OPEN ACCESS Freely available online
http://www.banglajol.info/index.php/BJID/index
Original Article
Bangladesh Journal of Infectious Diseases
December 2023, Volume 10, Number 2, Page 77-84
ISSN (Online) 2411-670X
ISSN (Print) 2411-4820
DOI: https://doi.org/10.3329/bjid.v10i2.70629

Innovative Approaches for Ecological Monitoring Disease Outbreaks Carried by Horseflies (Diptera, Tabanidae): A Systematic Review

Elena Sivkova[1], Vladimir Domatskiy[2]

[1]Candidate of Biological Sciences, Researcher, ASRIVEA - Branch of Tyumen Scientific Centre SB RAS, Russia; [2]Doctor of Biological Sciences, Professor, ASRIVEA - Branch of Tyumen Scientific Centre SB RAS Russia

Abstract

Background: The spread and adaptation of horseflies to new habitats, driven by global climate change, threatens not only animal health but also human well-being. **Objective:** This article addresses the significant health risks posed by horseflies, which are known carriers of multiple pathogens causing up to 25 different infectious, parasitic, and viral diseases, including anthrax, tularemia, leptospirosis, and anaplasmosis. **Methodology:** The study provided an overview based on an extensive literature review from 1929 to 2022, analyzing both Russian and English publications. **Results:** The 2011 tularemia outbreak in Norway, linked to lemming population surges, and the higher susceptibility among men in Slovakia's annual tularemia cases highlight the role of animal reservoirs and gender in disease transmission. Leptospirosis, prevalent globally except in cold regions, is influenced by climate events, with significant public health impacts observed in various regions, including Russia and the Philippines following natural disasters. Anaplasmosis, transmitted by insects and ticks and more prevalent in warmer months, remains under-researched, with its rising threat exemplified by the growing ixodes tick population in Belarus. **Conclusion:** In conclusion, understanding the epidemiology and sources of these diseases, along with recognizing the environmental and anthropogenic factors that influence their transmission, is vital. The study underscores the importance of ongoing surveillance, research, and preventive measures to mitigate the impact of these infectious diseases on public health. [*Bangladesh Journal of Infectious Diseases, December 2023;10(2):77-84*]

Keywords: Horseflies; Vectors; Anthrax; Tularemia; Leptospirosis; Anaplasmosis

Correspondence: Elena Sivkova, Candidate of Biological Sciences, Researcher, ASRIVEA - Branch of Tyumen Scientific Centre SB RAS, Russia; **Email:** sivkovaei@mail.ru; Cell No.: +7 (345-2) 40-03-62; **ORCID:** https://orcid.org/0000-0002-2837-7235

Introduction

The harmful consequences of horseflies are aggravated by the fact that many of their species are carriers of pathogens of animal and human diseases (25 types of diseases) of infectious, parasitic, and viral origin: anthrax, tularemia, leptospirosis; anaplasmosis, infectious anemia of horses, necrobacteriosis of reindeer, besnoitia in cattle; setariosis; emphysematous carbuncle, polio, trypanosomiasis, su-aura, hemosporidiosis and many more[1, 2].

Global climate change impacts habitats of insects, including horseflies, which are carriers of dangerous infectious and invasive diseases. They develop new habitats and pose a threat to the health of not only animals but also humans. Thus, the risk of the spread of socially significant diseases is quite high and requires continuity of monitoring of the species composition of parasitic insects and the forecast of their numbers, especially in epizootically and epidemiologically disadvantaged territories. to assess the probability of the spread of diseases whose pathogens are transmitted by horseflies (diptera, tabanidae) in various territories of the Russian federation and abroad it is.

Methodology

Selection Process: This study focused on diseases transmitted by horseflies (Diptera, Tabanidae), particularly within the Russian Federation. Only diseases with substantial information available in literary sources were included. The eligibility criteria for selecting literature sources were based on relevance to the research topic, focusing on disease outbreaks attributed to pathogens carried by horseflies.

Information Sources: A comprehensive literature search was conducted using several databases: Russian Scientific Electronic Library, Cyberleninka, PubMed, WoS, and Scopus. The search strategy involved using primary keywords such as "horseflies," "vectors," "anthrax," "tularemia," "leptospirosis," and "anaplasmosis." The time frame for the literature search spanned from 1929 to 2022, ensuring a thorough historical perspective.

