

## Original Article

# Geographical Features and Seroprevalence of *Borrelia burgdorferi* in Erzincan, Turkey

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### Abstract

**Background:** We aimed to determine the geographical features and seroprevalence of *Borrelia burgdorferi* in Erzincan, Turkey, which has a high tick population due to its geographical position and climatic conditions.

**Methods:** From January to December 2014, 368 people living in Erzincan, northeastern Turkey were enrolled. *B. burgdorferi* IgG antibodies were investigated in the collected serum samples using the ELISA method in 2015. Positive and borderline results were confirmed using the Western Blot (WB) method.

**Results:** *Borrelia burgdorferi* IgG positivity was found to be 4.1% by ELISA and 2.17% by WB. Of the seropositive people according to WB, 25% resided in areas within 2000m of rivers, 50% in areas with a slope of 0–5°, and 62.5% in areas with an altitude of lower than 1500 meters.

**Conclusion:** The seroprevalence of Lyme borreliosis was high in Erzincan, particularly among people engaged in animal husbandry in rural areas. In addition, the seroprevalence of *Borrelia* varied according to geographical features, increasing in areas with a lower slope and altitude.

**Keywords:** *Borrelia burgdorferi*, Seroprevalence, Geographical features, Altitude, Slope degree, Turkey

### Introduction

Lyme borreliosis (LB), also known as Lyme disease, is the most common tick-borne infectious disease caused by spirochetes of the *Borrelia burgdorferi* sensu lato (s.l.) complex and is transmitted by *Ixodes* ticks (1, 2). To date, 19 different species have been identified in the *B. burgdorferi* s.l. complex. LB is mainly caused by three pathogenic genomic species: *Borrelia burgdorferi* sensu stricto (*B. burgdorferi*), *B. garinii*, and *B. afzelii* (3, 4).

There are 14 different species of ticks in the ‘*Ixodes ricinus* complex’, in which *Borrelia* continues its life cycle in nature (5). In addition to the *Ixodes*, which are the vector of spirochetes, other hematophagous insects, rodents and some warm-blooded animals such as birds

are also important in the ecological transmission of the disease (6). LB seroprevalence is increased in areas where these ticks live and cases of tick bites are commonly seen. LB is known to have a widespread distribution, particularly in forests and woodlands (7, 8). The risk areas for ticks in cities are green areas and parks. Therefore, the highest risk group for LB is forest and agricultural workers, hunters, livestock farmers, and individuals living in areas with a large tick population (9, 10).

LB has different clinical episodes. A typical lesion in the early stage of the disease is erythema chronicum migrans. However, the majority of patients also present with fever, flulike symptoms, and regional lymphadeno-

megaly (9, 11-13). In untreated cases, systemic manifestations such as musculoskeletal involvement, cardiovascular, and neurologic involvement may also develop during the later stages of the disease due to hematogenous dissemination (11, 14).

It is difficult to diagnose LB due to the different clinical manifestation of overlapping symptoms and the high antigenic variability of *B. burgdorferi*. A two-step standard diagnostic protocol is recommended for the laboratory confirmation of LB. In the first step, an ELISA or an indirect fluorescent antibody (IFA) method is used for the detection of antibodies. In the second step, Western blot (WB) test is recommended to confirm the positive results obtained from the first step (15-17).

LB is the most common tick-borne infectious disease in the northern hemisphere, and climatic, economic and social changes in recent years have been reported to increase the incidence of the disease (6, 18, 19). Located in the northern hemisphere, Turkey has similar geographical and climatic conditions to many European countries, in which LB is frequently reported (20). *Ixodes* are the most common type of ticks observed in Turkey (21). However, in Turkey, there are only limited studies on the seroprevalence of LB.

Therefore, we aimed to determine the seroprevalence of LB in Erzincan located in the northeast of Turkey using the ELISA and WB methods and to evaluate some of the risk factors.

## Materials and Methods

### Study Area

The study was carried out from January to December 2014 in Erzincan, located between 39° 02'–40° 05' north latitude and 38° 16'–40° 45' east longitude in northeast Turkey. Erzincan comprises nine districts, Refahiye, Kemah, Kemaliye, Tercan, Çayırılı, İliç, Otlukbeli, Üzümlü, and Central district. Erzincan is

located in the Kelkit Valley which has a large tick fauna. It has many rivers, streams, and wetlands, which facilitate farming and animal husbandry practices. Erzincan has the characteristics of a terrestrial climate characterized by relatively cold and rainy winters and hot and dry summers. The annual average temperature is 10.9 °C and the coldest and hottest months are January and July with average temperatures of -6.7 °C and 31.4 °C, respectively. Erzincan has an average rainfall of 380.6mm with the maximum being 633.1mm and the minimum being 206.1mm. The annual average humidity is 64.26% (22).

