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TICK BITES ON HUMANS IN THE AGRICULTURAL AND RECREATIONAL AREAS IN SOUTH-EASTERN POLAND

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Abstract: The investigations were conducted in the Lublin province (south-eastern Poland) in areas of high agricultural and recreational value. Among the 418 patients admitted to medical clinics due to arthropod bites in the years 2003–2005, 184 people (44%) had been bitten by ticks. As shown by the research, high-risk groups include people whose stay in tick habitats is connected with their occupational work (54.5%) as well as recreation and tourism (45.5%). As many as 78.7% of the patients were attacked by *Ixodes ricinus* ticks in forests, and much fewer (31.3%) in other habitats located in urban and rural areas. In one case, a *Dermacentor reticulatus* female was attached to the skin. Ticks were most commonly located on the upper (28.8%) and lower (27.2%) extremities, and on the abdomen (15.8%). Local skin reactions (57.6%) with predominance of erythema were the most prevalent. Combined local and systemic symptoms were reported less frequently (20.1%). The general symptoms were headache (10.8% of patients), fever (5.4%), lymphadenitis (5.9%) and arthralgia (4.3%). No lesions produced by tick bites were reported in 22.3% of the patients. Field studies conducted in 2003–2004 demonstrated that *I. ricinus* is a common species in the southern part of the Lublin province, where the density of nymphs and adult forms in various localities during the period of peak seasonal activity (in May) ranges from 18.5–26 specimens/1 h of collection. Two tick species, *I. ricinus* and *D. reticulatus*, occur in the northern part of the province. The density of *I. ricinus* nymphs and adult forms as well as *D. reticulatus* adults is in the range of 2.5–42 specimens/1 hr of collection and 19.5–64.0 speciments/1 hr of collection, respectively. Due to the high risk of tick attacks in the study area, there arises the necessity to permanent the monitoring of ticks numbers and tick-borne diseases.

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INTRODUCTION

Ticks are common human and animal parasites producing a variety of symptoms associated with the harmful effects of components of their saliva [9, 11, 14, 28] and with transmission of numerous pathogens of tick-borne diseases [6, 63, 73]. Due to their wide distribution in different types of habitats, they represent a major threat to hosts' health. Man may be infested by various species of ticks [45, 79], but more than 12 argasid and 20 ixodid tick species that feed on domestic and wild living animals are usually found attached to the skin of humans [29]. In Europe, the common tick species *Ixodes ricinus* [20, 38] parasitises humans most frequently [58].

Most literature data indicate the role of *I. ricinus* in the transmission of pathogens: viruses [18, 35, 46, 65], bacteria [13, 41, 43, 59, 65, 74, 75, 76] and protozoa [13, 36, 64, 70, 75, 81]. The direct effects of tick parasitism on humans have rarely been reported [28, 57, 61].

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This paper presents the results of examinations of tick-infested patients admitted to health care facilities from two popular tourist areas in the Lublin province. Furthermore, in order to estimate the degree of risk of tick attack and tick-borne diseases, we assessed the density of ticks in localities that are frequently visited by humans for occupational or recreational reasons.

MATERIALS AND METHODS

Study area. The study was conducted in the years 2003–2005 in two typically agricultural parts of the Lublin province, which are also a recreational region for the inhabitants of south-eastern Poland. In the south of the province, the study area included Roztocze, covered by forests in 2/3 of its area. Pine is the dominant species in the forests, accompanied by fir and Carpathian beech. There are water reserves in the valleys of the rivers Wieprz, Sołokija and Opornica, and numerous marshes and bogs in Solska Primeval Forest. In the north of the province, there are two large forest complexes, i.e. Parczewskie Forest and Kozłowieckie Forest. The former is a pine coniferous and mixed forest. Additionally, there are alder, hornbeam-oak and riparian forest communities. In the neighbourhood of the forested areas, there are fishponds, lakes, forest meadows and cultivated fields. The Kozłowieckie Forest consists of lowland mixed forests: old pine stands with the addition of oak, aspen, hornbeam, linden, and spruce.

Collection of ticks. Ticks were collected using the flagging method in May 2003 and 2004, i.e. during the spring peak of seasonal activity of *Ixodes ricinus* and *Dermacentor reticulatus* in areas frequently visited by locals and tourists in the southern and northern parts of the province. In order to determine the real threat of tick attacks, tick density was determined in the study area (number of specimens collected with the use of one flag during one hour). The method applied facilitates collection of all stages of *I. ricinus* and adult forms of *D. reticulatus*. However, in the case of *I. ricinus*, the collection was only focused on the tick stages that attack humans most frequently, i.e. nymphs and adults. The tick specimens were transferred to 70% ethyl alcohol, and their species and developmental stage were determined in laboratory conditions.

Examination of the effects of tick bites. The study involved patients from four health care facilities in the southern and northern parts of the Lublin province, referred to a doctor due to symptoms appearing upon bites of parasitic arthropods. Epidemiological interviews were conducted with each of the 184 patients in order to obtain information about their occupation as well the location and time of tick attacks. Additionally, skin lesions produced by tick infestations were identified. Physical examination was conducted in patients with skin and systemic symptoms.

