Tick-borne diseases epidemiological monitoring system in the Russian Federation

V V Belimenko and A M Gulyukin
Federal State Budget Scientific Institution “Federal Scientific Centre VIEV”, 24/1, Ryazanskiy avenue, Moscow, 109428, Russia

E-mail: Vlad_belimenko@mail.ru

Abstract. The article presents an overview of information flows within the epizootological monitoring of tick-borne diseases in animals. Epizootological monitoring is the system of data collection on the spread of pathogens and animal disease outbreaks, following statistical processing and analysis of the effectiveness of veterinary control as well as for the evaluation and forecast of the epizootic status of particular territories. It is necessary to concentrate information flows and track operative data exchange in real-time management and to coordinate actions between various Departments for effective risk-based tick-borne disease epizootological monitoring to decrease or eliminate negative consequences of illness breakouts with an account of up-to-date evaluation methods, risk management, and auditon. An important aspect is the creation of specialized epizootological databases together with integration with geoinformation systems.

1. Introduction
According to the “Veterinary Act” of the Russian Federation from May 14, 1993 No4979-1, the main scope of State Veterinary Service of the Russian Federation is provision on animal infectious diseases welfare and provision of animal origin food products quality. Therefore, it is necessary to constantly observe the epizootic situation on animal infectious diseases. And complex epizootological monitoring is the most important part of control measures.

Epizootological monitoring is the system of data collection on the spread of pathogens and animal disease outbreaks, following statistical processing and analysis of the effectiveness of veterinary control as well as for the evaluation and forecast of the epizootic status of particular territories [1, 2].

2. Tick-borne infections and invasions and epizootological monitoring in the Russian Federation
Tick-borne diseases are infections and invasions transmitted to humans and animals via ticks’ bites. Ixodids feed blood and infect a host with various transmissive illnesses. Also, ticks are capable of transphasedal and transvarial transfer of infectious pathogens.

Epidemiological monitoring of vector-borne diseases carries out by several State Services separately. Vector-borne infections in human, monitored by Sanitary Epidemiological Supervision Agencies in the Russian Federation, are Tick-borne encephalitis, Lyme Disease, Congo-Crimean hemorrhagic fever, Omsk
hemorrhagic fever, Rickettsioses (Siberian tick-borne typhoid, Astrakhan spotted fever, Marseilles Mediterranean fever), Human monocytic ehrlichiosis, Human granulocytic anaplasmosis, Tularemia, Q fever [3, 4].

At the same time, the State Veterinary Service of the Russian Federation carries out monitoring only of five animal tick-borne diseases, which are included in WAHO (OIE) List (bovine babesiosis, theileriosis, bovine anaplasmosis, equine babesiosis, and equine nuttalliosis). Meanwhile, such tick-borne infections as Lyme disease and granulocytic anaplasmosis, that are common for human and animals, are not covered by epizootological monitoring [5].

As a result of our survey in 2016-2020, it was found that bovine piroplasmosis (causative agent is P. bigemina Smith et Kilborne, 1889) spread in the southern and southeastern regions of Russia. Animals infected by ticks B. calcarius, Rh. bursa and H. punctata. Depending on the vector, the disease can occur in spring, summer and autumn. Foci of piroplasmosis recorded in the North Caucasus Federal District (Chechen Republic and the Republic of Dagestan) and Southern Federal District (Republic of Adygea, Krasnodar Territory, Volgograd and Rostov Regions). Most sick animals (1-3 thousand animals annually) are in the Chechen Republic.

Northern cattle babesiosis (B. divergens Mac Fadyean et Stockman, 1911) is widespread in the northwestern and central regions of Russia. Carriers are ticks of Ixodes ricinus and less often I. persulcatus. The disease is recorded mainly in the summer and autumn. Cases of disease of animals without fatal outcome were recorded in 2010-2012. only in the Kaliningrad region.

Southern cattle babesiosis (B. bovis Babes, 1888) is common in the southern and southeastern regions of the country. Vector is Boophilus calcarius. Often the disease proceeds in the form of invasion mixed with piroplasmosis and anaplasmosis. The first outbreak is observed in the summer, the second - in the fall. According to veterinary reporting, cattle babesiosis in recent years does not cause significant economic damage to livestock production in the Russian Federation. Single foci of the disease were recorded in the South (Rostov region), Central (Lipetsk and Kaluga regions) and the Volga Federal District (Republic of Mordovia). The largest number of sick animals (349 animals) was observed in 2008. There is no data on the death of sick cattle.