### Collection of blood samples

This study was conducted with the approval of Erzincan University Ethics Committee (Approval no: 2014/7).

The study was planned as cross-sectional epidemiological research. The sample size was determined using a cluster sampling method. Overall, 368 healthy volunteers were included in the study.

All the participants were informed about the study and signed the informed consent forms. The participants were also asked to complete a short questionnaire to reveal information on their gender, age, occupation, place of residence, engagement in animal husbandry, and tick exposure.

A 10mL venous blood sample was taken from all participants. The samples were transferred to the laboratory maintaining the cold chain and then centrifuged at 1610g for 10min to separate the sera and stored at -80 °C until the time of serological tests.

### Detection of antibodies using ELISA

*Borrelia burgdorferi* immunoglobulin G (IgG) antibodies were determined in all serum samples using a SERION ELISA classic kit (Institut Virion\Serion GmbH, Würzburg, Germany) according to the manufacturer's recommendations. The samples were diluted 1:100 using a dilution buffer. The standards and diluted samples were transferred to microtiter

wells and incubated at 37 °C for 60min in a moist chamber. The residual serum was removed from the wells by washing four times with a wash buffer. Anti-human IgG conjugated to alkaline phosphatase was added and incubated at 37 °C for 30min in a moist chamber. The wells were washed four times with the wash buffer; then, substrate p-nitrophenyl phosphate was added and incubated at 37 °C for 30min, followed by the addition of a stop solution. The optic density was determined at 405nm (at the 650nm reference wavelength) using an Epoch ELISA spectrophotometer (BioTek Instruments, Inc., Winooski, VT, USA). Each kit was used with a negative control, positive control, and standards in duplicate. Interpretation of the results was performed assisted by Serion Easy Base 4PL software, and the results were expressed in units /milliliter (IgG, <3U/ml [negative], 3–5U/ml [borderline], >5 U/ml [positive]).

#### Detection of antibodies using WB

The serum samples that had a positive or borderline value in the ELISA IgG test were further analyzed using a Viro-Blot kit (Viro-Immun Labor-Diagnostika GmbH, Germany) to confirm the presence of *B. burgdorferi* IgG antibodies according to manufacturer's recommendations. Briefly, nitrocellulose strips containing electrophoresis-separated *B. afzelii*/*B. garinii*/sensu stricto proteins were blocked and then incubated with 1020µl of the diluted serum sample (1:51) for 60min. The membrane strips were washed and incubated with alkaline phosphatase (AP)-conjugated anti-human IgG antibody for 30min. Following a final wash, strips were incubated with a chromogen-substrate solution for 10–15min, washed and air-dried on a rocking platform. The quantitative analysis of bands on each blot was carried out using the BLOTrix software (Viro-Immun Labor-Diagnostika GmbH, Germany). The software corrected the background and determined the cutoff values for positivity for the recombinant VlsE borrelial protein bands. The IgG assay was considered to be positive if five or

more of the following ten bands were present: p17/p19 complex, p20/p21 complex, p25 (OspC), p30, p31 (OspA), p35, p45, p59/ p62 complex, p100, and VlsE.

#### Mapping

ArcGIS 10.1 and Google Earth programs were used to draw the maps and conduct analyses. First, a map of Erzincan including its districts and river and stream branches was drawn to be used in the spatial analysis. Next, baseline data were created using the ArcGIS Basemap OpenStreetMap service. Then, the locations of the seropositive cases were detected in Google Earth program and transferred to ArcMap software. Addition, the relationship between seropositive cases and the altitude and slope degrees of their places of residence was evaluated. To determine the geographic correlations with seropositive samples, we obtained data from the Advanced Spaceborne Thermal Emission and Reflection Radiometer Global Digital Elevation Model (ASTER GDEM), National Aeronautics and Space Administration (NASA), and the Ministry of Economy, Trade, and Industry (METI). In addition, spatial analysis was performed through buffer analyses (Buffer, Multiple Ring Buffer) on the river and streams and their branches.