Data Collection Process: From the initial search, 221 entries were identified. This included 165 Russian-language publications and 56 English-language sources. Each source was meticulously reviewed to extract relevant data about disease outbreaks associated with horseflies.

Data Items: The extracted data from the selected sources primarily included information about the prevalence of diseases transmitted by horseflies. This encompassed details about specific diseases, their geographical occurrences, and the associated outbreaks within the defined study period.

Study Risk of Bias Assessment: A risk of bias assessment was conducted to evaluate the quality and reliability of the selected sources. This assessment aimed to ensure the credibility of the findings by identifying any potential biases in the selected literature.

Data Synthesis: The collected data were systematically analyzed and synthesized to provide an overview of the prevalence and characteristics of horsefly-transmitted diseases, primarily in the Russian Federation. This synthesis aimed to fill the gaps in existing literature about the role of horseflies as disease vectors.

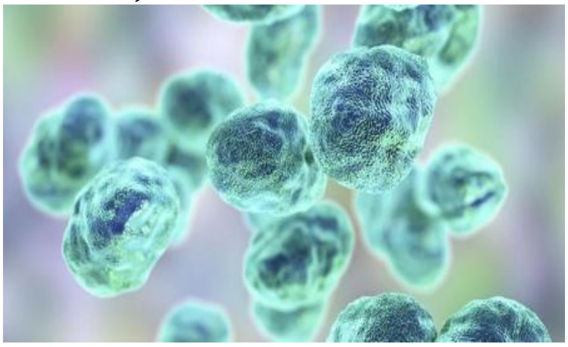
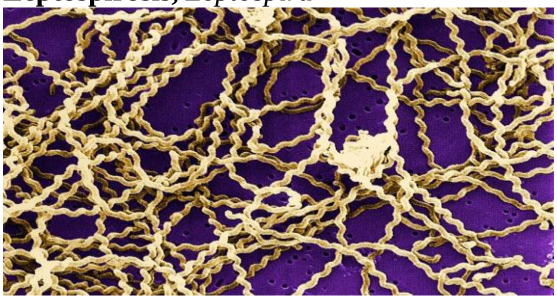
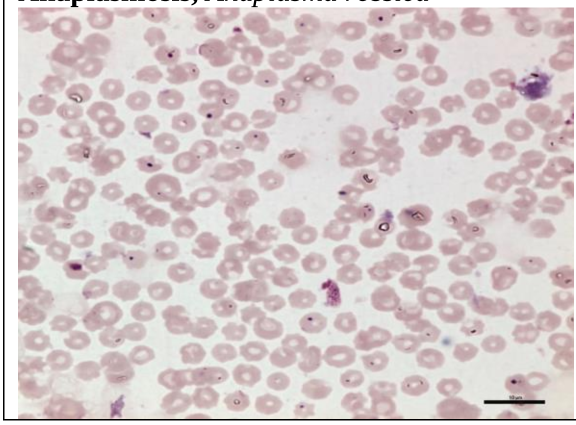
Results

Using the outlined methodology, the study yielded a comprehensive overview of the prevalence and characteristics of diseases transmitted by horseflies, particularly within the Russian Federation. It involved identifying and analyzing specific diseases such as anthrax, tularemia, leptospirosis, and anaplasmosis, which are known to be transmitted by horseflies, and examining their geographical distribution and occurrence, along with notable outbreaks over the period from 1929 to 2022.

This provided insights into the various factors contributing to the transmission and spread of these diseases, with a focus on the role of horseflies as vectors (Table 1).