Since in most cases patients reported to the doctor after removal of ticks, it was impossible to identify the developmental stage that had infested them.

RESULTS

Two species of ticks – *I. ricinus* and *D. reticulatus* – were identified in the tick collections. In the southern part of the Lublin province, specimens of *I. ricinus* only were collected, whereas in the north specimens of both species were found (Tab. 1). The forest complexes in the study area were dominated by of nymphs and adult *I. ricinus*, while adult *D. reticulatus* were predominant on the meadows. Depending on the locality, the density of *I. ricinus* nymphs and adults ranged from 18.5–42 specimens/1 hr of collection. In the case of adult *D. reticulatus*, the density was in the range of 19.5–64 specimens/1 hr of collection.

Table 1. Number of active *Ixodes ricinus* and *Dermacentor reticulatus* ticks collected in sites located in southern (A) and northern (B) parts of Lublin province in 2003–2004.

Site	*Ixodes ricinus*					*Dermacentor reticulatus*			
	Total[a]	Mean tick density[b]	F	M	N	Total	Mean tick density[a]	F	M
A									
Solska Primeval Forest (Józefów area)	111	18.5	50	36	25	0	0	0	0
Roztoczański National Park (Zwierzyniec area)	104	26	43	37	24	0	0	0	0
B									
Parczewskie Forests (Sosnowica area)	100	25	25	15	60	78	19.5	50	28
Łęczyńsko-Włodawskie Lakeland (Stary Uścimów area)	5	2.5	4	1	0	128	64	87	41
Kozłowieckie Forests (area of Majdan Kozłowiecki)	84	42	36	37	11	42	22	39	3

[a] – total number of collected ticks; [b] – average number of ticks collected with one flag during 1 h of collection; F – females; M – males; N – nymphs.

Table 2. Number and percentage of tick attacks depending on the habitats in the Lublin province.

Habitat	Number of bites	Percentage of bites
Farmland	6	2.9
Forest	163	78.7
Estate	3	1.5
Meadow	13	6.3
Orchard	12	5.8
Park	10	4.8

Table 3. Incidence of skin and systemic lesions in patients bitten by *Ixodes ricinus* tick.

Group	Cases	Local skin reaction	Combined local and systemic symptoms	No Symptoms
Females	109	61 (33.1%)	18 (9.8%)	30 (16.4%)
Males	75	45 (24.5%)	19 (10.3%)	11 (5.9%)
Total	184 (100%)	106 (57.6%)	37 (20.1%)	41 (22.3%)

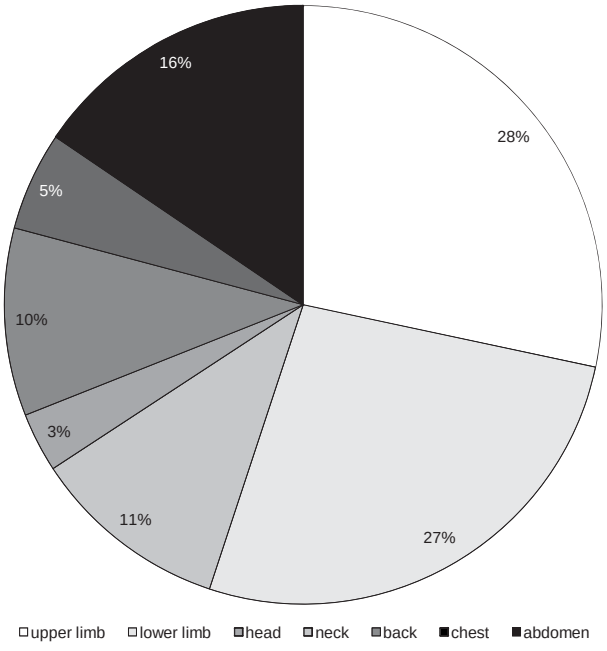

Figure 1. Anatomical sites of bites noted in patients.

As many as 184 (44%) patients out of the 418 people seeking medical assistance after attacks of arthropods had been bitten by ticks. The group consisted of 109 women and 75 men. Most patients (32.5%) were manual workers – farmers, forest workers, hunters and horticulture farmers, i.e. workers that are occupationally exposed to tick attacks. A considerable proportion of people attacked by arthropods included white-collar workers (21.2%), students (17.1%), workers employed in various firms and working on their own farms (16.3%), and pensioners (11%). Children constituted only 1.9%.

The patients reported tick bites in the period from April (0.6%)–September (7.8%). However, most cases of tick infestations in humans were reported in July (45%), June (23.3%) and August (19.4%).

Ticks attacked humans in various habitats (Tab. 2). In as many as 78.7% of the cases, the arthropod attacks took place in forests and over two-fold less often (31.3% of the cases) in other places, such as meadows, orchards, parks, farmlands and private estates.

The most common sites of tick bites were upper and lower extremities, 28.8 and 27.1%, respectively. In a lower percentage of the patients, the ticks attached to on the abdomen, head and back, and in individual cases, on the chest and neck (Fig. 1). 77.7% of the patients exhibited symptoms after tick infestations. As many as 57.6% of the patients, including 33.1% of women and 24.5% of men, developed local skin lesions. The incidence of combined local and systemic symptoms was similar in the groups of men and women. No symptoms after tick bites were reported in 22.3% of the cases, the percentage in women being three-fold higher than in men (Tab. 3).

