ALICJA BUCZEK, KATARZYNA BARTOSIK

Kleszcze (*Ixodida: Ixodidae, Amblyommidae*) w południowo-wschodniej Polsce z uwzględnieniem ich znaczenia medycznego i epidemiologicznego

Streszczenie

Wstęp. Kleszcze należą do najważniejszych wektorów licznych drobnoustrojów chorobotwórczych dla człowieka i zwierząt. Rola tych stawonogów w utrzymywaniu i przenoszeniu patogenów uzasadnia potrzebę identyfikacji gatunków występujących na obszarze województwa lubelskiego.

Cel. Praca miała na celu podsumowanie wyników badań własnych i danych literaturowych dotyczących występowania kleszczy właściwych (*Ixodidae, Amblyommidae*) oraz ich znaczenia medycznego i epidemiologicznego w województwie lubelskim (południowo-wschodnia Polska).

Materiał i metody. Nasze badania prowadzone były w latach 1998-2010 w siedliskach kleszczy na obszarze województwa lubelskiego. Do zbioru kleszczy wykorzystano metodę flagową polegającą na omiataniu roślin flanelową flagą o wymiarach 1x1m. Zebrane kleszcze konserwowano w 70% ETOH, a następnie oznaczano gatunek i stadium rozwojowe w oparciu o klucze opracowane przez Filippovą i Siudę.

Wyniki. Dotychczas na badanym obszarze stwierdzono 6 gatunków kleszczy, tj. *Ixodes (Ixodes) ricinus*, *I. (I.) apronophorus*, *I. (E.) trianguliceps*, *I. (Ph.) hexagonus*, *I. (Ph.) crenulatus* i *D. (D.) reticulatus* uznanych za stały element fauny oraz dwa gatunki – *Haemaphysalis punctata (A.)* i *Rhipicephalus (Rh.) rossicus* zawleczone ze zwierzętami z innych części kontynentu.

Wnioski. Położenie geograficzne i ukształtowanie terenu województwa lubelskiego oraz wpływ mas powietrza kontynentalnego sugerują, że na tym obszarze mogą być znajdowane inne gatunki bytujące w cieplejszym klimacie. Dane na temat fauny kleszczy na badanym obszarze mogą przyczynić sie do skuteczniejszego przewidywania występowania ognisk chorób odkleszczowych. Słabo poznana fauna południowo-wschodniej Polski wskazuje na konieczność prowadzenia dalszych badań nad składem gatunkowym i rozprzestrzenieniem kleszczy.

Słowa kluczowe: fauna kleszczy, południowo-wschodnia Polska, *Ixodes ricinus*, *Ixodes apronophorus*, *Ixodes trianguliceps*, *Ixodes hexagonus, Ixodes crenulatus, Dermacentor reticulatus.*

Ticks (*Ixodida: Ixodidae, Amblyommidae*) in south-eastern Poland and their medical and epidemiological importance

Abstract

Introduction. Ixodid ticks are the major vectors of pathogens threatening animal and human health. The important role of those arthropods in maintaining and transmitting tick-borne pathogens reinforces the need to establish the tick species that occur in the Lublin province.

Aim. The aim of the study was to summarize the results of our own investigations and literature data on the occurrence of ixodid ticks (*Ixodidae, Amblyommidae*) and their medical and epidemiological importance in the Lublin Province (southeastern Poland).

Material and methods. Our studies were conducted in 1998-2010 in different sites located in Lublin Province. Ticks were collected using the flagging method, which involved sweeping the vegetation with a 1x1m white cloth. The collected tick specimens were preserved in 70% ETOH and identified to the species and the gender using a key developed by Filippova as well as by Siuda.