Table 1: Outbreaks of Diseases and Factors Contributing

Disease, pathogen	Factors contributing to disease outbreaks	Major outbreaks
Anthrax, *Bacillus anthracis* 	• periods of mass flight of horseflies • prolonged presence of the pathogen in abiotic or biotic environmental objects	August 28 to September 27, 2011, southern regions of Basilicata and Campania, Italy

Tularemia, *Francisella tularensis* 	• vectors (blood-sucking arthropods) and feeders (rodents) constantly exchange tularemia pathogens • increase in temperature and change in pH in aquatic ecosystems • global warming	July – August 2005, Central Russia; June 26 to the beginning of October, 2010, Central Russia; August–September 2013, Khanty-Mansiysk, Russia; January to April 2011, Norway. May to September 2011, Norway
Leptospirosis, *Leptospira* 	• moderate average temperatures; • prevalence of open, intensively used reservoirs; • anthropurgic cycle of infection; • heavy rains	June – November 2014, Republic of Mordovia; September – October 2009, Manila, Philippines; 2000, Island of Borneo, Malaysia
Anaplasmosis, *Anaplasma rossica* 	• warm season; • parasitization of blood–sucking mites and insects	From April to October, annually, Tver region, Russia; From April to October, annually, Belarus

Discussion

Anthrax: Anthrax is an infectious disease, the pathogen of which is the spore-forming bacterium *Bacillus anthracis*. It is a zoonotic infection that usually affects herbivorous animals (such as cows, sheep and goats)[3]. Anthrax is transmitted from a sick animal to a person, rarely from one person to another. The primary source of the disease is herbivorous cattle. The pathogen of anthrax B. anthracis (translated as "coal stick") is excreted in urine and feces, getting into the ground. The humus-rich soil becomes an additional reservoir of the pathogen. New animals get sick by eating infected grass, hay or by drinking infected water. It is supposed that the focus of infection with the disease (the place where the main source of infection is located) is the soil. It can be primary – this is typical for direct infection of the soil (burying the corpses of infectious animals). Secondary foci of the disease are formed when burials are washed away, sewage breaks through and the pathogen enters new ground areas. Carriers of infection can be: pigs, in which the disease may not show symptoms; cattle; sheep; camels; horses; donkeys; deer[4]. The infection can be transmitted through the bites of blood-sucking insects. Horseflies carry the pathogen of the disease after contact with the corpse of an animal that died from anthrax. In some cases, transmission can take place by air, but through direct contact with animals, the infection does not go.

According to Trojan, it is known that 80% of cases of diseases of cattle with anthrax are due to the transfer of the pathogen by horseflies. *Bacillus anthrax* can persist in the body of horseflies for up to 5 days[5-8]. There are reports that outbreaks of this infection coincide with periods of mass flight of horseflies. K.P. Samko noted that along with the flight of horseflies, there was an increase in anthrax diseases in the vicinity of Tobolsk. *T. bovinus*, *H. lurida*, *H. bimaculata*, *H. lundbecki* and *A. rusticus* – horseflies that were spontaneously infected with the anthrax pathogens, were found in nature[9].

According to Lucia Palazzo, 28 anthrax outbreaks were registered in Italy on an area of about 50 km^2 between the southern regions of Basilicata and Campania from August 28 to September 27, 2011. Laboratory tests confirmed the presence of anthrax in cattle, horses and sheep. Genetic analysis of strains from infected animals showed that outbreaks in these two regions were not correlated. Interestingly, the incidence of horses was very significant compared to the incidence of cattle, sheep or goats, which were the predominant species in the animal population. In addition, in all infected horses and a large number of cattle a deadly subacute form of anthrax developed, characterized by the presence of massive edema, usually absent in the superacute form. The characteristics of these outbreaks suggest a possible role of horseflies as vectors in the transmission of *B. anthracis* -like epidemic infection[10].