Erythema (66.8%) and pruritus (50%) were the most commonly found local skin symptoms. Additionally, the patients complained of pain, tingling, or burning sensation at the site of the bite (Fig. 2). Headache was the predominant systemic symptom (10.8% of the patients). Significantly fewer patients reported inflammation of the lymph nodes, increased body temperature and pain in the joints (Fig. 3).

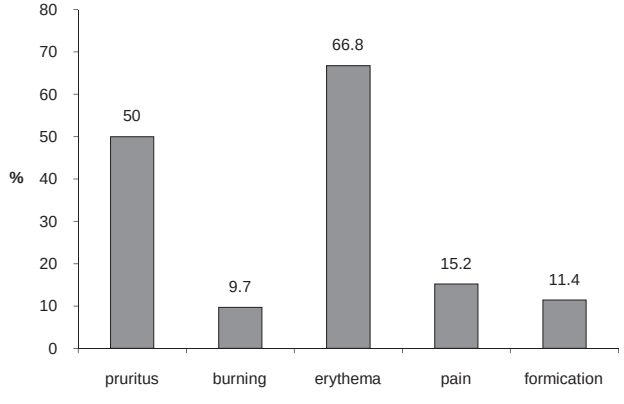

Figure 2. Local skin reaction after tick bites.

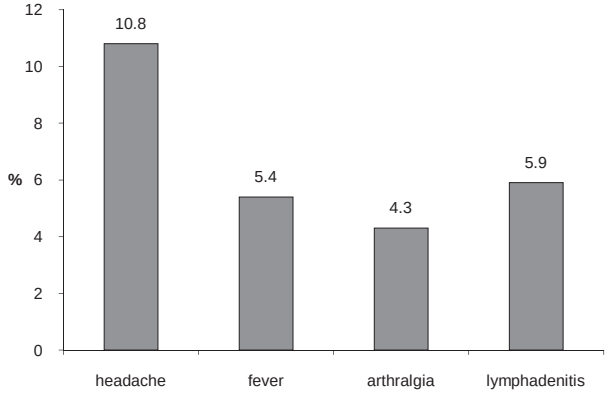

Figure 3. Systemic symptoms after tick bites.

DISCUSSION

Studies indicate a high level of risk of tick attacks to humans and animals in the agricultural and recreational regions of the Lublin province. This is confirmed by both field studies demonstrating a high density of *I. ricinus* and *D. reticulatus* and numerous reports of local and systemic symptoms in humans caused by parasitic ticks. A great number of environmental factors can be responsible for the differences in the tick density in the Lublin province found in our study and studies of other authors [17]. These factors include topography, the vegetation structure ensuring presence of tick hosts, humidity and temperature conditions, and climatic changes [8, 30, 33, 40]. Many populations of *I. ricinus* were also found in other recreational areas around Poland [10, 60, 74, 80] and Europe [22, 32, 34, 39, 51]. Like other authors [48, 50, 72, 79], we found that the density of *I. ricinus* ticks in dense, humid mixed forests (Kozłowieckie and Parczewskie Forests) was higher than that in coniferous forests (Solska Primeval Forest). In this type of biotope, there is the highest probability of infection with the tick-borne encephalitis virus and *Borrelia burgdorferi* spirochetes [20, 21]. However, there is not always a correlation between *I. ricinus* tick density and the degree of their infection with pathogens [31]. Transmission of pathogens is determined by the activity of animals – ticks' hosts – inhabiting the biotope [26, 42, 56, 60, 68, 71]. In our study area, a high rate of infection of *I. ricinus* ticks with pathogens was found; depending on the habitat and study period, it was in the range of 5.3–15.1% for *B. burgdorferi* [69], 0.7–28.1% for *Anaplasma phagocytophilum* [15, 82] and 1.8–4.2% for the tick-borne encephalitis virus [18].

The highest density of adult *D. reticulatus* was found in typical habitats for this species, i.e. in meadows (Łęczyńsko-Włodawskie Lakeland) and in mid-forest clearings of the Parczewskie Forest. This species is widespread in eastern Poland [25, 27, 53, 72].

Our study suggests that human behaviour has a significant impact on the incidence of tick bites. Staying in tick habitats during their seasonal activity for occupational or recreational purposes increases the risk of arthropod attack. In our research, the largest numbers of tick bites were reported from June–August, i.e. in the period of field and forest work, and during recreational activities in forests, meadows and parks.

The cases of tick bites in the group of elderly people (pensioners) found in our study may be associated with both recreation and the need to collect forest groundcover products for commercial gain, which is necessitated by the deterioration socioeconomic condition in this part of Poland. In 2008, the indicator of material deprivation (at least three of the nine symptoms of poverty taken into account) in the European Union was 17%, while in Poland 32% – nearly twice the average of the European Union. Most Polish people at risk of income poverty live in the Lublin province [37].

