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PATHOGENS OF HUMAN AND ANIMAL INFECTIOUS DISEASES AND THEIR SPREAD IN EUROPE BY THE IXODID TICK DERMACENTOR RETICULATUS

Due to climate change, the possibility of human infective diseases caused by pathogens from the genera Borelia, Anaplasma, Rickettsia, Babesia, Bartonella, Coxiella, etc. is increasing in Europe. Generally, these pathogens are directly related to arthropod vectors, in particular, to Ixodes ticks. The aim of the study was to determine the current trends in the spread of tick-borne infections transmitted by Dermacentor reticulatus ticks in some European countries, including Ukraine, based on the analysis of literature. Over the past 10 years, in the vast majority of countries, including Europe, the situation with the defeat of farm and wild animals, as well as humans, by pathogens of severe infectious diseases from the genera Borrelia, Anaplasma, Rickettsia, Babesia, Theileria, Coxiella, Bartonella, Francisella, etc. has been aggravated. Representatives of these genera lead to severe diseases, such as tick-borne borreliosis, which are accompanied by damage to the central nervous system, joints, skin, and cardiovascular system. Members of the Rickettsiales genus cause a variety of feverish conditions in animals and humans. Species of the genus Babesia cause babesiosis, a disease caused by damage to red blood cells and the appearance of anti-erythrocyte antibodies, and representatives of the genus Toxoplasma cause toxoplasmosis, accompanied by damage to the nervous, lymphatic, and cardiovascular systems. Q fever is caused by species of the genus Coxiella. Severe human diseases are caused by tick-borne encephalitis viruses. Various PCR test systems have been developed and used to detect these pathogens. For example, in Poland, PCR for Borrelia burgdorferi s.l. was performed using the B. burgdorferi s.l. PCR kit (GeneProof, Czech Republic) for in vitro diagnosis. Anaplasma PCR kits (Blirt-DNA Gdańsk, Poland) were used to detect Anaplasma phagocytophilum DNA. For the detection of Babesia spp., a fragment of the 18S rDNA gene encoding a small ribosomal subunit localized in the conserved region V4 was used. To detect Bartonella spp., the tests Hum PCR Bartonella, Hum PCR Coxiella burnetii, and Vet PCR Rickettsia kit (BioIngenTech, Chile), Coxiella burnetii and Rickettsia spp. were used. In the Laboratory for the Study of Ticks and Tick-Borne Infections of Ternopil National Medical University (Ukraine), pathogens were identified using several test systems, namely DNA A. phagocytophilum, / DNA E. muris, / DNA E. chaffeensis, DNA B. burgdorferi s.l., DNA B. myamotoi;

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DNA Babesia sp., and RNA Ticks borne of encephalitis viruses (MolGen, Italy), which allow real-time determination on anamplifier «ROTOR Gene 6000» by Corbett Research. Studies in many European countries have shown infection of the Dermacentor reticulatus tick with the pathogens B. burgdorferi s.l. in the range from 1.6 to 49.8%; A. phagocytophilum — 0.1—2.2%; Babesia spp. — 9.8—43.8%; Coxiella spp. — 0.1—0.2%; Francisella spp. — 0.7—95%; Toxoplasma spp. — 3.2—16.7%; and ticks borne of encephalitis viruses 8.5—16.6%. Some Ukrainian scientists presented data on D. reticulatus infection, in particular B. burgdorferi s. l. — 10.1—22.1%; A. phagocytophilum — 3—25.36%; Babesia spp. — 1—41.2%; Rickettsia sp. — 28%; Bartonella spp. — 5%; Coxiella spp. — 5.1%, and tick-borne f encephalitis viruses — 11.9—71%. The spread of many infectious agents is largely correlated with the spread of their vectors, including ticks of the D. reticulatus species. According to many scientists, this species is widespread in Europe, in particular, two metapopulations are currently distinguished as the western one, which includes the territories of France, Belgium, Slovakia, the Czech Republic, the Netherlands, and Germany, and the eastern one, which covers Lithuania, Latvia, Belarus, eastern and central Poland, and west of the Vistula River up to the Ural Mountains. In the Czech Republic, this species is found in all regions, more often in the southeastern and northwestern regions. In the UK, ticks have been found in West Wales, Devon, and Essex. In Romania, D. reticulatus was found in 17 counties, and in Moldova — in the Lower Dniester region. In Ukraine, this species is widespread from the Carpathians and Prykarpattia, Polissya, and Forest-Steppe, to the southeastern regions and Crimea.