Tularemia: Tularemia is an obligate natural focal, bacterial zoonosis that develops with intoxication, fever, lymphadenitis and damage to various organs. The pathogen of tularemia – *Francisella tularensis* is in the highest A category as a particularly dangerous pathogen. The microbe is stable in the external environment and distinct in contagious. Only 10-50 pathogens got into the human body through the respiratory tract is enough to cause the disease. The epidemiological features of this disease are associated with the natural infection of more than 100 species of vertebrates, mainly rodents. Preservation of the pathogen in nature and its transmission are possible through blood-sucking arthropods. Natural foci of tularemia are characterized by persistence, duration of existence and the ability to revitalize after many years of epizootic and epidemic calm, which is due the fact that vectors (blood-sucking arthropods) and feeders (rodents) constantly exchange tularemia pathogens. The leading role in maintaining the epizootic activity of natural foci of tularemia is attributed to water. Temperature and pH significantly influence the intensity and duration of the persistence of the tularemium microbe in aquatic ecosystems. Another risk factor affecting the maintenance of morbidity, according to experts, may be the climatic factor. Warming results in an increase in the number of rodents, an expansion of the areas of blood-sucking arthropods and an increase in their number[11]. The area of tularemia pathogen covers all landscape zones of the Northern hemisphere, and in the Russian Federation this infection is found in almost all regions, and in the north, it goes beyond the Arctic Circle to 71 ^{o}N. In Russia, from 100 to 400 cases of tularemia are registered annually, 75% of which are in the Northern, Central and Siberian regions of the country. The incidence of an outbreak nature is periodically recorded. Currently, there are six types of natural foci of tularemia in Russia. The list of types of tularemia carriers is compiled on the basis of data from long-term field studies in different regions of country and obtained from literary sources. 101 mammalian species were studied for tularemia, of which 56 species were highly susceptible and highly sensitive to the pathogen (group I) – 55.5±5.0% of the total number studied with a positive result from three groups differing in susceptibility and sensitivity to the pathogen of tularemia[12]. The reservoir of infection in natural foci – and there are 7 types of them (floodplain-swamp, meadow, forest, steppe (beam), foothill-stream, tugai and tundra) – also the source of infection of people are small rodents, as well as hares, muskrats, chipmunks. Infection happens in various routes: contact, alimentary, aspiration and facultative-transmissible. In the latter case, the pathogen does not develop in any way in the carrier and does not multiply, but is only kept for a period of time. Carriers are ticks, mosquitoes, horseflies and other blood-sucking diptera. Of these, horseflies are the most effective, both due to the structure of the oral apparatus, and because many of their species are most active in hot and dry weather[13, 14]. The incidence is sporadic, but there are local outbreaks. 53 and 128 patients were registered in Russia in 2011-2012. Vaccination is the most reliable way of prevention[15, 16]. The climatic risk factors for this disease are the same as for hemorrhagic fever with renal syndrome and leptospirosis − an increase in the number of rodents with warming, as well as the expansion of the areas of blood-sucking arthropods and an increase in their number, since the infection has a facultative-transmissible route of infection[17]. Transmission and contact transmission routes of infection are typical for summer, while aspiration – for late autumn, winter and spring.

In 2005, in July – August, there was an outbreak of tularemia, it was a classic transmissible, as evidenced by the high (more than 90%) specific gravity of skin-bubonic forms. All the sick Muscovites (139 people) were infected outside Moscow, either in various districts of the Moscow region (Shatura, Orekhovo-Zuevsky, Yegoryevsky), or in other regions of the center of Russia (Ryazan, Vladimir, Yaroslavl, etc.). All patients noted numerous bites by various insects (horseflies and midges) preceding the disease, because in the summer of 2005, a high number of blood-sucking diptera was noted. It is fundamentally important that there were no cases of recording the suction of ticks by the patients. Epidemic manifestations of tularemia infection led to a transmission epidemic outbreak in the summer of 2010 (40 cases), which affected a significant part of local residents and visitors. A significant number of sick children – 11 people aged 3 to 14 years – is worth paying attention. All patients were not vaccinated against tularemia, and the diseases were not related to their professional activities. The analysis of clinical manifestations (forms) of the disease, as well as the time of infection – summer 2010 (the beginning of the disease on 26.06, the last cases - the beginning of October 2010) indicate a predominantly transmissible mechanism of infection (in most cases caused by horsefly bites).

In August–September 2013, a transmission epidemic outbreak of tularemia was registered in the city of Khanty-Mansiysk, affecting 1005 people. Diseases of people were associated with their stay on the territory of the natural focus of tularemia. The high epizootic activity of the natural focus is confirmed by the isolation of cultures of the pathogen of tularemia, the detection of antibodies in the blood of many species of small mammals. The infection occurred both within the city and outside it. The sources of infection were small mammals, and the carriers were blood-sucking diptera[18].