Equine piroplasmosidoses (B. caball Nuttall et Strickland, 1910 and N. equi Laveran, 1901) are observed in spring, less often in summer and autumn. The main carrier is ticks of the genus Dermacentor. During the study period, outbreaks of babesiosis of horses were recorded in the North Caucasus Federal District (Chechen Republic) and Southern Federal District (Rostov Region). And 3 animals got sick in the Kaliningrad region in 2009.

Equine nuttalliosis (Pathogen is Nuttallia equi Laveran, 1901) is often encountered in clinical practice in the form of a mixed invasion with piroplasmosis, which can be diagnosed only when typical piroplasms (paired at an acute pear-shaped angle) and nuttallia (in the form of Maltese cross) are found in blood smears cross. Nuttallia vectors are ticks Dermacentor pictus, D. marginatus, D. silvarum, D. nuttalli, Hyalomma marginatum, H. scupense, Rhipicephalus bursa, Rh. turanicus. The disease is recorded mainly in the spring and summer. In the middle zone of the country, nuttalliosis is found after piroplasmosis, and in the south - simultaneously. Foci of nuttalliosis are historically registered in the central regions of Russia, in the Volga region, Siberia, Transbaikalia, and in the Far East. The North Caucasus, Stavropol Territory, Kalmykia are considered as an enzootic zone. However, according to veterinary reporting over the past 6 years, cases of horse nuttalliosis were registered only in 4 settlements of the Rostov region in 2007. 10 animals got sick. There were no fallen.

During the studying period, regions of the Central (Kaluga, Bryansk, Ryazan regions), North-West (Kaliningrad region) and Volga Federal Districts (Kirov Region) were unsuccessful on bovine anaplasmosis.
Lyme borreliosis is constantly recorded in Russia in humans in animals. However, information on cases of disease in animals is not reflected in veterinary reporting. As a result of our studies, it was found that Lyme disease is annually recorded in the spring among dogs in Moscow.

One of the main ways of monitoring system improvement is the optimization of information flows.

Information stream is a concern of messages, describing elements of a system at the moment of time and direct from source to a recipient. Information stream forms a message set that is necessary to represent activity management and circulating in definite direction. Information streams, information arrays (data files), models, messages, documents, signs, codes and signals are structural units of information flow.

Information streams reflect a set of direct and inverse links in the management system. Messages can come in paper or oral forms as well as in e-form.

While projecting of information streams, the following criteria are usually distinguished among the most important: operativity of managing subjects and organization specialists to become familiar with newly delivered and generated by organization itself information, awareness of managing subjects and specialists in the volume necessary for accomplishment by them of their functions (official duties); minimization of labor costs connected with information forming and transfer and familiarizing with it of managing subjects and organization specialists; organization confidential information secure from unauthorized access to it.

There are of important significance the priority of tasks solved by executive branch divisions, the divisions activity dedication outwards or the activity orientation inward of an organization itself, the demands to operativity level of their adopted decisions. The character and intensity of information mutual interactions of department divisions are also considered.

Late awareness of management entities of newly received and generated information decreases the value of circulating information by modernity criteria. Its consequence is a time deficit increase for their working-out, delays in decision adoption and their follow to performers, an adoption of decisions with delays and time loss for their realization.

On the other hand, insufficient operativity in awareness leads to the reinforcement of uncertainty effect during management decision adoption, to the necessity to adopt management decisions in limited time conditions. It stands out as an additional powerful stress-factor for managing subject that, as a result, lowers the effectiveness of being adopted decisions essentially.

Managing subject insufficient awareness leads to unreasonable effort application on organizing and pursuing of independent developments for the settlement of already researched and finished to practical embodiment tasks.

Excessive labor costs, connected with information forming and transfer and its awareness of managing entities and organization specialists, have constant character, mean ineffective usage of available staff potential, lower organization target effectiveness and cause a harm to a financial state. Information distortion and break can have its consequence as economic damage.