***Keywords**: tick-borne pathogens, PCR diagnostics, ixodid ticks, Dermacentor reticulatus.*

Analyzing the epidemiological situation in Europe and in Ukraine particularly, we should note the significant spread of various pathogens of severe infectious diseases in humans and pets. These are diseases caused by pathogens from many genera such as *Borrelia, Anaplasma, Rickettsia, Babesia, Theileria, Coxiella, Bartonella, Francisella*, etc. It has been proven that most of these pathogens are transmitted to hosts by vectors, i.e. through the bites of arthropods, including ticks.

Among ticks, the most studied is the *Ixodes ricinus* species, which most often transmits these pathogens to humans and animals. However, in the last 10 years, according to research by European scientists, another species, the pasture tick (*D. reticulatus*), has been gaining importance, which, due to warming, is actively moving from south to north throughout Europe, up to its northern regions, namely Finland, Denmark, and Norway. Many literature sources cover specific issues of the spread of many infectious agents using ixodid ticks as vectors. However, there is a need to combine these disparate reports into a general overview to obtain a holistic picture.

Based on this situation, the purpose of the study was to conduct a detailed analysis of the literature of European and Ukrainian researchers to obtain the complete picture of the spread of the most known infectious agents in Europe and Ukraine and to establish the role of the *D. reticulatus* tick in this process.

In the European countries, the most common causative agents of severe infectious diseases in humans and animals are representatives of the *Borrelia* (*Swellengrebel 1907), Anaplasma* (Theiler, 1910), *Rickettsia* (da Rocha-Lima, 1916), *Babesia* (Starcovici, 1893), *Theileria, Coxiella, Bartonella* (Strong et al., 1915), *Francisella* (McCoy and Chapin 1912), etc.

Borrelia belong to the gram-negative bacteria of the *Spirochaetae* (Cavalier-Smith, 2002). They can cause severe infectious diseases in humans. Different genus species can affect different organs and systems, including the nervous, skeletal, and cardiovascular ones, or cause dermatological problems. The genotypes found in *D. reticulatus* (Fabricius, 1794) so far belong exclusively to *B. burgdorferi sensu lato* (Földvári et al, 2016).

The obligate intracellular bacteria *Rickettsia raoultii* (Mediannikov et al. 2008) and *Rickettsia slovaca* are important representatives of the group of spotted fever rickettsiae belonging to

the *Rickettsia* (Sekeyová, 2013). Rickettsioses are caused by various obligate intracellular bacteria of the genus *Rickettsia* and are grouped into one of four categories, namely the spotted fever group, the typhus group, the ancestral group, and the transitional group (Dehhaghi et al, 2019). *Rickettsia* mainly affect endothelial cells that line small and medium-sized blood vessels throughout the body, causing systemic symptoms and high mortality in patients.

The family *Anaplasmataceae* also belongs to the *Rickettsia* and includes the *Anaplasma, Ehrlichia,* and *Candidatus Neoehrlichia* (Silaghi, 2020).

Until recently, representatives of *Anaplasmataceae* were considered only as pathogens of animals or as benign symbiotic bacteria. To date, it has been established that each of the human pathogenic *Anaplasmataceae* is present in the endosome of phagocytes in vivo. Although not yet proven for all species, these intracellular bacteria attach to ligands on phagocytic cells, are taken up and then destroyed by intracellular endosomal transport to avoid lysosomal fusion and allow replication within the vacuole (Dumler & Walker, 2006).

Babesia spp. is a genus of intraerythrocytic protozoan parasites, from the type *Apicomplexa.* More than one hundred species of *Babesia* are known, which infect mainly mammals (including humans) and birds and are transmitted by ticks (Montero, 2022). Species of the genus *Toxoplasma* (Nicolle & Manceaux, 1908) also belong to the *Apicomplexa*, affecting warm-blooded animals and humans, causing toxoplasmosis of varying severity.

Coxiella burnetii (Derrick, 1939) is an intracellular bacterium that causes acute and chronic Q fever.

The RNA-containing tick-borne encephalitis virus (TBEV), which is a presenter of the *Flaviviridae* family, can cause a serious infection of the human central nervous system, leading to neurological complications and death. TBEV is transmitted to humans primarily through the bites of infected ticks, and the viral agent circulates between ticks and animals such as deer and small mammals (Pustijanac, 2023).

Different methods with appropriate special reagents are used to detect these pathogens in European countries. The most commonly used is PCR testing.

So, for example, in Poland, *B. burgdorferi s.l.* PCR was performed with the *B. burgdorferi* PCR kit (GeneProof, Czech Republic) for in vitro diagnostics.

A 120-bp fragment of the 16S rRNA gene encoding small ribosomal subunit was amplified. The final reaction mix volume of 40 μL comprised 30 μL of MasterMix and 10 μL of the template DNA extract.