Results. The results show that six species of ixodid ticks have been reported so far in this region: *Ixodes (Ixodes) ricinus*, *I. (I.) apronophorus*, *I. (E.) trianguliceps*, *I. (Ph.) hexagonus*, *I. (Ph.) crenulatus* and *D. (D.) reticulatus*, which are considered as a permanent element of the fauna. Two other species – *Haemaphysalis punctata (A.)* and *Rhipicephalus (Rh.) rossicus* – have been brought by animals from other parts of the continent.

Conclusions. The geographic location and topography of the Lublin Province as well as the influence of the continental air masses suggest that tick species from warmer climatic zones may also be found here. Data on tick prevalence in the area under study may improve our ability to predict human outbreaks of vector-borne zoonoses. The poor knowledge of the fauna in south-eastern Poland necessitates further research into the tick species composition and distribution.

Key words: tick fauna, south-eastern Poland, *Ixodes ricinus*, *Ixodes apronophorus*, *Ixodes trianguliceps*, *Ixodes hexagonus, Ixodes crenulatus, Dermacentor reticulatus.*

Chair and Department of Biology and Parasitology, Medical University of Lublin

INTRODUCTION

Ticks are haematophagic arthropods, whose all extraembryonic stages infest various species of terrestial vertebrates. Some of them may parasite the human [1]. Tick saliva, which is rich in bioactive substances, may stimulate local and systemic reactions when it is introduced to the host during feeding. Ticks are also vectors of many pathogens of tick-borne diseases in humans and animals, and thus they contribute to substantial economic losses.

Ticks species occurring in Poland are adapted to the temperate climate; occasionally birds, mammals or reptiles bring ticks from warmer zones from various regions of the world.

Tick fauna has not been extensively investigated in some parts of Poland. For instance, the south-eastern part of the country is one of the poorly examined regions in this respect. Therefore, this paper is an attempt to summarize the hitherto conducted studies of tick occurrence in the Lublin Province and to present new tick localities that have been found during 13-year-long studies of tick ecology and biology carried out at the Chair and Department of Biology and Parasitology at the Medical University in Lublin.

AIM

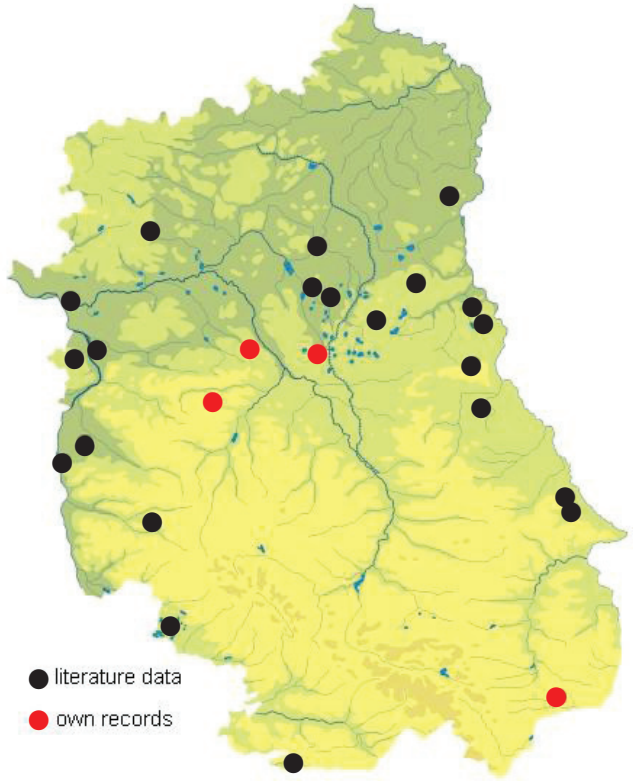
The aim of the study was to summarize the results of our own investigations and literature data on the occurrence of ixodid ticks (*Ixodidae, Amblyommidae*) and their medical and epidemiological importance in the Lublin Province (south-eastern Poland).