3. Epizootological Geoinformation systems (GIS)

One of important way to carry out epizootological monitoring is to collect, storage, and analysis of epizootic information with its integration in GIS with diseases focus location and their spread vectors in accordance with geographical coordinates. Thereby, it is extremely important to develop and widely apply the information and geoinformation systems for epizootological monitoring.

GIS is an interconnected set of means, methods, and staff used for storage, processing, analysis and issue of epizootological information to achieve aims in the sphere of epizootological welfare provision of a state in a whole as well as of definite regions.

GIS allows collect, storage, and analysis the epizootological information, display it via geographical maps and creates reports according to set parameters. GIS allows studying more complete the mechanisms
of epizootic process and geography of animal most dangerous diseases and to improve epizootological analysis methodology [6, 7, 8].

One of the most important aspects of GIS application is the usage of its capabilities to study epizootological processes while animal various infections. It is managing technology allowing to use of maximally the resources to fight epizootics.

The epizootics of most diseases, especially nature-foci, do not accept administrative borders. The analysis and prognosis of transboard moves of infectious illnesses is the most effectively fulfilled ones in the geoinformation system [9, 10].

GIS is an ideal tool for monitoring of nature-foci infectious and parasitical diseases. In comparison with paper epizootic maps with limited possibilities to fill and to reflect process dynamics in space and in time, GIS makes it possible to collect, process, model and analyze data depending on task being settled as well as to display on a monitor screen or on paper. Meanwhile, map display in various scales is possible and as separate parts (from small local biotope to global map). GIS maps have unlimited different layers (for example, transmitter areas, disease focuses and loimopotential).

Also, GIS databases allow to pursue a current and retrospective adjacent monitoring of epizootic and epidemiological situation on the basis of summarizing reports of veterinary research organizations and supervision agencies.

GIS employment lets to research epizootic process laws and listed animal disease geography more complete. GIS are the modern tool of epizootological analysis and risk assessment, providing optimal management decisions.

4. Information flow optimization within epizootological monitoring

From our view, the most effective way to optimize and improve epizootological monitoring is the creation on Federal level of the single expert analytical center under Executive branch divisions where all information will be accumulated, processed and analyzed which represents epizootological and epidemiological value.

At present, epizootological information is transferred by its most into Federal Executive agencies as quarterly and annual reports which contain information about unfavorable point number, diseased, fallen or forced killed animal quantity. Thus, the epizootic situation in the country as a whole and in regions can be described by very large strokes [11].

At the same time, epizootological information accumulated in scientific research organizations not considered. Nevertheless, according to prof. V.I. Korenberg “... there is the growing gap between research data and the results of sanitary-epidemiological public service within the control of nature-focus zoonoses” [12].

Modern technologies allow making databases unlimited by volume and productivity (Big Data), including those with artificial intellect application and machine learning systems. The integration of similar databases with geoinformation systems makes it possible to demonstrate vividly the epizootic situation with the maximally precise tie to definite geolocation.

It’s worth noting that to analyze and forecast the epizootic situation, the different information on environment biotic and abiotic factors can be significant. Data on water and soil biochemical content, species content of infectious and invasion disease transmitters (Arthropoda, Chiroptera), their migration and behavior as climate change consequence, the possibility of their transmission on welfare territories, species content of possible reservoir hosts and many other issues are of specific value [13, 14, 15].

According to aforesaid, we consider it necessary to create interdepartmental expert information-analytical Center specialized on collection of information from research results, held in the frames of public assignment and discovery research having direct as well as indirect epizootic significance, on information
storage in unlimited time, information analysis, analytical research performance for Executive agencies and so on.

Responsibilities for search, selection and introduction of monitoring, diagnostics, treatment innovation methods for tick-borne diseases in human and animal should be also put on Center.

5. Conclusion
It is necessary to concentrate information streams and track operative data exchange in real-time management and to coordinate actions between various State Servises for effective risk-based epizootological monitoring of tick-borne disease for decrease or eliminate negative consequences of breakouts with an account of up-to-date evaluation methods, risk management and audition. An important aspect is the creation of specialized epizootological databases together with integration with geoinformation systems.