To detect *A. phagocytophilum* DNA, a nested PCR was used targeting a fragment of 16S rDNA gene encoding a small ribosomal 16S RNA subunit. Reactions were performed with the *Anaplasma* PCR kit (Blirt-DNA Gdańsk, Poland) (Dumler et al., 2001).

For detection of *Babesia* spp., a fragment of 18S rDNA gene was used, encoding a small ribosomal subunit, localized on conservative region V4.

PCR was performed with Taq PCR Core Kit (Qiagen, Germany) with the use of a pair of highly specific primers: 18S rDNA BAB-F2 sense 5'—GAC ACA GGG AGG TAG TGA CAA G—3', and 18S rDNA BAB-R2 antisense 5'—CTA AGA ATT TCA CCT CTG ACA GT—3' (Sigma—Aldrich, Germany) (Pichon, 2006; Katargina et al., 2011; Moniuszko-Malinowska et al., 2016; Dunaj, 2018).

PCR Diagnostic Hum PCR *Bartonella*, Hum PCR *C. burnetiid*,and Vet PCR *Rickettsia* detection kit (BioIngenTech, Chile) were used to detect *Bartonella* spp., *C. burnetii* and *Rickettsia* spp., respectively. Reaction mixture (10.7 μL) contained 2.7 μL of HumPCR *Bartonella* Premixture, HumPCR *C. burnetii* Premixture or VetPCR *Rickettsia* Premixture (Grochowska, 2021).

In our research, to establish the composition of pathogens that ticks can carry, we performed PCR to detect the DNA of *A. phagocytophilum, Ehrlichia muris* (Wen et al., 1995)*, Ehrlichia chaffeensis, B. burgdorferi s. l., Borrelia myamotoi* (Fukunaga et al., 1995)*, Babesia* sp., and ticks borne of encephalitis viruses. The pathogens themselves were identified using several test systems, namely DNA *A. phagocytophilum,* / DNA *E. muris,* / DNA *E. chaffeensis*, DNA *B. burgdorferi s. l.*, DNA *B. myamotoi*, DNA *Babesia* sp., and RNA Ticks borne of encephalitis viruses (manufactured by MolGen (Italy)), which allow real-time determination on the amplifier «ROTOR Gene 6000» Corbett Research (Marchuk, 2021).

Research by European and Ukrainian scientists shows that all of the above-mentioned pathogens can develop in Ixodes ticks, including *D. reticulatus*, and spread to new territories.

According to Slovak scientists, *D. reticulatus* ticks, along with *Ixodes ricinus* and *Ixodes persulcatus*, can play an important role in maintaining tick-borne encephalitis virus in nature (Ličková, 2020). Laboratory studies have shown that ticks specially infect with tick-borne encephalitis virus transmitted the pathogen to mice on which they fed, and even observed non-viremic transmission of this pathogen to other ticks that also fed on the same host. Thus, *D. reticulatus* can be a biologically effective carrier of the tick-borne encephalitis virus and even contribute to the expansion of foci of this infection.

D. reticulatus is often a carrier of babesiosis. This is evidenced by the data of many researchers, in particular German scientists (Silaghi, 2020). So, in Bavaria, these ticks were found mainly in very wet areas. Of the 308 ticks examined by PCR, two (0.3%) were positive for *Babesia canis* (Piana & Galli-Valerio, 1895).

The results of the study of the infection of *Ixodes* ticks in Poland showed that *D. reticulatus* was a carrier of six pathogens, sometimes in combination. Thus, *Toxoplasma gondii* (Nicolle & Manceaux, 1908) and *Theileria (Babesia) microti* were detected in 37% of ticks examined in Upper Silesia, Poland (Asman et al., 2015). According to research in eastern Poland, 6 pathogens were detected in *D. reticulatus*: tick-borne encephalitis virus, *A. phagocytophilum*, *R. raoultii*, *B. burgdorferi s. l.*, *Babesia* spp., and *T. gondii*. Ticks were most often infected with *R. raoultii* (43.8%), tick-borne encephalitis virus less often (8.5%), and *Babesia* spp. (2.5%), *T. gondii* (2.1%), *B. burgdorferi s. l.* (1.6%), and *A. phagocytophilum* (1.1%). In 54 (8.5%) ticks, double co-infection was detected, with 2 pathogens in each. Double infections involving *R. raoultii* (7.41%) were most common; followed by viruses with the participation of tick-borne encephalitis virus (5.21%), *T. gondii* (1.58%), *B. burgdorferi s. l.* (1.26%), *A. phagocytophilum* (0.95%), and *Babesia* spp. (0.63%) (Zając et al., 2017).