As in our study reporting the highest incidence of skin lesions and systemic symptoms appearing upon tick bites in manual workers, other authors [5, 12, 23, 77] observed high rates of infection with tick-borne pathogens among forestry workers and farmers exposed to direct contact with ticks. In the Lublin province, seropositive test results indicating presence of *B. burgdorferi* in serum were obtained in ca. 40% of forest workers [19]. *A. phagocytophilum* bacteria were detected in 20.6–33.3% [16, 78], and tick-borne encephalitis viruses in 14.8–53.5% of forestry workers and farmers [17]. In the provinces of Małopolska and Silesia (southern Poland), the percentage of positive results of anti-*Borrelia burgdorferi* antibodies in IgM class ranged from 7.5–25.0%, while for the IgG class it was 16.3–29.1% [12]; in Lower Silesia (western Poland) it was 35.0% [24] and in West Pomerania 35–61.9% [62]. The high incidence of infection with *B. burgdorferi* spirochetes in forestry workers and other workers occupationally exposed to tick bites was found in neighbouring countries, namely in Germany – 30% [66] and Slovakia – 12.8% [4]. In France, the presence of anti-*Borrelia burgdorferi* antibodies was confirmed in 14.1% [77], in Turkey in 10.0% [54] and in Italy in 7.5% of people occupationally exposed to tick attacks [67].

Our current as well as previous observations show that the places on adult human skin most preferred by *I. ricinus* ticks are the extremities and the abdomen [1]. Also, according to other studies by Hügli *et al.* [49], the legs were the major anatomical sites of bites for women (40.7%), men (44.4%), and almost all age groups.

The inconsiderable number of tick bites in children in the Lublin province makes it impossible to determine the most common tick-feeding sites in patients from this age group. In our study, we found an asymptomatic case of attachment of *D. reticulatus* female to human skin. Although this tick species most commonly infests domestic and wild animals, it plays an important epidemiological role in circulation of pathogens that cause human diseases [47, 55, 83].

In the examined patients, the most common local symptom induced by components of *I. ricinus* saliva was erythema appearing in the bite site. The incidence of combined local and systemic symptoms was three-fold lower than that of local symptoms. In the tick bitten patients, we did not perform serological tests for antibodies against pathogens transmitted by ticks; therefore, we cannot exclude the possibility of infection by bacteria or viruses, the symptoms of which in the first phase are similar to those observed in our study [3, 7, 44, 52]. Skin lesions and systemic symptoms may not be present in a large percentage of patients bitten by ticks. It is difficult to explain unambiguously the higher proportion of asymptomatic cases found in women in our study. It is likely to result from increased women's outdoor activity (e.g. fieldwork, haymaking, collecting forest groundcover fruit), and their higher exposure to arthropod bites. Our group consisted of patients reporting bites of a variety of arthropods (black flies, biting midges).

Although eastern and south-eastern Poland is a an area of high risk of tick attacks and infections by tick-borne pathogens, residents' knowledge of the principles of tick prophylaxis is insufficient [2]. The high density of ticks in recreational and agricultural areas demands that residents and should pay attention to the consequences of tick parasitism and the medical services promote prevention methods.

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REFERENCES

1. Bartosik K, Kubrak T, Sitarz M, Święcicka M, Buczek A: The public health risk of ticks and tick-borne diseases in the south-eastern Poland. *Wiad Parazytol* 2004, **50**, 249–252.

2. Bartosik K, Kubrak T, Olszewski T, Jung M, Buczek A: Prevention of tick bites and protection against tick-borne diseases in south-eastern Poland. *Ann Agric Environ Med* 2008, **15**, 181–185.

3. Baumann D, Pusterla N, Péter O, Grimm F, Fournier PE, Schär G, Bossart W, Lutz H, Weber R: Fieber nach Zeckenstich: Klinik und Diagnostic von akuten Zeckenstich-assoziierten Infektionskrankheiten in der Nord-Ostschweiz. *Dtsch Med Wochenschr* 2003, **128**, 1042–1047.

4. Bazovska S, Machacova E, Spalekova M, Kontrosova S: Reported incidence of Lyme disease in Slovakia and antibodies to *B. burgdorferi* antigens detected in healthy population. *Bratisl Lek Listy* 2005, **106**, 270–273.

5. Bilski B: Occurrence of cases of borreliosis certified as an occupational disease in the province of Wielkopolska (Poland). *Ann Agric Environ Med* 2009, **16**, 211–217.

6. Bitam I, Raoult D: Other tick-borne diseases in Europe. *Curr Probl Dermatol* 2009, **37**, 130–154.

7. Björsdorff A, Wittesjö B, Berglund J, Massung RF, Eliasson I: Human granulocytic ehrlichiosis as a common cause of tick-associated fever in southeast Sweden: report from a prospective clinical study. *Scand J Infect Dis* 2002, **34**, 187–191.

8. Brownstein JS, Skelly DK, Holford TR, Fish D: Forest fragmentation predicts local scale heterogenity of Lyme disease risk. *Oecologia* 2005, **146**, 469–475.