Periods of outbreaks of tularemia among people in the lower reaches of the Ob coincided with the period of mass flight of *Chrysops relictus* twin-lobed deerfly (Isakov, Sazonova, 1946). The natural infection of horseflies with tularemia microbe was proven for females of the following species: *T. autumnalis, T. bromius, Hm. pluviakis*. Transmission of the tularemia pathogen from a sick or dead animal to a healthy one was experimentally proven for horseflies *Chr. caecutirns, Chr. relictus, T. bromius, T. autumnalis, H. ciureai, H. muehlfeldi, Hm. pluvialis, Hm. turkestanica*[19].

A major outbreak of tularemia was registered in Norway in 2011 (180 cases, the incidence rate was 3.7). It was associated with an increase in the number of lemmings and the spread of infection among them. From January to April, 57 anginal-bubonic cases of tularemia were registered caused by the use of water from private wells. From May to September, 40 cases of bubonic and ulcerative-bubonic tularemia were registered, in 15 cases those infected associated the disease with an insect bite[20].

On the territory of Slovakia, individual cases of tularemia are registered annually, among men 2 times more often than among women. The maximum incidence in the country falls in the month of July, the incidence rate per 100 thousand population ranges from 0.09 to 2.50. Epidemiological studies have shown that the main cause of infection is the contamination of food, indoor air, and animal feed by infected rodents (58.5%). Contacts with brown hares led to tularemia in 16.3% of cases. The proportion of cases of infection with ticks and insect bites was 12.8%, and in the remaining 12.4% of cases, the causes were not clarified[21].

Leptospirosis: Leptospirosis is an acute zoonotic infectious disease, its pathogen is bacteria of the genus *Leptospira*. Foci of infection at different times of the year are found almost everywhere, except in eternally cold places. World Health Organization includes Leptospirosis in the category of the most important infectious disease with which a person becomes infected by animals. Climatic and geographical conditions, in particular, moderate average temperatures and many open, intensively used reservoirs create favourable conditions for the natural circulation of the pathogen. During mild winters, active circulation and epizootics with high infection of rodents and predators continue in certain zones, which indicates the anthropurgic cycle of infection. The registered incidence of people reaches half of that in the country, mainly the Krasnodar Territory is disadvantaged (up to 89% of the incidence in the region). Hydrological phenomena that increase the weight of the water factor as the main risk factor for this "water-loving" infection certainly contribute to an increase in the intensity of the epidemic situation. So, in 1997, after heavy rains with flooding of vast territories, there was a peak increase in the incidence (more than 2.5 times higher than the endemic level). The forecast of the intensification of the epidemic process due to flooding in 2002 required the implementation of enhanced epizootic and epidemiological surveillance; within this framework a set of strict anti-leptospirosis measures (diagnostics, deratization, vaccination of animals) allowed to keep the epidemic situation under control and to prevent the aggravation of the situation[22-24].

A retrospective epidemiological analysis of the incidence of leptospirosis from 2001 to 2006 showed that the highest incidence was recorded in the Southern, Volga, Central districts with an average IP of 1,7±0,3, 1,0±0,3, 0,8±0,4, the share of the total incidence in Russia of 31.5; 27.6; 25.5%, respectively. In all 7 federal districts and in the whole country, there was a downtrend in the incidence of leptospirosis[25]. The pathogen of bovine leptospirosis (*Leptospira grippotyphosa*) in the body of horseflies *Hybomitra peculiaris, Haematopota pallens retains viability for 12 hours* without the additional intake of fresh blood into the intestine[26].

In 2014, an outbreak of leptospirosis happened in the Republic of Mordovia, where 45 people fell ill, 25 of them were hospitalized (the incidence rate was 5.5 per 100 thousand population). Cases of leptospirosis were observed in 7 districts of the republic and the city of Saransk. Epidemiologically, it is important that most patients were infected through the water. 15 patients (33.3%) consumed water from two springs in the village of Polyanka in the Oktyabrsky district of Saransk. In 28 cases (62.2%), the diseases are associated with bathing, drinking well water, in 4.4% a household route of infection was identified, in 4.4% – construction work, in 4.4% – visiting the forest, in 4.4% of cases, patients went fishing, in 2.2% – worked in the country, garden, in 2.2% – took care of animals, 2.2% visited the countryside. In 4.4% of cases, it was not possible to identify the source of infection. When distributing cases of diseases over a month, it was established that the outbreak of leptospirosis began in June – 12 cases (26.7%). In July, 19 cases (42.2%) were registered, in August – 4 (8.9%), in September – 9 cases (20%), in November – 1 case (2.2%)[27].