Another study in Eastern Poland showed *T. gondii* infection in up to 16.7% of *D. reticulatus* ticks (Wojcik-Fatla, 2015). *T. gondii* was also detected in 3.2% of *D. reticulatus* individuals collected in six towns of the Lublin Voivodeship (Mierzejewska, 2015). Therefore, it can be assumed that *D. reticulatus* is a potential vector of *T. gondii* and contributes to its spread among herbivorous mammals and birds. However, this statement is not conclusive and needs additional research.

A number of researchers confirm the fact that *D. reticulatus* ticks are infected with the bacterium *B. burgdorferi s. l.*, but they are still looking for convincing evidence about their ability to transmit this borreliosis pathogen to humans (Zając et al, 2017; Kubiak et al, 2017; Daněk, 2022).

During March 2004, 132 ticks, males of *D. reticulatus*, were collected on European bison in Bialowieza Forest, Poland (Matsumoto, 2017). 13 ticks were subjected to PCR studies for the presence of *A. phagocytophilum* and *Rickettsia* spp., and *R. raoultii Marne* was detected only in 4 ticks.

In 2018—2019, a team of scientists conducted research on *D. reticulatus* for the presence of 28 types of pathogens in European countries. Based on real-time PCR, 1741 ticks from Belgium, Great Britain, Germany, and the Netherlands were examined. It was possible to detect the DNA of *Borrelia* spp. (7%), *B. afzelii* (0.1%), *B. garinii* (0.1%), *B. spielmanii* (0.1%), *B. miyamotoi* (0.2%), *Anaplasma marginale* (0.1%), *A. phagocytophilum* (0.1%), *Ehrlichia canis* (2%), *Rickettsia helvetica* (0.2%), *Rickettsia conorii* (9.6%), *Francisella tularensis* (95%), *C. burnettii* (0.1%), *Babesia divergens* (0.2%), *B. canis* (0.9%), *Babesia vogeli* (5.6%), and *Theileria equi* (0.1%). Therefore, the absolute majority of ticks were infected with the causative agent of tularemia, other pathogens were found occasionally, for example, *D. reticulatus* as possibility to transmit Om hemorrhagic fever and tick-borne encephalitis viruses to humans, *R. raoultii* and *R. slovaca*, *R. helvetica*, *B. burgdorferi s. l.*, *A. phagocytophilum,* and *C. burnetii*; the last two cause tick-borne lymphadenopathy (TIBOLA) (Sprong, 2019).

The presence of *B. sanis* in *D. reticulatus* ticks has been confirmed in the Czech Republic. During 2018-2021, 783 ticks of this species were investigated. DNA of this pathogen was detected in 22 samples (2.81%) (Daněk, 2022). In Poland, infection of *D. reticulatus* with this pathogen ranges from 1% to 4% (Zygner, 2009; Dwużnik-Szarek, 2021). In Italy, the parallel circulation of *D. reticulatus* and *B. sanis ticks* was studied, but a direct relationship between them was not established (Olivieri, 2017). Studies in Germany showed that *D. reticulatus* is still an endemic species that is occasionally infected with various pathogens: only 0.3% of ticks were found to be *B. sanis* (Heile, 2006: Silaghi, 2020).

In the Republic of Belarus, during 2011—2012, ixodes ticks were studied for the presence of the tick-borne encephalitis virus. Using ELISA, it was established that 79 out of 565 (16.5%) *D. reticulatus* ticks were carriers of tick-borne encephalitis virus antigen. It was noted that this indicator increased by almost 2% compared to the 2009—2010 period (Samoylova, 2013; Reye et al., 2013). At the same time, in Belarus, *I. ricinus* and *D. reticulatus* ticks were analyzed for pathogens of *Borrelia, Rickettsia, Anaplasma, Coxiella, Francisella*, and *Babesia*. It was established that 45.6% of *D. reticulatus* ticks were carriers of these pathogens. In particular, 9.4% of ticks had the bacterium *B. burgdorferi s. l.* and 40.4% — *B. afzelii*. As less common among ticks were indicated *A. phagocytophilum* (2.2%), *C. burnetii* (0.2%), *F. tularensis subspecies* (0.7%), *B. henselae* (0.7%), *B. microti* (0.5%), and *Babesia venatorum* 0.4%) (Vinograd & Komarenko, 2014).

A number of *Ixodes* ticks studies were conducted in different regions of Ukraine. In Kyiv oblast, infection of *D. reticulatus* with the causative agent of tularemia *F. tularensis* was confirmed, somewhat more often in the forest-steppe region than in Polissia. PCR analysis of ticks for the presence of the causative agent of Ku fever *C. burnetii* was also carried out. It was established that 5.1% of *D. reticulatus* ticks carried it in the forest-steppe region (Levytska et all., 2021).