MATERIAL AND METHODS

Study area

The Lublin Province (25 122 km^2 area) is located in south-eastern Poland between the Vistula and Bug Rivers. The Lublin Upland occupies the central and south-eastern part of the province, and borders the Volhyn Upland in the east. The Roztocze Range extends in the south-east (from Kraśnik to Hrebenne) and descends towards the Sandomierz Basin. North of the Lublin Upland, there are lowlands and plains of the Polesie Lubelskie and Południowopodlaska Lowland. Approximately 21.7% of the province area is covered by forests; the largest forested areas are situated in the Counties of Janów (38.1%), Biłgoraj (37.9%) and Włodawa (37.3%). Coniferous trees are predominant in this area (ca. 75%). The biggest forest complexes in the Lubelszczyzna region are the Solska Primaeval Forest as well as Janowskie, Parczewskie, and Włodawskie Forests.

The climate of the Lublin Province is determined by conflicting oceanic and continental air masses. It is characterized by considerable fluctuations of the annual temperature, hot summers, freezing winters, and moderate precipitation. The annual precipitation ranges from 550 to 650 mm. The length of the vegetation period ranges from 205 to 210 days.



● sites documented in the literature cited, ● according to L. Buczek, A. Buczek, M. Roczeń-Karczmarz, K. Bartosik and D. Bzowski.

FIGURE 1. Sites of *Dermacentor reticulatus* documented in Lublin Province.

Tick collection

Several new localities were found during the search for material for laboratory examinations of tick biology and during the field study of ecology of these arthropods. Ticks were collected with the flagging method of catching unfed specimens from vegetation. A 1m^2 flannel cloth was used to sweep the vegetation and the ticks attached to it were transferred to test tubes. The tick species and the developmental stage were identified in the laboratory. Specimens that were not used in the investigations of tick biology were preserved in 70% EtOH. Specimens described in the new localities were collected from domestic and wild-living animals. They were preserved in 70% EtOH. Available keys [2,3] were used for identification of the tick species and the developmental stage.

RESULTS AND DISCUSSION

So far, six species of ixodid ticks, including five species from the genus *Ixodes* and one species from the genus Dermacentor, have been found in the Lublin Province. Additionally, there were two species introduced from other regions, i.e. *Haemaphysalis* (*A.*) *punctata* and *Rhipicephalus* (*Rh.*) *rossicus*.

The family Ixodidae

***Ixodes (Ixodes) ricinus* (Linnaeus, 1758) – the castor bean tick**

This is a *non-nidicolous* species occurring across south-eastern Poland, both in urban agglomerations and other environments. It was collected in localities characterized by

32-89% humidity and temperature ranging from 12 to 23°C [4]. The abundance of *I. ricinus* varied substantially between the study localities; the highest was reported from Kozłowieckie Forests (42 specimens/1 h of collection), and lower from Star Uścimów area (2.5 specimens/1 h of collection) [5].

Siuda [3] in the monograph described numerous localities of the species in the Lublin Province. As indicated by our observations and information provided by the inhabitants of the Lublin Province, *I. ricinus* ticks occur across the region. In literature, the following sites of tick collection have been mentioned: the surroundings of Lubycza Królewska (own observations), Ostrów Lubelski, Dys, Sosnowica (Parczewskie Forests), Józefów (Solska Primaveral Forest), Zwierzyniec (the Roztoczański National Park), Stary Uścimów (Łęczyńsko-Włodawskie Lakeland) and Majdan Kozłowiecki (Kozłowieckie Forests) [5], Zemborzyce (Dąbrowa Forest) [6, own observations], Lublin, Jakubowice Murowane [7] and in Gułowskie Forests [8].

I. ricinus ticks used in our laboratory investigations of tick biology were collected in Nałęczów, Kazimierz Dolny, Puławy, surroundings of Lublin and Lubartów, Horyniec Zdrój and in many localities in Roztocze and Polesie Lubelskie.