The obtained results can be recommended for drawing up a clear picture of the epizootic situation for vector-borne tick-borne diseases (piroplasmodoses, anaplasmoses, Lyme disease) in the European part of the Russian Federation and for improving anti-epizootic measures taken by executive authorities and the veterinary service to optimize monitoring of this group of diseases.

For complete risk-assessment of the epizootic situation, it is necessary to combine research institutes and the veterinary service and develop a monitoring system taking into account the recommendations of the OIE.

The research carries out within Program of Fundamental Research of Russian Academies of Sciences on 2013-2020, theme No.0578-2019-0003 (project No.0578-2015-0002 “Risk-Analysis and Risk-Assessment of Transmissive Tick-borne Diseases (piroplasmodoses, anaplasmoses, Lyme disease) spread on the territory of Europe Part of the Russian Federation”).

The financing was obtained in the frames of State Assignment from the federal budget without the attraction of additional financing sources. The authors confirm the absence of any conflict of interest.

References
[1] Olenev N O 1931 Parasitic Ixodid ticks of USSR fauna (Leningrad: Izdatetstvo AS USSR)
[2] Fernandez P J and White W R 2010 Atlas of transboundary animal diseases (France: OIE)
[3] Belimenco V V 2016 Protozoan diseases in pets (Moscow: Infra-M) DOI: 10.12737/17436
[4] Sirotkin M B and Korenberg E I 2018 Influence of abiotic factors on different developmental stages of the Taiga tick Ixodes persulcatus and the sheep tick Ixodes ricinus Entomological Review 98(4) 496-513. DOI: 10.1134/S0013873818040115
[5] Koster L, Lobetti R and Kelly P 2015 Canine babesiosis: a perspective on clinical complications, biomarkers, and treatment Veterinary Medicine: Research and Reports 6 119-28 DOI https://doi.org/10.2147/VMRR.S60431
[6] Makarov V V, Gusev A A, Guseva E V and Sukharev O I 2001 Epizootological lexicon (Moscow: Infra-M)
[7] Makarov V V, Svyatkovsky A V, Kuzmin V A and O I Sukharev 2009 Epizootological research method (Moscow: Infra-M)
[8] Uskov A N, Lobzin Yu V and Burgasova O A 2010 Tick-borne encephalitis, ehrlichiosis, babesiosis and other topical tick-borne infections in Russia Infection Diseases 2 83-8
[9] Korenberg E I, Sirotkin M B and Kovalyevskiy Yu V 2016 A general scheme of the circulation of ixodid tick-borne borrelioses pathogens in natural foci of Eurasia Zoological Journal 95(3) 283-99 DOI: 10.7868/S0044513416030090
[10] Belimenco V V, Khristianovsky P I, Novosad E V and Gulyukin A M 2019 Formation of hard ticks' biotopes on urban territories IOP Conf. Ser. Earth Environ. Sci. 315 042024
https://doi.org/10.1088/1755-1315/548/4/042024
[11] Gulyukin A M, Belimenko V V, Shabeykin A A, Droshnev A E and Laishevtsev A I 2020 Epizootological geo-information systems IOP Conf. Ser.: Earth Environ. Sci. 421 042013
https://doi.org/10.1088/1755-1315/421/4/042013
[12] Korenberg E I, Kovalevskiy Yu V, Gorelova N B and Nefedova V V 2015 Comparative analysis of the roles of Ixodes persulcatus and I. trianguliceps ticks in natural foci of ixodid tick-borne borrelioses in the Middle Urals, Russia Ticks and Tick-Borne Diseases 6(3) 316-21 DOI: 10.1016/j.ttbdis.2015.02.004
[13] Makarov V V, Vasilevich F I and Gulyukin N I 2014 Vector competence and ability of insect vectors Russian Journal of Parasitology 3(29) 38-47
[14] Novosad E V, Belimenko V V, Shamsheva O V and Rossina A L 2019 Clinical case of imported visceral leishmaniasis in a child in Moscow Pediatria 98(1) 250-3 DOI: 10.24110/0031-403X-2019-98-1-250-253
[15] Klaudsley-Thompson G 1982 Migrations of Animals (Moscow: MIR)