During 2009—2012, *D. reticulatus* ticks were collected in the Chornobyl zone, followed by their examination for the presence of *B. canis* and *A. phagocytophilum*. It was established that 3.41% of ticks were carriers of the former, and 25.36% — of the latter (Karbowiak, 2014b).

In 2021, *D. reticulatus* ticks were collected and studied in 5 cities of Ukraine: Chernivtsi, Ternopil, Khmelnytskyi, Vinnytsia, Kyiv. 422 ticks were subjected to PCR analysis. Of them, 3% had *A. phagocytophilum*, 28% — *Rickettsia* spp., 1% — *Babesia* sp., 5% — *Bartonella* spp. (Levytska et all., 2021).

The role of ticks *I. ricinus* and *D. reticulatus* in the transmission of spirochetes *B. burgdorferi s. l.* in Lviv oblast was studied. The presence of *B. burgdorferi s. l.* was confirmed in $10.1 \pm 1.2\%$ of *D. reticulatus* in forest and $14.4 \pm 2.0\%$ in forest-steppe regions. The maximum indicators

of natural infection of the pasture ticks were found in Kamianko-Buzky (18.0%), Pustomytivskyi (18.2%) districts, and in Lviv (22.1%) (Shulhan, 2019).

During 2017—2021, a PCR study was carried out on 121 ticks of the *D. reticulatus* species removed from people and domestic animals in different regions of Ukraine. Of the 11 ticks taken from humans, 2 were found to have *A. phagocytophilum*. Out of 36 ticks removed from animals in 2017, 5 samples were carriers of *B. burgdorferi s. l.*, 2 — *A. phagocytophilum*, 2 more were simultaneously carriers of *B. burgdorferi s. l.* and *A. phagocytophilum*. Out of 9 ticks collected in 2018, 4 were carriers of *Babesia* sp. and 1 — *B. burgdorferi s. l.* Of the 25 ticks caught in 2019, 17 had different infectious agents. Among them, 7 carriers of *Babesia sp*. and 2 — carriers of the tick-borne encephalitis virus. 3 ticks simultaneously had *Babesia* sp.*; A. phagocytophilum* was found in 3 cases, *B. burgdorferi s. l.* in one sample, the other 2 samples — *A. phagocytophilum* and *B. burgdorferi s. l.* In 2020, PCR was used to examine 20 ticks from one dog, and in 14 of them, tick-borne encephalitis virus was detected (Podobivskiy, 2022).

In 2020, PCR was additionally performed on 21 tick samples selected by random sampling from the total number of *D. reticulatus* ticks (447 specimens) collected in 66 settlements in 10 oblasts of Ukraine. Ticks were removed from humans and domestic animals such as cats, dogs, cows, and horses. *B. burgdorferi s. l.* was detected in 3 ticks, *A. phagocytophilum* in 1 tick, and co-infection with *B. burgdorferi s. l.* and *A. phagocytophilum* -- in 1 tick (Fedoniuk, 2021a).

In 2022, a PCR study was conducted on ticks collected in 2021 from dogs, cats, and cows in 7 oblasts of Ukraine (Ternopil, Lviv, Volyn, Rivne, Khmelnytsky, Vinnytsia, Zhytomyr). A total of 102 samples of *D. reticulatus* were collected, of these, 30 were found to contain infectious agents: 22 (71%) of which were found to contain tick-borne encephalitis virus, 7 (23,3%) — *Babesia* spp., and 1 (3,3%) — *A. phagocytophilum* (Fedoniuk, 2021b).

The causative agents of zoonotic and zooanthroponotic infections have their permanent hosts (humans, carnivorous mammals, mouse-like rodents, reptiles, and birds). The spread of these pathogens is determined by the expansion of not only the ranges of their natural hosts but also their temporary vectors — ixodid ticks. In this regard, to understand the prospects for the emergence of certain pathogens, it is necessary to see a general picture of changes in the ranges of both obligate and facultative hosts.

The analysis of the distribution of ixodid ticks, including *D. reticulatus*, shows their wide expansion from the south to the north of Europe. Many scientific papers have been devoted to the distribution of this species in Europe.

There is evidence that in the northeast of Poland, in particular in the Warmia and Mazury Voivodeships, there are ticks bordering the eastern population but not forming a continuous range. Out of 25 samples from different localities, ticks of this species were found in 13 cases (Kubiak, 2018).

According to the investigations of the Polish authors, the *D. reticulatus* range in Poland is represented by eastern and western populations. Both of them are concentrated mainly in river basins (Silaghi, 2020).

It is also reported that Eastern Poland has its own population of *D. reticulatus* with peaks of their activity in spring or autumn. In recent years, the range and seasonal periods of this species have changed, which may be related to warming (Zając, 2021).