I. ricinus feeds on many domestic and wild-living animals [e.g. 3, 9-11]. This species attacks humans in Europe most frequently [1]. As many as 44% of patients of the surveyed Lublin Province clinics present with local and systemic symptoms produced by various arthropod bites (black flies, mosquitoes, ticks) had been attacked by *I. ricinus* [5]. Upon infestation with *I. ricinus* females, large and intense histological changes in host's dermis and epidermis were reported. Thinned epidermis with effaced cellular structures and covered by scales lay on the smooth basement membrane. Non-specific cell infiltrations with abscesses surrounded by predominantly eosinophils, macrophages and lymphocytes were visible in the dermis. Thick, fragmented basement membranes of irregular hair follicles, the internal structure of which was completely obliterated, were characteristic for histological images [12]. Ultrastructural examination of skin sections demonstrated severe cytological changes (chromatin condensation at the periphery of the nucleus, presence of large nucleoli and nuclear bodies, widening of the outer nuclear layer, numerous vacuoles and granules), indicating damage and metabolic disorder in the cells [13].

The following pathogens have been so far detected in the *I. ricinus* collected in south-eastern Poland: the tick-borne encephalitis virus, *Borrelia burgdorferi*, *Anaplasma phagocytophilum*, *Babesia microti* and *Toxoplasma gondii*. The degree of infection of ticks with these pathogens varied greatly, depending on the habitat and year of study. Borrelia burgdorferi spirochetes were the most frequently identified pathogens; they were found in 2.0- 12.7% of the ticks [6,14]. There were localities where the prevalence of spirochetes in ticks reached 22.25% [14]. From 0.7 to 10.2% of *I. ricinus* ticks in the Lublin Province were infected with *Anaplasma phagocytophilum* [6,15], and 0.4 - 6.6% with the protozoan *Babesia microti* [6]. The TBE virus was found in 1.6-4.2% of ticks [16,17]. DNA of *Toxoplasma gondii* was detected in 2.8-12.6 % of *I. ricinus* [18,19].

***Ixodes (Exopalpiger) trianguliceps* Birula, 1895 – the vole tick**

This is a non-*nidicolous species* [2], which lives in humid habitats, mainly in mixed and deciduous forests; it can be found in areas where rodents appear on soil litter, on the soil surface at the entrances to burrows of small mammals and on the lower level of the groundcover [3].

In south-eastern Poland, localities of this species have been reported in Radzyń Podlaski and Hrubieszów [20].

The hosts of adult stages include small mammals: the mole, velvet shrew, Laxmann's shrew, pygmy shrew, mountain shrew, Eurasian water shrew, Mediterranean water shrew, greater mouse-eared bat, bank vole, European water Vole, European pine vole, *Microtus* sp., European snow vole, field vole, common vole, house mouse, harvest mouse, striped field mouse, yellow-necked mouse, wood mouse, pygmy field mouse, and northern birch mouse.

Adult stages most often attack voles and mice, whereas larvae mainly parasitize insectivores and voles.

This tick species has not been investigated in terms of pathogen infection in south-eastern Poland; however, according to Lachmajer [21,22] and Filippova [2], it may transmit the virus of tick-borne encephalitis among small mammals. It is also a vector of *Anaplasma phagocytophilum* and *Babesia microti* [23].

***Ixodes (Pholeoixodes) hexagonus* Leach, 1985 – the hedgehog tick**

The tick is a nidicolous and burrow- inhabiting species living in dens, caves and rock shelters. Its localities in the Lubelszczyzna region are situated in Machnów, Niemirówek and Rachanie [24].

I. hexagonus usually parasitizes medium-sized and large mammals, which have permanent dwelling, e.g. carnivores [25], but may also attack humans [26].

It transmits the virus of tick-borne encephalitis, mainly among hedgehogs from suburban and urban populations, and may play a role in the circulation of *Borrelia burgdorferi* [27, 28] and *Theileria annae* [29] in nature.