#### Statistical analysis

The data were evaluated using the (IBM SPSS Statistics for Windows, Version 20.0, IBM Corp., Armonk, NY, USA, Released 2011). The values of the variables were expressed in mean±standard deviation and median (max–min) percent and frequency. The categorical data were analyzed by Fisher's Exact Test and the Chi-square test. When the expected frequency was less than 20%, the Monte Carlo Simulation Method was used to evaluate and determine the frequencies to be included in the analysis. P< 0.05 were accepted as the significance levels for the tests.

## Results

Of the 368 individuals included in the study, 225 (61.1%) were female and the average age was calculated as  $51.43 \pm 16.91$  year. There was no statistically significant difference between the participants in terms of average age and gender ( $P=0.578$ ). Using the ELISA method, *B. burgdorferi* IgG antibodies were found to be positive in 15 individuals (4.1%) and the results of 36 individuals were within borderline value range. These 51 samples with positive or borderline values were further analyzed using the WB technique to determine their *B. burgdorferi* IgG levels. WB confirmed positivity in 8 of the 51 samples. Thus, the overall *B. burgdorferi* IgG positivity was calculated as 2.17% (8/368) (Table 1).

Among the 8 individuals with *B. Burgdorferi* positivity confirmed by the WB method, 7 lived in rural areas, 6 were engaged in animal farming and 4 were exposed to ticks. Three of these eight cases were men aged 65 to 75yr engaged in farming, lived in rural areas and were exposed to ticks. When all the indi-

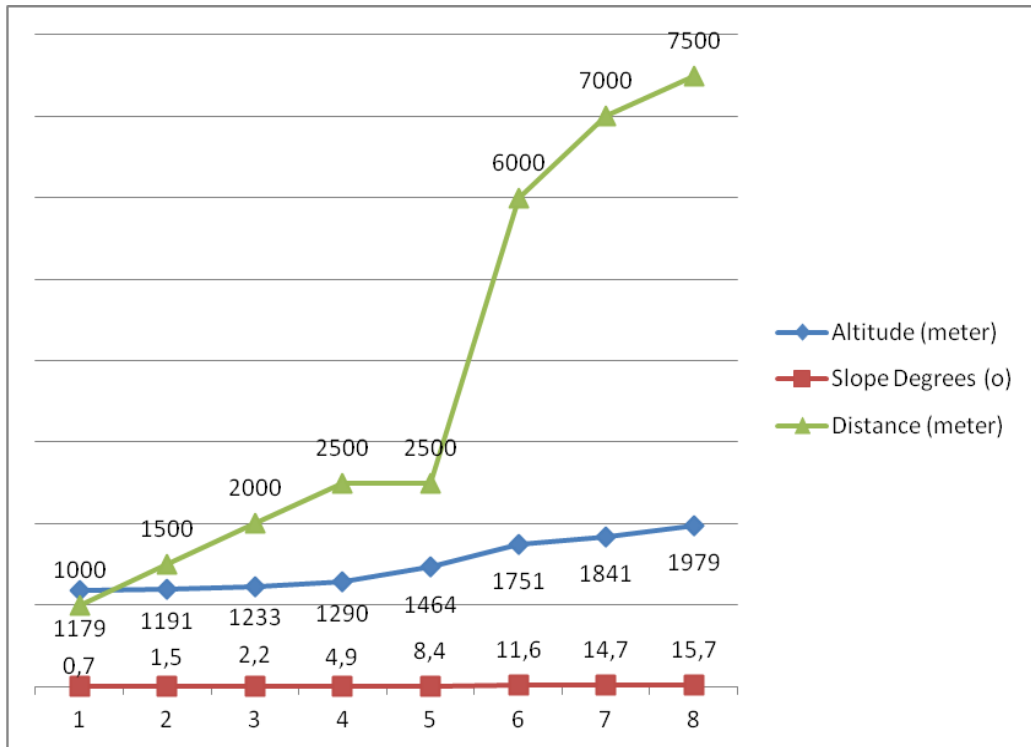
viduals were evaluated, living in rural areas was found to be statistically significant in relation to ELISA and WB values ( $P=0.010$ ). Furthermore, tick exposure and engagement in animal farming had a statistically significant effect on the positivity of the ELISA IgG values, but not the positivity of the WB values (Table 1).