Currently, two metapopulations are distinguished now: the western one, which includes the territories of France, Belgium, Slovakia, the Czech Republic, the Netherlands, and Germany (Martinod, 1991; Pichon, 2006; Bullová, 2009; Široký, 2011), and the eastern one, which includes Lithuania, Latvia, the eastern and central parts of Poland, and also the regions located west

of the Vistula up to the Ural Mountains (Rar, 2005; Reye, 2013; Mierzejewska, 2016; Radzijevskaja, 2018).

During 2009—2016, the distribution of *D. reticulatus* in Great Britain was studied. Ticks were found in 4 locations: West Wales, North and South Devon, and Essekx (Karbowiak, 2014a). In 2015—2016, 444 samples of *D. reticulatus* adults were collected in suburban parks in Italy. More often they were found in mixed forests, where oak plantations prevailed and there were water reservoirs (Olivieri, 2016).

In Bavaria (Germany), studies were conducted in 2010—2013, during which 2 types of ticks, *I. ricinus* and *D. reticulatus,* were found on 60 sites. In 12 samples, both types of ticks were detected simultaneously, of which the latter accounted for 8.3% of samples (Silaghi, 2020).

In the Czech Republic, this species is found in almost all regions, more often in the south-east and north-west (Daněk, 2022).

Some publications present the results of the analysis of literature data and the authors' research on the distribution of *D. reticulatus* from the Atlantic coast of Portugal to Western Siberia, with 2188 locations of this species identified. These locations were found in areas with a temperate warm climate, where year-round precipitation is 57%, and boreal climate with precipitation of 40% (Karbowiak, 2014a; Rubel, 2020).

The results of studies on the distribution of *D. reticulatus* and associated pathogens in northwestern Europe show the expansion of this species in the specified territory (Sprong, 2023). Some authors consider that it is caused by several factors, in particular, the development of tourism, trade, business, climate changes, and use of the earth's subsoil (Karbowiak, 2010; Široký, 2011; Medlock, 2011; Hofmeester, 2016; Kloch, 2017).

According to the results of research during 2012—2014 in Romania, *D. reticulatus* was detected in 17 counties, 14 of them for the first time (Chitimia-Dobler, 2015). At the same time, in the Republic of Moldova, Ixodes ticks were selected in the Lower Dniester region. 6 species of ticks of the *Ixodidae* family were registered, namely *I. ricinus, Ixodes frontalis, Ixodes laguri, Dermacentor marginatus, D. reticulatus,* and *Haemophysalis punctata*. *D. reticulatus* ticks in these collections were only 1.8% (Kravchenko, 2015).

The study of the distribution of *D. reticulatus* ticks in Ukraine began back in the 60—70s of the XX century. One of the first scholars to comprehensively study this issue was Yemchuk E. M. (1960). According to the results presented in her book, this type of tick was found in 10 oblasts of Ukraine, namely Lviv, Ternopil, Volyn, Rivne, Khmelnytskyi, Vinnytsia, Kyiv, Sumy, Zhytomyr, and Chernihiv oblasts. Thus, in the conditions of Ukrainian Polissia, the species *D. reticulatus* were identified along with other 7 species of *Ixodes ticks*, *Dermacentor*, *Haemaphysalis,* and *Hyalomma*. In the Carpathians, this species is commonly present in the foothills of their southern and northern mountain slopes.

I. I. Turyanin studied the distribution of ticks of the genus *Dermacentor* in the Carpathians, Prykarpattia, and Zakarpattia. In particular, he points to the presence of ticks of this species in Zakarpattia, Ivano-Frankivsk, Lviv, and Chernivtsi oblasts. *D reticulatus* (*pictus*) and *D. marginatus* are listed among the other 11 species of Ixodes ticks, mainly from the genus Ixodes. *D. reticulatus* was found in lowland and foothill areas on domestic animals (April-August), especially during grazing on dry pastures (Turyanin, 1964).

The books and scientific articles written by I. A. Akimov and I. V. Nebogatkin (Akimov, 2002; 2011; 2016; Nebohatkin, 2018) show the distribution of the species in the biotopes of Kyiv and its surroundings. In particular, it is indicated that 26 species of Ixodes ticks of 106 (about 37%) are found in the urbocenoses of the world, of which 23 species attack humans. In the Kyiv metropolis, 12 types of ticks were detected, of which the absolute majority were ticks of the species *I. rici-*

nus and *D. reticulatus*, or 98.6% of all ticks collected (54% and 44.6%, respectively) (Akimov, 2002; 2011; 2016).