9. Buczek A, Czerny K, Łańcut M, Buczek L, Kuśmierz A, Olszewski K: Ultrastructural examination of rabbit skin after feeding of females *Ixodes ricinus* (L.) (Acari: Ixodida: Ixodidae). *Acta Parasitol* 2000, **45**, 216.

10. Buczek A, Lonc E: Density and activity of *Ixodes ricinus* (L.) in various habitats in Lower Silesia (Western Poland). *Acta Parasitol* 2000, **45**, 215.

11. Buczek A, Kuśmierz A, Olszewski K, Buczek L, Czerny K, Łańcut M: Comparison of rabbit skin changes after feeding of *Ixodes ricinus* (L.) and *Dermacentor reticulatus* (Fabr.). **In:** Bernini F, Nannelli R, Nuzzaci G, de Lillo E (Eds): *Acarid phylogeny and evolution: adaptation in mites and ticks. Proceedings of the IV Symposium of the European Association of Acarologists*, 419–424. Kluwer Acad Publ, Dordrecht 2002.

12. Buczek A, Rudek A, Bartosik K, Szymanska J, Wojcik-Fatla A: Seroepidemiological study of Lyme borreliosis among forestry workers in southern Poland. *Ann Agric Environ Med* 2009, **16**, 257–261.

13. Burri C, Dupasquier C, Bastic V, Gern L: Pathogens of emerging tick-borne siseases, *Anaplasma phagocytophilum*, *Rickettsia* spp., and *Babesia* spp., in *Ixodes* ticks collected from rodents at four sites in Switzerland (Canton of Bern). *Vector Borne Zoonotic Dis* 2011 Mar 21. [E-pub ahead of print]

14. Castelli E, Caputo V, Morello V, Tomasino RM: Local reactions to tick bites. *Am J Dermatopathol* 2008, **30**, 241–248.

15. Chmielewska-Badora J, Zwoliński J, Cisak E, Wójcik-Fatla A, Buczek A, Dutkiewicz J: Prevalence of *Anaplasma phagocytophilum* in *Ixodes ricinus* ticks determined by polymerase chain reaction with two pairs of primers detecting 16S rRNA and ankA genes. *Ann Agric Environ Med* 2007, **14**, 281–285.

16. Chmielewska-Badora J, Zwoliński J, Cisak E, Wójcik-Fatla A: Study on human anaplasmosis in forestry workers from the Lublin region in connection with environmental research. *Wiad Parazytol* 2007, **53 (Suppl)**, 137.

17. Cisak E, Chmielewska-Badora J, Dutkiewicz J, Zwoliński J: Preliminary studies on the relationship between *Ixodes ricinus* activity and tick-borne infection among occupationally-exposed inhabitants of eastern Poland. *Ann Agric Environ Med* 2001, **8**, 293–295.

18. Cisak E, Chmielewska-Badora J, Rajtar B, Zwoliński J, Jabłonski L, Dutkiewicz J: Study on the occurrence of *Borrelia burgdorferi* sensu lato and tick-borne encephalitis virus (TBEV) in ticks collected in Lublin region (eastern Poland). *Ann Agric Environ Med* 2002, **9**, 105–110.

19. Cisak E, Chmielewska-Badora J, Zwoliński J, Wójcik-Fatla A, Polak J, Dutkiewicz J: Risk of tick-borne bacterial diseases among workers of Roztocze National Park (southeastern Poland). *Ann Agric Environ Med* 2005, **12**, 127–132.

20. Daniel M, Kolar J, Zeman P, Pavelka K, Sadlo J: Predictive map of *Ixodes ricinus* high-incidence habitats and a tick-borne encephalitis risk assessment using satellite data. *Exp Appl Acarol* 1998, **22**, 417–433.

21. Daniel M, Kolár J, Zeman P, Pavelka K, Sádlo J: Tick-borne encephalitis and Lyme borreliosis: comparison of habitat risk assessments using satellite data (an experience from the Central Bohemian region of the Czech Republic). *Cent Eur J Public Health* 1999, **7**, 35–39.

22. Dautel H, Dippel C, Kämmer D, Werkhausen A, Kahl O: Winter activity of *Ixodes ricinus* in a Berlin forest. *Int J Med Microbiol* 2008, **298**, 50–54.

23. Di Renzi S, Martini A, Binazzi A, Marinaccio A, Vonesch N, D'Amico W, Moro T, Fiorentini C, Ciufolini MG, Visca P, Tomao P: Risk of acquiring tick-borne infections in forestry workers from Lazio, Italy. *Eur J Clin Microbiol Infect Dis* 2010, **29**, 1579–1581.

24. Dobracki W, Dobracka B, Paczosa W, Zięba J, Bereś P: Epidemiology of borreliosis in workers of the district forestry offices in Lower Silesia. *Przegl Epidemiol* 2007, **61**, 385–391.

25. Dróżdż J: Występowanie kleszczy z rodzaju *Dermacentor* w Polsce. *Wiad Parazytol* 1963, **9**, 57–60.

26. Duh D, Petrovec M, Trilar T, Avsic-Zupanic T: The molecular evidence of *Babesia microti* infection in small mammals collected in Slovenia. *Parasitology* 2003, **126**, 113–117.