The relationship between WB positivity and geographical features namely distance to rivers, altitude, and slope was investigated. Twenty-five percent of people with IgG positivity lived within 2000m of rivers or their main branches in the study area. The slope of the study area ranged from 0 to  $72.44^\circ$ . The slope degrees of the residential places of the seropositive people were  $0-5^\circ$  for 50%,  $5-10^\circ$  for 13%, and greater than  $10^\circ$  for 37%. Lastly, the study area had an altitude of 817 to 3518m above sea level, and 62.5% of seropositive cases lived in places with an altitude of fewer than 1500 meters (Fig. 1, 2).

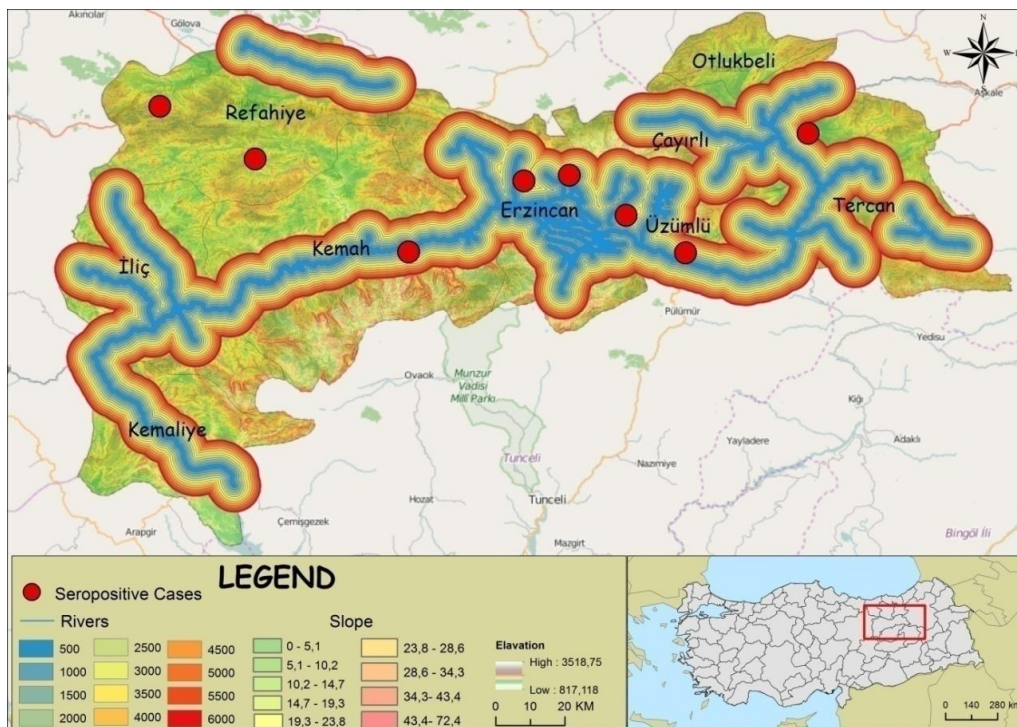
**Table 1.** The seroprevalence of *Borrelia burgdorferi* and associated risk factors

		ELISA IgG (n=368)			WB (n=51)		
		Borderline (n=36)	Positive (n=15)	P	Borderline (n=17)	Positive (n=8)	P
<b>Gender</b>	<b>Female</b>	22	11	0.405	10	5	0.861
	<b>Male</b>	14	4		7	3	
<b>Age</b>	<b>≤ 45</b>	10	6	0.391	4	3	0.468
	<b>&gt; 45</b>	26	9		13	5	
<b>Animal farming</b>	<b>Yes</b>	28	12	<b>0.010*</b>	14	6	0.668
	<b>No</b>	8	3		3	2	
<b>Tick exposure</b>	<b>Yes</b>	16	3	<b>0.010*</b>	9	4	0.891
	<b>No</b>	20	12		8	4	
<b>Living area</b>	<b>Rural</b>	30	13	<b>0.010*</b>	15	7	<b>0.010*</b>
	<b>Urban</b>	6	2		2	1	

\* $P < 0.05$



**Fig. 1.** The relationship between IgG positivity and altitude (meter), slope degrees (°) and distance (meter) according to the WB method



**Fig. 2.** The geographical features of areas in which seropositive individuals lived according to the results of the WB method

## Discussion

LB poses serious problems among tick-borne diseases. LB is particularly well known in the northern hemisphere and is the most common infectious disease caused by ticks in North America and Europe (23, 24). The incidence of LB in Europe has been reported to range from 5% to 25% (25). The incidence of LB is high in the south of Scandinavia and the north of Mediterranean countries increasing from the west to the east. Central and Eastern Europe are the endemic areas in which the disease is most frequently seen (26).