According to the results of research carried out by scientists of the Institute of Zoology of the National Academy of Sciences of Ukraine for more than ten years, the southern ranges of *D. reticulatus*, including in Crimea, were established. The presence of this species in human areas, including cities, has been revealed. Ticks of this species were found in 311 locations of Odesa, Mykolaiv, Kherson, Zaporizhzhia, and Donetsk oblasts and the Autonomous Republic of Crimea (Nebohatkin, 2018).

A study of ticks in Sumy oblast showed that in the Polissya, the share of *D. reticulatus* ticks significantly exceeded the share of ticks of this species in the forest-steppe region (from 6.06% in 2009 to 24.88% in 2012). Conversely, in the forest-steppe region, the share of *I. ricinus* was higher (from 9.91% in 2011 to 24.93% in 2012 (Kassich, 2017).

From May 2017 to November 2019, 447 samples of *D. reticulatus* ticks were selected and identified, including 287 females and 160 males, collected in 74 settlements in 10 oblasts of Ukraine, namely Ternopil (from 28 locations), Lviv (8 locations), Ivano-Frankivsk (3), Zakarpattia (2), Volyn (9), Rivne (10), Zhytomyr (3), Khmelnytsky (8), Vinnytsia (2), and Chernihiv (from one location) (Fedonyuk & Podobivskiy, 2020). The results of our research on the distribution, biology, and epidemiological significance of *D. reticulatus* and *I. ricinus* ticks, conducted in 2017—2019, were illustrated in a medical GIS (geographic informational system) (Podobivskyi et al., 2019). On the basis of this system, an interactive map was created, which includes data on more than 900 samples of *D. reticulatus*, the places of their collection, the hosts from which they were taken, morphological characteristics, and the results of the PCR study.

Separate sections of the collective monograph of scientists of the Ternopil I. Gorbachevsky National Medical University contain generalized information on the causative agents of Lyme borreliosis and some other tick-borne infections and their vectors — Ixodes ticks, in particular *D. reticulatus*, as of 2021 (Andreichyn et al, 2021).

Conclusions. The causative agents of tick-borne encephalitis virus, borrelia (*B. burgdorferi s. l., B. afzelii, B. garinii, B. spielmanii, B. miyamotoi*), *Anaplasma* (*A. phagocytophilum, A. marginale*), *Babesia* (*Babesia* sp*, B. canis, B. microti, B. venatorum, B. divergens*), *Tularemia bacteria* (*F. tularensis*), *Rickettsia* (*Rickettsia spp., R. raoultii, R. slovaca, R. helvetica*), *Bartonella* (*Bartonella* spp*, B. henselae*), *Ehrlichia* (*Ehrlichia canis*), *Coxiellae* (*C. burnetii*), *Theileries* (*T. equi*), and *Toxoplasma* (*T. gondii*) are widespread in Europe and transmitted by ticks in the egg-larva-nymph-imago sequence through transstadial and transovarian mechanisms and are transmitted from one host to another (from rodents and birds to larger mammals and humans), often causing severe tick-borne infections in humans.

Based on the results of the analysis of publications of foreign and Ukrainian scientists, including personal ones, it can be stated that the degree of infection with the most common pathogens of infectious diseases of *D. reticulatus* ticks in Europe in general and Ukraine in particular is sufficiently correlated with each other. The general trend is an increase in the frequency of tick infection with various pathogens and the expansion of the geography of these ticks.

The analysis of the distribution of *D. reticulatus* showed its spread throughout Europe, in particular in Germany, Sweden, Denmark, the Netherlands, the Czech Republic, Slovakia, Poland, Estonia, Hungary, Romania, Moldova, Ukraine, etc. There is a growing tendency for it to occupy more northern territories and even displace the forest tick (*I. ricinus*) in some regions. In Ukraine, this tick has spread to the Carpathians, Polissya, and part of the Forest-Steppe and occupies more humid habitats in river valleys, near natural and artificial reservoirs, etc.

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ЗБУДНИКИ ІНФЕКЦІЙНИХ ХВОРОБ ЛЮДИНИ І ТВАРИН ТА ЇХ РОЗПОВСЮДЖЕННЯ В ЄВРОПІ ІКСОДОВИМ КЛІЩЕМ *DERMACENTOR RETICULATUS*