27. Dutkiewicz J, Siuda K: Nowe ognisko kleszczy *Dermacentor pictus* Herm. w południowej Lubelszczyźnie. *Med Weter* 1969, **25**, 44–47.

28. Edlow JA: Tick paralysis. *Curr Treat Options Neurol* 2010, **12**, 167–177.

29. Estrada-Peña A, Jongejan F: Ticks feeding on humans: a review of records on human-biting Ixodoidea with special reference to pathogen transmission. *Exp Appl Acarol* 1999, **23**, 685–715.

30. Estrada-Peña A, Venzal JM, Sánchez Acedo C: The tick *Ixodes ricinus*: distribution and climate preferences in the western Palaearctic. *Med Vet Entomol* 2006, **20**, 189–197.

31. Ferquel E, Garnier M, Marie J, Bernède-Bauduin C, Baranton G, Pérez-Eid C, Postic D: Prevalence of *Borrelia burgdorferi* sensu lato and Anaplasmataceae members in *Ixodes ricinus* ticks in Alsace, a focus of Lyme borreliosis endemicity in France. *Appl Environ Microbiol* 2006, **72**, 3074–3078.

32. Franke J, Hildebrandt A, Meier F, Straube E, Dorn W: Prevalence of Lyme disease agents and several emerging pathogens in questing ticks from the German Baltic coast. *J Med Entomol* 2011, **48**, 441–444.

33. Gardiner WP, Gray JS: A computer simulation of the effects of specific environmental factors on the development of the sheep tick *Ixodes ricinus* L. *Vet Parasitol* 1986, **19**, 133–144.

34. Gassner F, van Vliet AJ, Burgers SL, Jacobs F, Verbaarschot P, Hovius EK, Mulder S, Verhulst NO, van Overbeek LS, Takken W: Geographic and temporal variations in population dynamics of *Ixodes ricinus* and associated *Borrelia* infections in The Netherlands. *Vector Borne Zoonotic Dis* 2010. [E-pub ahead of print]

35. Gäumann R, Růžek D, Mühlemann K, Strasser M, Beuret CM: Phylogenetic and virulence analysis of tick-borne encephalitis virus field isolates from Switzerland. *J Med Virol* 2011, **83**, 853–863.

36. Gigandet L, Stauffer E, Douet V, Rais O, Moret J, Gern L: Prevalence of three zoonotic *Babesia* species in *Ixodes ricinus* (Linné, 1758) nymphs in a suburban forest in Switzerland. *Vector Borne Zoonotic Dis* 2011, **11**, 363–366.

37. Główny Urząd Statystyczny, Departament Warunków Życia: *Ubóstwo w Polsce na tle krajów Unii Europejskiej w świetle Europejskiego Badania Dochodów i Warunków Życia – EU-SILC 2008. Materiał na konferencję prasową w dniu 28 stycznia 2010 r*. Available from: http://www.stat.gov.pl/cps/rde/xbcr/gus/PUBL_wz_Ubostwo_w_PL_na_tle_UE_EU-SILC_2008.pdf

38. Gray JS: The development and seasonal activity of the tick *Ixodes ricinus*: a vector of Lyme borreliosis. *Rev Med Vet Entomol* 1991, **79**, 323–333.

39. Gray JS, Kirstein F, Robertson JN, Stien J, Kahl O: *Borrelia burgdorferi* sensu lato in *Ixodes ricinus* and rodents in a recreational park in south-western Ireland. *Exp Appl Acarol* 1999, **23**, 717–729.

40. Gray JS, Dautel H, Estrada-Peña A, Kahl O, Lindgren E: Effects of climate change on ticks and tick-borne diseases in Europe. *Interdiscip Perspect Infect Dis* 2009, 593232.

41. Grzeszczuk A, Stańczak J, Kubica-Biernat B: Serological and molecular evidence of human granulocytic ehrlichiosis focus in the Białowieża Primeval Forest (Puszcza Białowieska), Northeastern Poland. *Eur J Clin Microbiol Infect Dis* 2002, **21**, 6–11.

42. Grzeszczuk A, Karbowiak G, Ziarko S, Kovalchuk O: The root-vole *Microtus oeconomus* (Pallas, 1776): a new potential reservoir of *Anaplasma phagocytophilum*. *Vector Borne Zoonotic Dis* 2006, **6**, 240–243.

43. Grzeszczuk A, Stańczak J: High prevalence of *Anaplasma phagocytophilum* infection in ticks removed from human skin in north-eastern Poland. *Ann Agric Environ Med* 2006, **13**, 1–4.

44. Grzeszczuk A, Ziarko S, Kovalchuk O, Stańczak J: Etiology of tick-borne febrile illnesses in adult residents of north-eastern Poland: report from a prospective clinical study. *Int J Med Microbiol* 2006, **296 (Suppl 1)**, 242–249.

45. Guglielmone AA, Beati L, Barros-Battesti DM, Labruna MB, Nava S, Venzal JM, Mangold AJ, Szabó, Martins JR, González-Acuñ D, Estrada-Peña A: Ticks (Ixodidae) on humans in South America. *Exp Appl Acarol* 2006, **40**, 83–100.