Although different *Borrelia* species can cause LB, the most common agents in Europe are *B. afzelii* and *B. garinii* (27). Turkey has a similar tick fauna to many European countries (21). In this study, taking into consideration the reported results (21), we used an ELISA kit containing *B. burgdorferi* sensu stricto, *B. afzelii* and *B. garinii* antigens (second generation). In the second phase of the study, we employed a highly specific immunoblot method including the VlsE surface antigen, reported to have the highest sensitivity and specificity (28, 29).

In Turkey, although LB is not a notifiable infectious disease and it is relatively less known, studies conducted in recent years have revealed its prevalence. The seroprevalence of *B. burgdorferi* was evaluated among people engaged in agriculture and animal husbandry and reported it to be 3.3% (30). The *B. Burgdorferi* IgG antibody positivity in risk groups was found as 3.8% using the ELISA method (20). The WB technique confirmed the positive result in 0.9% of the cases. In the current study, we found a similar percentage of *B. burgdorferi* IgG positivity (4.1%) using ELISA compared to previous studies. However, the percentage of WB *B. burgdorferi* positivity (2.17%) was higher than previous reports. This higher ratio can be attributed to the current study area having a large tick fauna.

Agricultural workers, hunters, and livestock

farmers form the risk group of LB. However, these groups also vary according to the natural habitat of different tick species (31, 32). In the current study, using the ELISA method, risk factors were determined to be living in a rural area, exposure to ticks, and engagement in animal husbandry. However, with the WB method, only living in rural areas was found to have a statistically significant effect on the incidence of LB. This can be explained by the lower number of positive cases detected by WB.

LB cases in Europe are generally reported between the latitudes of 40°N and 60°N. The incidence of LB also varies according to geographical location and species of ticks (9, 33). Tick species infected with *Borrelia* were more common in areas with an altitude lower than 1300 meters (9). In Norway, LB seroprevalence was lower in inland areas but increased in coastal areas and those close to the south. However, the seroprevalence of LB also differed according to geographical characteristics (34). Similarly, in the current study, 62.5 % of the seropositive individuals lived in areas with an altitude below 1500m. Furthermore, concerning the slope degrees of the places of residence of seropositive cases, 50% had a 0–5° slope. The results of the current study are similar to those reported for Norway in terms of the higher percentage of seropositive individuals living in coastal areas. LB is more frequently seen in areas with a lower slope and lower altitude. As another geographic feature, we also examined the distance of the positively identified people to the rivers in the study area and found that 25% lived within 2000 m from the rivers. Contrary to our expectation, this data indicates that LB is more common in areas away from wetlands.

The seroprevalence of LB will vary according to the geographical characteristics. This is one of the rare studies, in which the relationship between LB seroprevalence and geographical features (such as distance to river,

altitude, and slope degree) was explored. In addition to geographical features, environmental factors such as climate, living conditions and the presence of reservoir animals affect LB seropositivity. The current study is also important in terms of being the first to investigate LB seroprevalence in Erzincan, an area with a large tick fauna.

## Conclusion

The seroprevalence of LB was found to be high in Erzincan, particularly among people engaged in animal husbandry and exposed to ticks. The seroprevalence of *Borrelia* varies according to geographical features and is higher in areas with a lower slope degree and altitude.

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The authors declare that there is no conflict of interests.