У зв'язку з кліматичними змінами в Європі підвищується ймовірність захворювань людей і сільськогосподарських тварин, зумовлених патогенами з родів *Borelia, Anaplasma, Rickettsia, Babesia, Bartonella, Coxiella* тощо. Своєю чергою, ці збудники безпосередньо пов'язані з членистоногими переносниками, зокрема з іксодовими кліщами. На основі аналізу літературних джерел встановити сучасні тенденції щодо поширення ряду збудників кліщових інфекцій, які передаються кліщами *Dermacentor reticulatus* у деяких країнах Європи і в Україні. Впродовж останніх 10 років у переважній більшості країн світу, в тому числі і в країнах Європи, загострюється ситуація щодо ураження сільськогосподарських і диких тварин, а також часто і людей збудниками важких інфекційних захворювань з родів *Borrelia, Anaplasma, Rickettsia, Babesia, Theileria, Coxiella, Bartonella, Francisella* та ін. Представники цих родів призводять до виникнення важких хвороб, таких як кліщові бореліози, які супроводжуються ураженням центральної нервової системи, суглобів, шкіри, серцево-судинної системи. Представники ряду *Rickettsiales* зумовлюють різноманітні лихоманкові стани у тварин і людей. Види родів *Babesia* спричиняють захворювання бабезіози, викликані ураженням еритроцитів та появою антиеритроцитарних антитіл, а представники роду *Toxoplasma* викликають токсоплазмози, що супроводжуються ураженням нервової, лімфатичної та серцево-судинної систем. Ку — лихоманку викликають види роду *Coxiella*. Важкі захворювання людини спричиняють віруси кліщового енцефаліту. Для виявлення цих збудників розроблені і використовуються різноманітні тест-системи ПЛР-досліджень. Так, у Польщі ПЛР на *Borrelia burgdorferi s. l.* проводили з використанням набору для ПЛР *B. burgdorferi* (GeneProof, Чехія) для діагностики *in vitro*. Для виявлення ДНК *A. phagocytophilum* використовували набори для ПЛР *Anaplasma* (Blirt-DNA Gdańsk, Польща). Для виявлення *Babesia* spp. використовували фрагмент гена 18S рДНК, що кодує малу субодиницю рибосоми, локалізован**у** в консервативній ділянці V4. Для виявлення *Bartonella* spp. використовували тести Hum PCR BARTONELLA, Hum PCR *Coxiella burnetii* і набір для виявлення Vet PCR *RICKETTSIA* (BioIngenTech, Чілі), *C. burnetii* та *Rickettsia* spp. В лабораторії з дослідження кліщів і кліщових інфекцій Тернопільського національного медичного університету (Україна) визначення збудників здійснювали за допомогою декількох тестових систем, а саме ДНК *A. phagocytophilum,* ДНК *E. Muris,* ДНК *E. Chaffeensis*, ДНК *B. burgdorferi s. l.*, ДНК *B. Myamotoi*, ДНК *Babesia species* і РНК *Ticks borne of encephalitis viruses* (виробництва«MolGen» (Italy)), що дозволяють проводити визначення в режимі реального часу на ампліфікаторі «ROTOR Gene 6000» «Corbett Research». Дослідження в багатьох країнах Європи показали зараженість кліща *D. reticulatus* збудниками: *B. burgdorferi s. l.* у проміжку від 1,6 до 49,8 %; *A. phagocytophilum* — 0,1—2,2 %; *Babesia* sp. — 0,3—37 %; *Rickettsia* spp.— 9,8—43,8 %; *Coxiella* spp. — 0,1—0,2 %; *Francisella* spp. — 0,7—95 %; *Toxoplasma* spp. — 3,2—16,7%; ВКЕ — 8,5—16,6 %. Українські вчені отримали такі дані щодо зараженості *D. reticulatus*: *Borrelia burgdorferi s. l.* — 10,1—22,1 %; *A. phagocytophilum* — 3—25,36 %; *Babesia* spp. — 1—41,2 %; *Rickettsia* spp. — 28 %; *Bartonella* spp. — 5%; *Coxiella* spp. — 5,1 %; ВКЕ — 11,9—71 %. Поширення багатьох збудників інфекцій у значній мірі корелюється з поширенням їх векторів, зокрема і кліщів виду *D. reticulatus*. За даними багатьох учених цей вид широко розповсюджений у Європі, зокрема розрізняють дві метапопуляції: західну, яка охоплює території Франції, Бельгії, Словаччини, Чехії, Нідерландів і Німеччини, та східну — охоплює Литву, Латвію, Білорусь, східну і центральну частини Польщі і на захід від Вісли аж до Уральських гір. У Чехії цей вид виявляють у всіх регіонах, частіше в південно-східному і північно-західному. У Великій Британії кліщі знайдено у Західному Уельсі, в Девоні та Ессексі. У Румунії кліщі *D. reticulatus* виявлено *цього виду* в 17 повітах, а в Молдові — у регіоні Нижнього Дністра. В Україні цей вид широко розповсюджений від Карпат і Прикарпаття, Полісся і Лісостепу до південно-східних областей і Криму.

Ключові слова: *збудники кліщових інфекцій, ПЛР-діагностика, іксодові кліщі, Dermacentor reticulatus.*