***Ixodes (Pholeoixodes) crenulatus* Koch, 1844- the fox tick**

The tick is a nidicolous and burrow-inhabiting species living in burrows of rodents and carnivorous mammals, deep burrow corridors providing insignificant microclimatic fluctuations and in caves. Up to date, in south-eastern Poland, the species has only been reported from Roztocze by Zwolski [24].

The tick parasitizes insectivorous mammals, rodents and carnivorous mammals; most frequently, it infests marmots and carnivorous mammals – usually foxes and badgers [3], and domestic and livestock animals (sheep, dogs and horses). It may also attack humans [2].

The epidemiologic role of the tick in Poland has not been investigated so far. According to Fillipova [2], it may be a vector of the plague bacillus (*Yersinia pestis*) and Q fever rickettsiae (*Coxiella burnetii*).

***Ixodes (Ixodes) apronophorus* Schulze, 1924 – the marsh tick**

The tick is a nidicolous and burrow-inhabiting species living in nests and burrows of mammals on wetlands. Up to date, in south-eastern Poland, it has only been reported from Niemirówek [24].

The hosts of *I. apronophorus* include mammals, rodents, insectivores and small carnivorous mammals, and less frequently wetland birds. In Poland, the species primarily parasitizes the velvet vole, Eurasian water shrew, Eurasian beaver, bank vole, *Microtus* sp., and root vole [3,9,24].

According to Fillipova [2], the species transmits *Francisella tularensis bacilli*, the Omsk hemorrhagic fever virus (OHFV) and *Rickettsia sibrica* and *Coxiella burnetii* rickettsiae among burrowing mammals. The role of this tick species in transmission and maintenance of pathogens has not been investigated in Poland.

The family *Amblyommidae*

***Dermacentor (Dermacentor) reticulatus (*Fabricius 1794*) – the ornate cow tick**

In terms of geographical distribution, *D. reticulatus* is the second species after *I. ricinus* in south-eastern Poland. It inhabits forest meadows, pastures, and river valleys. Dutkiewicz and Siuda [30], and Szymański [31] reported its occurrence in the Pobuże Basin, in marsh areas and forests on the Sołokija River between the villages of Machnów, Kornie and Wierzbica (Pobuże centre).

In the southern part of the Polesie Lubelskie (Polesie centre), the species was found by Szymański [31] in the Parczewskie Forests; near Makoszka and Uhnin; in the area between the Bug river in the east, the eastern edge of Krowie Bagno in the west, the Hanna river valley and in the north and Pagórki Chełmskie in the south (the villages of Stulno, Zbereże, Żłóbek, Osowa, Kosyń, Macoszyn, Kołacze, Suchawa, Wyrki, Kaplonosy, Żuków, Krasówka, Mosty and Holeszów). After many years, Biaduń et al. [32] collected D. reticulatus in this focus in the Parczewskie Forests; Makoszka village; Gułowskie forests (region of Łuków); Kozłowieckie Forests (near Nowy Staw, Wandzin and Lubartów), the Kurówka river valley (Vistula tributary); north of Puławy and in the Vistula river valley north of Góra Puławska (near Puławy). Additionally, *D. reticulatus* was collected in Okuninka and Tarasiuki, from vegetation on the Glinki and Orchowo lakes, from grazing cows on Lake Glinki, and in a forest east of Sawin-Borek [3].

Within the so-called Hrubieszów centre, *D. reticulatus* was collected on forest meadows in the Strzeleckie Forests north of Hrubieszów (Strzelce, the Chełm Province), and in the Bug river valley between Matcze and Skryhiczyn (Siuda 1993). Two males of this species were removed from cow's skin near Puławy [3].