## References

1. Melaun C, Zotzmann S, Santaella VG, Werblow A, Zumkowski-Xylander H, Kraiczy P, Klimpel S (2016) Occurrence of *Borrelia burgdorferi* s.l. in different genera of mosquitoes (Culicidae) in Central Europe. *Ticks Tick Borne Dis.* 7(2): 256–263.
2. Potkonjak A, Kleinerman G, Gutiérrez R, Savić S, Vračar V, Nachum-Biala Y, Jurišić A, Rojas A, Petrović A, Ivanović I, Harrus S, Baneth G (2016) Occurrence of *Borrelia burgdorferi* Sensu Lato in *Ixodes ricinus* ticks with first identification of *Borrelia miyamotoi* in Vojvodina, Serbia. *Vector Borne Zoonotic Dis.* 16(10): 631–635.
3. Millins C, Gilbert L, Johnson P, James M, Kilbride E, Birtles R, Biek R (2016) Heterogeneity in the abundance and distribution of *Ixodes ricinus* and *Borrelia burgdorferi* (sensu lato) in Scotland: implications for risk prediction. *Parasit Vectors.* 9: 595.
4. Wójcik-Fatla A, Zając V, Sawczyn A, Sroka J, Cisak E, Dutkiewicz J (2016) Infections and mixed infections with the selected species of *Borrelia burgdorferi* sensu lato complex in *Ixodes ricinus* ticks collected in eastern Poland: a significant increase in the course of 5 years. *Exp Appl Acarol.* 68(2): 197–212.
5. Araya-Anchetta A, Busch JD, Scoles GA, Wagner DM (2015) Thirty years of tick population genetics: a comprehensive review. *Infect Genet Evol.* 29: 164–179.
6. Jovanovic D, Atanasievska S, Protic-Djokic V, Rakic U, Lukac-Radoncic E, Ristanovic E (2015) Seroprevalence of *Borrelia burgdorferi* in occupationally exposed persons in the Belgrade area, Serbia. *Braz J Microbiol.* 46(3): 807–814.
7. Heymann WR, Ellis DL (2012) *Borrelia burgdorferi* infections in the United States. *J Clin Aesthet Dermatol.* 5(8): 18–28.
8. Vourc'h G, Abrial D, Bord S, Jacquot M, Masségli S, Poux V, Pisanu B, Bailly X, Chapuis JL (2016) Mapping human risk of infection with *Borrelia burgdorferi* sensu lato, the agent of Lyme borreliosis, in a periurban forest in France. *Ticks Tick Borne Dis.* 7(5): 644–652.
9. Rizzoli A, Hauffe H, Carpi G, Vourc'h G, Neteler M, Rosa R (2011) Lyme borreliosis in Europe. *Euro Surveill.* 16(27): 19906.
10. De Keukeleire M, Robert A, Kabamba B, Dion E, Luyasu V, Vanwambeke SO (2016) Individual and environmental factors associated with the seroprevalence