46. Han X, Aho M, Vene S, Peltomaa M, Vaheri A, Vapalahti O: Prevalence of tick-borne encephalitis virus in *Ixodes ricinus* ticks in Finland. *J Med Virol* 2001, **64**, 21–28.

47. Hubálek Z, Treml F, Halouzka J, Juricová Z, Hunady M, Janík V: Frequent isolation of *Francisella tularensis* from *Dermacentor reticulatus* ticks in an enzootic focus of tularaemia. *Med Vet Entomol* 1996, **10**, 241–246.

48. Hubálek Z, Halouzka J, Juricová Z, Sikutová S, Rudolf I: Effect of forest clearing on the abundance of *Ixodes ricinus* ticks and the prevalence of *Borrelia burgdorferi* s.l. *Med Vet Entomol* 2006, **20**, 166–172.

49. Hügli D, Moret J, Rais O, Moosmann Y, Erard P, Malinverni R, Gern L: Tick bites in a Lyme borreliosis highly endemic area in Switzerland. *Int J Med Microbiol* 2009, **299**, 155–160.

50. Humiczewska M: Ekologiczne uwarunkowania prewalencji kleszcza pospolitego *Ixodes ricinus* oraz zakażenie krętkami *Borrelia burgdorferi* na zachodnim wybrzeżu Bałtyku. **In:** Buczek A, Błaszak Cz (Ed): *Stawonogi. Różnorodność Form i Oddziaływań*, 225–233. Wydawnictwo Koliber, Lublin 2005.

51. Junttila J, Peltomaa M, Soini H, Marjamäki M, Viljanen MK: Prevalence of *Borrelia burgdorferi* in *Ixodes ricinus* ticks in urban recreational areas of Helsinki. *J Clin Microbiol* 1999, **37**, 1361–1365.

52. Kaiser R: The clinical and epidemiological profile of tick-borne encephalitis in southern Germany 1994–98: a prospective study of 656 patients. *Brain* 1999, **122**, 2067–2078.

53. Karbowiak G, Kiewra D: New locations of *Dermacentor reticulatus* ticks in Western Poland: the first evidence of the merge in *D. reticulatus* occurrence areas? *Wiad Parazytol* 2010, **56**, 333–336.

54. Kaya AD, Parlak AH, Ozturk CE, Behcet M: Seroprevalence of *Borrelia burgdorferi* infection among forestry workers and farmers in Duzce, north-western Turkey. *New Microbiol* 2008, **31**, 203–209.

55. Kislenko GS, Korotkov IuS, Shmakov LV: The meadow tick *Dermacentor reticulatus* in natural foci of tick-borne encephalitis in Udmurtia. *Parazitologiia* 1987, **21**, 730–735.

56. Klaus-Hügi C, Aeschlimann A, Papadopoulos B: Distribution, density and migration dynamics of *Ixodes ricinus* in an area of the Jurassic mountains of Switzerland. *Parassitologia* 2002, **44**, 73–82.

57. Kwiatkowska-Kawecka Z: Kleszcz pastwiskowy (*Ixodes ricinus* L.) jako pasożyt powieki ludzkiej. *Klin Oczna* 1964, **44**, 1293–1295.

58. Manfredi MT, Dini V, Piacenza S, Genchi C: Tick species parasitizing people in an area endemic for tick-borne diseases in north-western Italy. *Parassitologia* 1999, **41**, 555–560.

59. Maetzel D, Maier WA, Kampen H: *Borrelia burgdorferi* infection prevalence in questing *Ixodes ricinus* ticks (Acari: Ixodidae) in urban and suburban Bonn, western Germany. *Parasitol Res* 2005, **95**, 5–12.

60. Michalik J, Hofman T, Buczek A, Skoracki M, Sikora B: *Borrelia burgdorferi* s.l. in *Ixodes ricinus* (Acari: Ixodidae) ticks collected from vegetation and small rodents in recreational areas of the city of Poznań. *J Med Entomol* 2003, **40**, 690–697.

61. Moneret-Vantrin DA, Beaudouin E, Kanny G, Guerin L, Roche JF: Anaphylactic shock caused by ticks (*Ixodes ricinus*). *J Allergy Clin Immunol* 1998, **101**, 144–145.

62. Niścigorska J, Morańska I, Szych Z: Serological marker of *Borrelia burgdorferi* infection among forestry workers of West Pomerania region during a five year period. *Adv Agric Sci* 2004, **9**, 63–68.

63. Parola P, Rault D: Ticks and tickborne bacterial diseases in humans: an emerging infectious threat. *Clin Infect Dis* 2001, **32**, 897–928.

64. Pieniążek N, Sawczuk M, Skotarczak B: Molecular identification of *Babesia* parasites isolated from *Ixodes ricinus* ticks collected in north-western Poland. *J Parasitol* 2006, **92**, 32–35.

65. Rizzoli A, Rosà R, Mantelli B, Pecchioli E, Hauffe H, Tagliapietra V, Beninati T, Neteler M, Genchi C: *Ixodes ricinus*, transmitted diseases and reservoirs. *Parassitologia* 2004, 46, 119–122.