Adult stages used in our study of *D. reticulatus* morphology, biology and medical importance were collected in the following localities: Ostrów Lubelski (leg. L. Buczek, IX 1998), Sosnowica, Stary Uścimów C (Polesie Lubelskie) (leg. L. Buczek, IV 1999, V 2000; leg. M. Roczeń-Karczmarz, IV 2003), near Lubycza Królewska (leg. K. Bartosik and D. Bzowski, III 2000) and in Lubartów (leg. A. Buczek, V. 2010 r.). A *D. reticulatus* female was found on a dog in a Lublin district situated near the Zemborzycki lake (leg. K. Bartosik, V 2009). Figure 1 presents the documented localities of *D. reticulatus* in the Lublin Province.

Adult *D. reticulatus* parasitize on large mammals, particularly on Cervidae – Eurasian elk (*Alces alces*), red deer (*Cervus elaphus*), and fallow deer (*Dama dama*), whereas the immature stages on small mammals- representatives of Murinae, Microtinae and Soricidae [3]. It is assumed that this species does not infest humans. During the long-term studies carried out in the Lublin Province, we have recorded only one instance of a *D. reticulatus* female being attached to man's skin. Since the tick was immediately removed from the skin, it is not obvious whether it would feed on the host [5].

Histopathological examinations of host's skin revealed epidermal and dermal lesions. Epidermal thinning, accompanied by reduction of cell layers, and focal erosion of the epidermis were visible. The germ layer had an irregular shape and arrangement of nuclei; it also exhibited intracellular oedema. Inflammatory cell infiltration with numerous eosinophils, focal necrosis, and lipid accumulation were observed in the dermis cells. Ultrastructural studies have shown profound lesions at the cellular level [12].

DNA of Babesia microti was isolated from females of *D. reticulatus* collected from vegetation near Ostrów Lubelski (unpublished data). No *Borrelia burgdorferi* spirochetes were detected in the specimens from that area (unpublished data). The TBEV infection rate in *D. reticulatus* from Lublin is 10.8% [17].

***Haemaphysalis (Aboimisalis) punctata* Canestrini et Fanzago, 1877 – the red sheep tick**

This non-nidicolous tick species inhabits a variety of habitats at forest's edges, or semi-desert and desert environments. It occurs, e.g. in Ukraine, Byelorussia, Moldova, and Russia (North Caucasus, Kalmykia, and Astrakhan Oblast), therefore, there is high probability that it has been introduced to eastern Poland by birds. This was reported from Lublin by Lachmajer et al. [22], who found four females, two males and one nymph of *H. punctata* on a great black-backed gull that had been banded in Moscow.

The principal hosts of adults mainly are large, livestock mammals. In turn, immature ticks parasitize birds, but they occasionally may infest small mammals, including hares. Adults are active in spring and autumn, but immature ticks parasitize their hosts in summer. The species is a vector of tularemia, Lyme disease, tick-borne rickettsiosis, and other diseases [33].

***Rhipicephalus (Rhipicephalus) rossicus* Jakimov et Kohls-Jakimova, 1911**

This tick is a non-nidicolous species and has a wide host range. Adult *R. rossicus* stages parasitize many species of large and small mammals, most often livestock, carnivores, hares, hedgehogs, and hamsters. They may attack humans as

well. Immature ticks feed on small mammals and, less frequently, on birds.

In the Lublin Province, the species was found on a cow in Machnów (Dutkiewicz and Siuda 1969). It has probably been introduced to Poland. The occurrence of *R. rossicus* in Ukraine, a neighbour of the Lublin Province, and in other countries of Eastern (Russia) and Central (Bulgaria, Romania, Moldavia) Europe poses substantial threat of introduction of these ticks to the regions of eastern Poland.

Adult *R. rossicus* stages are active in the warm season of the year, and the peak of their activity is recorded from May to June. In Ukraine and the Volga region, larvae are active in a similar period as adults. Their highest activity is recorded from May to June and in August. Most frequently, nymphs attack rodents from June to July. This tick species is a vector of Crimean-Congo hemorrhagic fever and tularemia [35].