- of *Borrelia burgdorferi* in Belgian farmers and veterinarians. *Infect Ecol Epidemiol.* 6: 32793.
11. Bhate C, Schwartz RA (2011) Lyme disease: Part I. Advances and perspectives. *J Am Acad Dermatol.* 64(4): 619–636.
  12. Sanchez JL (2015) Clinical manifestations and treatment of Lyme disease. *Clin Lab Med.* 35(4): 765–778.
  13. Nazari M, Najafi A (2016) Epidemiological study of endemic relapsing fever in Hamadan Province, west of Iran. *J Arthropod Borne Dis.* 10(4): 586–594.
  14. Akin Belli A, Derviş E, Özbaş Gök S, Midilli K, Gargılı A (2015) Evaluation of 10 cases of Lyme disease presenting with erythema migrans in Istanbul, Turkey. *Mikrobiyol Bul.* 49(4): 525–531.
  15. Wright WF, Riedel DJ, Talwani R, Gilliam BL (2012) Diagnosis and management of Lyme disease. *Am Fam Physician.* 85(11): 1086–1093.
  16. Wilking H, Fingerle V, Klier C, Thamm M, Stark K (2015) Antibodies against *Borrelia burgdorferi* sensu lato among adults, Germany, 2008–2011. *Emerg Infect Dis.* 21(1): 107–110.
  17. Leeflang MM, Ang CW, Berkhout J, Bijlmer HA, Van Bortel W, Brandenburg AH, Van Burgel ND, Van Dam AP, Dessau RB, Fingerle V, Hovius JW, Jaulhac B, Meijer B, Van Pelt W, Schellekens JF, Spijker R, Stelma FF, Stanek G16, Verduyn-Lunel F, Zeller H, Sprong H (2016) The diagnostic accuracy of serological tests for Lyme borreliosis in Europe: a systematic review and meta-analysis. *BMC Infect Dis.* 16: 140.
  18. Schotthoefer AM, Frost HM (2015) Ecology and epidemiology of Lyme Borreliosis. *Clin Lab Med.* 35(4): 723–743.
  19. Pritt BS, Mead PS, Johnson DK, Neitzel DF, Respicio-Kingry LB, Davis JP, Schiffman E, Sloan LM, Schriefer ME, Replogle AJ, Paskewitz SM, Ray JA, Bjork J, Steward CR, Deedon A, Lee X, Kingry LC, Miller TK, Feist MA, Theel ES, Patel R, Irish CL, Petersen JM (2016) Identification of a novel pathogenic *Borrelia* species causing Lyme borreliosis with unusually high spirochaetaemia: a descriptive study. *Lancet Infect Dis.* 16(5): 556–564.
  20. Parlak M, Bayram Y, Çıkman A, Ceylan N, Berktaş M (2015) Seropositivity of *Borrelia burgdorferi* in risky groups in Van region, Turkey. *Mikrobiyol Bul.* 49(3): 439–445.
  21. Güner ES, Hashimoto N, Takada N, Kaneda K, Imai Y, Masuzawa T (2003) First isolation and characterization of *Borrelia burgdorferi* sensu lato strains from *Ixodes ricinus* ticks in Turkey. *J Med Microbiol.* 52(9): 807–813.
  22. [https://www.mmo.org.tr/sites/default/files/a2cdf81860c9093\\_ek.pdf](https://www.mmo.org.tr/sites/default/files/a2cdf81860c9093_ek.pdf).
  23. Mead PS (2015) Epidemiology of Lyme disease. *Infect Dis Clin North Am.* 29(2): 187–210.
  24. van den Wijngaard CC, Hofhuis A, Harms MG, Haagsma JA, Wong A, de With GA, Havelaar AH, Lugner AK, Suijkerbuijk AW, van Pelt W (2015) The burden of Lyme borreliosis expressed in disability-adjusted life years. *Eur J Public Health.* 25(6): 1071–1078.
  25. Biesiada G, Czepiel J, Leśniak MR, Garlićki A, Mach T (2012) Lyme disease: review. *Arch Med Sci.* 8(6): 978–982.
  26. Calderaro A, Montecchini S, Gorrini C, Piccolo G, Chezzi C, Dettori G (2011) Presence of anti-*Borrelia burgdorferi* antibodies and *Borrelia burgdorferi* sensu lato DNA in samples of subjects in an area of the Northern Italy in the period 2002–2008. *Diagn Microbiol Infect Dis.* 70(4): 455–460.
  27. Stanek G, Reiter M (2011) The expanding Lyme *Borrelia* complex-clinical significance of genomic species? *Clin Microbiol Infect.* 17(4): 487–493.



28. Schulte-Spechtel U, Lehnert G, Liegl G, Fingerle V, Heimerl C, Johnson BJ, Wilske B (2003) Significant improvement of the recombinant *Borrelia*-specific immunoglobulin G immunoblot test by addition of VlsE and a DbpA homologue derived from *Borrelia garinii* for diagnosis of early neuroborreliosis. J Clin Microbiol. 41(3): 1299–1303.
29. Branda JA, Strle F, Strle K, Sikand N, Ferraro MJ, Steere AC (2013) Performance of United States serologic assays in the diagnosis of Lyme borreliosis acquired in Europe. Clin Infect Dis. 57(3): 333–340.
30. Aslan Başbulut E, Gözalan A, Sönmez C, Cöplü N, Körhasan B, Esen B, Akın L, Ertek M (2012) Seroprevalence of *Borrelia burgdorferi* and tick-borne encephalitis virus in a rural area of Samsun, Turkey. Mikrobiyol Bul. 46(2): 247–256.
31. Lewandowska A, Kruba Z, Filip R (2013) Epidemiology of Lyme disease among workers of forest inspectorates in Poland. Ann Agric Environ Med. 20(2): 329–331.
32. Kmiecik W, Ciszewski M, Szewczyk EM (2016) Tick-borne diseases in Poland: Prevalence and difficulties in diagnostics. Med Pr. 67(1): 73–87.
33. Margos G, Piesman J, Lane RS, Ogden NH, Sing A, Straubinger RK, Fingerle V (2014) *Borrelia kurtenbachii* sp. nov., a widely distributed member of the *Borrelia burgdorferi* sensu lato species complex in North America. Int J Syst Evol Microbiol. 64(1): 128–130.
34. Vestheim DF, White RA, Aaberge IS, Aase A (2016) Geographical differences in seroprevalence of *Borrelia burgdorferi* antibodies in Norway, 2011–2013. Ticks Tick Borne Dis. 7(5): 698–702.