding host associations, the results may be biased by the ease of tick sampling from domestic animals as well as by the immediate economic interest regarding livestock. Nevertheless they could represent a departure point for studies on ecology, phenology, parasitology etc. and are open to continuous improvement as the awareness of researchers, physicians and general public on ticks as vectors is increasing.

Conclusions

To our knowledge this is the first attempt since 1965 to integrate data on the Romanian tick fauna distribution, seasonality and hosts in one paper and represents the updated tick distribution data onto GIS (geographical information system) compatible maps. These maps could serve as a first step to further development of an understanding of the distribution and behaviour of our resident ticks and may aid predicting the risk of tick-borne infectious diseases in Romania, using GIS techniques.

Still, our comprehension, at national level, on tick distribution, seasonality, host association and the pathogens they carry is scarce and further combined investigations on tick distribution and prevalence of infection with tick-borne pathogens in the vectors and in their hosts (human and animals as well) will allow us to improve our knowledge on the real status and dimension of ticks and tick-borne diseases in Romania.

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DISTRIBUŢIA, SEZONALITATEA ŞI ASOCIEREA CU GAZDELE LA SPECIILE DE CĂPUŞE (ACARI: IXODOIDEA) DIN ROMÂNIA

REZUMAT

Prin integrarea datelor din literatură cu cele rezultate din investigaţiile personale, autorii prezintă distribuţia pe teritoriul României a celor 27 specii de căpuşe (25 Ixodidae şi 2 Argasidae) identificate până în prezent, precum şi unele date referitoare la abundenţă, sezonalitate şi asocierea cu gazdele. Toate cele 1439 de semnalări de pe întreg teritoriul României (dintre care 256, din 25 de judeţe aparţin autorilor) au fost cartate într-un sistem de georeferinţă utilizând EpiMap (un sistem GIS compatibil cu ArcView®) din pachetul software CDC EpiInfo™ (v. 3.5.1), pe un fişier vectorial LAU2 (Unităţi Administrative Locale). Hărţile rezultate ca şi datele de sezonalitate şi asocierea cu gazdele pot fi ulterior utile ca sisteme de referinţă pentru studii referitoare la distribuţia, ecologia şi biologia diferitelor specii precum şi un instrument de prognoză pentru medicina umană şi veterinară, având în vedere rolul ixodidelor în transmiterea unor boli periculoase la om şi animale de interes economic.

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