66. Rojko T, Ruzic-Sabljic E, Strle F, Lotric-Furlan S: Prevalence and incidence of Lyme borreliosis among Slovene forestry workers during the period of tick activity. *Wien Klin Wochenschr* 2005, **117**, 219–225.

67. Santino I, Cammarata E, Franco S, Galdiero F, Oliva B, Sessa R, Cipriani P, Tempera G, Del Piano M: Multicentric study of seroprevalence of *Borrelia burgdorferi* and *Anaplasma phagocytophila* in high-risk groups in regions of central and southern Italy. *Int J Immunopathol Pharmacol* 2004, **17**, 219–223.

68. Sawczuk M, Maciejewska A, Adamska M, Skotarczak B: Roe deer (*Capreolus capreolus*) and red deer (*Cervus elaphus*) as reservoir of protozoan from *Babesia* and *Theileria* genus in north-western Poland. *Wiad Parazytol* 2005, **51**, 243–247.

69. Siński E, Karbowiak G, Siuda K, Buczek A, Jongejan F: Zakażenie kleszczy *Borrelia burgdorferi* w wybranych rejonach Polski. *Przegl Epidemiol* 1994, **48**, 461–465.

70. Siński E, Bajer A, Welc R, Pawełczyk A, Ogrzewalska M, Behnke JM: *Babesia microti*: prevalence in wild rodents and *Ixodes ricinus* ticks from the Mazury Lakes District of north-eastern Poland. *Int J Med Microbiol* 2006, **296 (Suppl)**, 137–143.

71. Siński E, Pawełczyk A, Bajer A, Behnke JM: Abundance of wild rodents, ticks and environmental risk of Lyme borreliosis: a longitudinal study in an area of Mazury Lakes district of Poland. *Ann Agric Environ Med* 2006, **13**, 295–300.

72. Siuda K: *Kleszcze (Acari: Ixodida) Polski. Część II. Systematyka i Rozmieszczenie*. Monogr Parazytol, PTP, Warsaw 1993.

73. Stanek G: Tick-transmitted diseases in Central Europe. *Wien Klin Wochenschr* 2002, **114**, 471–472.

74. Stańczak J, Racewicz M, Kubica-Biernat B, Kruminis-Lozowska W, Dabrowski J, Adamczyk A, Markowska M: Prevalence of *Borrelia burgdorferi* sensu lato in *Ixodes ricinus* ticks (Acari, Ixodidae) in different Polish woodlands. *Ann Agric Environ Med* 1999, **6**, 127–132.

75. Stańczak J, Gabre RM, Krumis-Łozowska W, Racewicz M, Kubica-Biernat B: *Ixodes riicnus* as a vector of *Borrelia burgdoreri* sensu lato, *Anaplasma phagocytophilum* and *Babesia microti* in urban and suburban forests. *Ann Agric Environ Med* 2004, **11**, 109–114.

76. Stańczak J, Racewicz M, Michalik J, Buczek A: Distribution of *Rickettsia helvetica* in *Ixodes ricinus* tick populations in Poland. *Int J Med Microbiol* 2008, **298**, 231–234.

77. Thorin C, Rigaud E, Capek I, André-Fontaine G, Oster B, Gastinger G, Abadia G: Seroprevalence of Lyme borreliosis and tick-borne encephalitis in workers at risk, in Eastern France. *Med Mal Infect* 2008, **38**, 533–542.

78. Tomasiewicz K, Modrzewska R, Buczek A, Stańczak J, Maciukajć J: The risk of exposure to *Anaplasma phagocytophilum* infection in Mid-Eastern Poland. *Ann Agric Environ Med* 2004, **11**, 261–264.

79. Vatansever Z, Gargili A, Aysul NS, Sengoz G, Estrada-Peña A: Ticks biting humans in the urban area of Istambul. *Parasitol Res* 2008, **102**, 551–553.

80. Wegner Z, Racewicz M, Kubica-Biernat B, Kruminis-Łozowska W, Stańczak J: Występowanie kleszczy *Ixodes ricinus* (Acari, Ixodidae) na zalesionych obszarach Trójmiasta i ich zakażenie krętkami *Borrelia burgdorferi*. *Przegl Epidemiol* 1997, **51**, 1–2.

81. Wójcik-Fatla A, Cisak E, Chmielewska-Badora J, Zwoliński J, Buczek A, Dutkiewicz J: Prevalence of *Babesia microti* in *Ixodes ricinus* ticks from Lublin region (eastern Poland). *Ann Agric Environ Med* 2006, **13**, 319–322.

82. Wójcik-Fatla A, Szymańska J, Wdowiak L, Buczek A, Dutkiewicz J: Coincidence of three pathogens (*Borrelia burgdorferi* sensu lato, *Anaplasma phagocytophilum* and *Babesia microti*) in *Ixodes ricinus* ticks in the Lublin macroregion. *Ann Agric Environ Med* 2009, **16**, 151–158.

83. Zahler M, Gothe R, Rinder H: *Dermacentor* ticks in France and Germany. Molecular biological differences in species, ecology and epidemiological implications. *Tierarztl Prax* 1996, **24**, 209–211.