It is evident from the literature review that the tick species composition in south-eastern Poland is poorly recognized. No research on the tick fauna had been carried out in this region for over 25 years. After this period, information on the presence of these arthropods was obtained in other investigations, e.g. studies of tick ecology and biology and prevalence of pathogen infection in ticks. The geographical location, topography and climatic conditions prevailing in the region promote emergence of other tick species. The extreme epidemiological importance of ticks justifies the necessity of conducting faunistic investigations in this part of Poland.

REFERENCES

1. 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(9):685-715.
2. Filippova NA. Iksodowyje kleszczy podsiem. Ixodinae.- Fauna SSSR. Paukoobraznyje 4, 3. Moskwa: Nauka; 1977.
3. Siuda K. Ticks of Poland (Acari: Ixodida). Part II. Systematics and distribution. Warsaw: Polskie Towarzystwo Parazytologiczne; 1993 (in Polish).
4. Bartosik K, Szymańska J, Buczek A. Risk to human health posed by *Ixodes ricinus* ticks in relation to diagnostic and therapeutic possibilities in south-eastern Poland. Zdr Publ. 2011a;121(4):263-6.
5. Bartosik K, Sitarz M, Szymańska J, Buczek A. Tick bites on humans in the agricultural and recreational areas in south-eastern Poland. Ann Agric Environ Med. 2011;18(1):151-7.
6. 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(1): 151-8.
7. Biaduń W. Habitat preferences of the common tick *Ixodes ricinus* L. in Lublin region. Wiad Parazytol. 2008;54(2):117-22 (inPolish).
8. Biaduń W, Krasnodębski S. Occurrence of the common tick *Ixodes ricinus* L. in environments of various degree and character of anthropogenic impact. Wiad Parazytol. 2007;53(2):133-7 (inPolish).
9. Kadulski, S. The occurrence of parasitic arthropods on the game Lagomorpha and Artiodactyla of Poland - a trial synthesis. Zeszyty Naukowe Uniwesytetu Gdańskiego. Rozprawy i Monografie. 1989;132;1-140 (in Polish).
10. 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(2):295-300.
11. 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 recteational areas of the city of Poznań. J Med Entomol. 2003;40(5):690-7.
12. 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: BF et al., eds. Acarid Phylogeny and Evolution: Adaptation in Mites and Ticks. Dortrecht: Kulwer Academic Publisher; 2002. p.419-24.
13. 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.
14. Siński E, Karbowiak G, Siuda K, Buczek A, Jongejan F. *Borrelia burgdorferi* infection of ticks in some regions of Poland. Przegl Epidemiol. 1994;48(4):461-5 (in Polish).
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(2):281-5.
16. 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(1):105-10.
17. Wójcik-Fatla A, Cisak E, Zając V, Zwoliński J, Dutkiewicz J. Prevalence of tick-borne encephalitis virus in *Ixodes ricinus* and *Dermacentor reticulatus* ticks collected from the Lublin region (eastern Poland). Ticks Tick Borne Dis. 2011;2(1):16-9.
18. Sroka J, Chmielewska-Badora J, Dutkiewicz J. *Ixodes ricinus* as a potential vector of *Toxoplasma gondii*. Ann Agric Environ Med. 2003;10(1):121-3.
19. Sroka J, Szymanska J, Wojcik-Fatla A. The occurrence of *Toxoplasma gondii* and *Borrelia burgdorferi* sensu lato in *Ixodes ricinus* ticks from east Poland with the use of pcr. Ann Agric Environ Med. 2009;16(2):313-9.
20. Bitkowska E, Żukowski K. Roztocze drobnych ssaków niektórych okolic północnej i wschodniej Polski (Acari: Ixodides, Mesostigmata, Trombidiformes, Sarcoptiformes). Fragm Faun. 1975;20(18):307-27 (in Polish).
21. Lachmajer J. The ecology of the tick *Ixodes trianguliceps* Bir., 1895. Biul Inst Med Morsk Gdańsk. 1962;13:149-60.
22. Lachmajer J. Potential harmfulness of ticks from the genus Ixodoidea in Poland. Wiad Parazytol. 1965;11 (Suppl.):171-7 (in Polish).
23. Bown KJ, Lambin X, Telford GR, Ogden NH, Telfer S, Woldehiwet Z, Birtles RJ. Relative importance of *Ixodes ricinus* and *Ixodes trianguliceps* as vectors for *Anaplasma phagocytophilum* and *Babesia microti* in field vole (*Microtus agrestis*) populations. Appl Exp Microbiol. 2008;74(23):7118-25.
24. Zwolski W. Studies upon ectoparasitic fauna of small mammals in natural foci of mud fever. Wiad Parazytol. 1960;6:519-27 (in Polish).
25. Jaenson GT, Tällekint L, Lundqvist L, Olsen B, Chirico J, Mejlon H. Geographical distribution, host associations, and vector roles of ticks (Acari: Ixodidae, Argasidae) in Sweden. J Med Entomol. 1993;31(2):240-56.
26. Carter WI. A case of human parasitization by *Ixodes hexagonus*, Leach (Hedgehog tick). Brit Med J.1955;2(4940):1012.
27. Gern L, Toutoungi LN, Hu CM, Aeschlimann A. *Ixodes (Pholeoixodes) hexagonus*, an efficient vector of *Borrelia burgdorferi* in the laboratory. Med Vet Entomol. 1991;5(4):431-5.
28. Gern L, Rouvinez E, Toutoungi LN, Godfroid E. Transmission cycles of *Borrelia burgdorferi sensu lato* involving *Ixodes ricinus* and/or *I. hexagonus* and the European hedgehog, *Erinaceus europaeus*, in suburban and urban areas in Switzerland. Folia Parasitol. 1997;44(4):309-14.
29. Camacho AT, Pallas E, Gestal JJ, Guitián FJ, Olmeda AS, Telford III SR, Spielman A. *Ixodes hexagonus* is the main candidate as vector of *Theileria annae* in northwest Spain. Vet Parasitol. 2003;112(1-2):157-63.
30. Dutkiewicz J, Siuda K. Nowe stanowisko kleszczy *Dermacentor pictus* Herm. w południowej Lubelszczyźnie. Med Wet. 1969;25:44-7.
31. Szymański S. Distribution of the tick *Dermacentor reticulatus* (Fabricius, 1794) (Ixodidae) in Poland. Acta Parasitol Pol. 1986;31;143-54.
32. Biaduń W, Chybowski J, Najda N. A new records of *Dermacentor reticulatus* (Fabricius, 1794) in Lublin region. Wiad Parazytol. 2007;53(1):29-32 (in Polish).

33. Hoogstraal H, Valdez R. Ticks (Ixodoidea) from wild sheep and goats in Iran and medical and veterinary implications. Fieldiana Zool. 1980;6:13-6.
34. Dutkiewicz J, Siuda K. *Rhipicephalus rossicus* Jakimov et Kohl-Jakimova, 1911- nowy dla fauny Polski rodzaj i gatunek kleszcza (Acarina, Ixodidae). Fragm Faun. 1969;15(8):99-105.
35. Walker JB, Keirans JE, Horak IG. The Genus *Rhipicephalus* (Acari, Ixodidae). A Guide to the Brown Ticks of the World. Cambridge Univ. Press; 2000. p.643.

Informacje o Autorkach
Prof. dr hab. Alicja Buczek – kierownik, Katedra i Zakład Biologii i Parazytologii, Uniwersytet Medyczny w Lublinie; dr n. med. Katarzyna Bartosik – adiunkt, Katedra i Zakład Biologii i Parazytologii, Uniwersytet Medyczny w Lublinie.

Adres do korespondencji
Alicja Buczek
ul. Radziwiłłowska 11, 20-080 Lublin
e-mail:alicja.buczek@umlub.pl