The probability of a sudden complication of the epidemiological situation increases many times in emergency situations like floods, earthquakes and so on. One of the largest outbreaks in current years which was 2,158 cases of diseases, including 167 deaths was registered in the Philippines (in Manila) shortly after two powerful typhoons and subsequent flooding in September – October 2009. Sporadic cases or group outbreaks of leptospirosis often occur during water sports events. An example is the "international" outbreak in Malaysia (on the island of Borneo) in 2000, when athletes from 27 countries of the world – participants in the multiathlon, which included canoeing – fell ill with a severe form of leptospirosis.

Anaplasmosis: Anaplasmosis is a transmissible disease characterized by fever of an unstable type, anemia, exhaustion. Carriers of anaplasmas are ixodes ticks and blood-sucking insects widespread on the globe, which largely determines the wide range of anaplasmas[28]. Anaplasmosis of cattle (the pathogen of *Anaplasma rossica*) is found everywhere. The experimentally proven carriers of the anaplasmosis pathogen are *Chr.divaricatus, Chr.relictus, T.bromius, T.bovinus, A.fulvus, H.bimaculata, H.lundbecki, Hm.pluvialis* [29].

The discovery and description in the first quarter of the twentieth century of the pathogens of anaplasmosis of cattle – *Anaplasma marginale, Theiler*, 1910 and *A. centrale, Theiler*, 1911; sheep – *A. ovis*, *Zestoguard*, 1924, gave impetus to numerous studies to identify the species composition, habitat, range of hosts, morphological and biological features of pathogens, to determine their nature, systematic position and pathogenic effects on the body of animals. However, to date, anaplasmosis is still an insufficiently studied animal disease.

Anaplasmosis is characterized by a certain seasonality due to the parasitization of blood–sucking mites and insects, and the disease is usually registered in the spring – summer - autumn period, epizootic outbreaks of anaplasmosis in winter are noted. Anaplasmosis was found in animals in 13 districts located in 4 zones of the Tver region (Vyshnevolotsk, Bezhetsky, Rzhevskaya, Torzhok)[30].

In Belarus, according to the Main Veterinary Department, 12 unfavourable points for anaplasmosis were identified. It should be taken into account that in recent years there has been a significant increase in the population of ixodes ticks, which are carriers of the pathogen of anaplasmosis, which, in turn, increases the risk of spreading the disease in the republic[31]. Blood-sucking insects can transfer anaplasm from one animal to another when feeding with blood, but pathogen does not reproduce in their body, so insects are considered mechanical carriers[32]. Carriers of anaplasmosis pathogens are argass (1 species) and ixodes (11 species) ticks, as well as mosquitoes, midges, horseflies, flies[33].

Conclusion

The presented data underscores the significance of zoonotic diseases and their spread in various regions, with specific focus on anthrax, tularemia, leptospirosis, and anaplasmosis. The 2011 tularemia outbreak in Norway correlated with a surge in lemming populations, highlighting the potential role of specific animal reservoirs in disease transmission. Similarly, Slovakia reports tularemia cases annually with men being twice as susceptible as women, and various sources of infection, including rodents and ticks, being identified.

Leptospirosis, a disease deemed critical by the World Health Organization, is present almost universally except in persistently cold regions. Climate events, such as flooding, exacerbate its prevalence, as seen in the 1997 epidemic post-heavy rains. However, a consistent downtrend in leptospirosis incidence was observed from 2001 to 2006 in Russia. The Republic of Mordovia's 2014 outbreak, where water sources were the primary means of infection, is a testament to its acute public health implications. Notably, emergency situations, such as floods and earthquakes, significantly heighten the risk of disease outbreaks, with the Philippines 2009 typhoon aftermath being a stark example.

Anaplasmosis, while a global concern due to its vectors, blood-sucking insects and ticks, still remains an inadequately studied disease in animals. Its seasonal occurrence, mainly during warmer months, underscores the role of environmental factors in its transmission. The recent increase in the ixodes tick population in Belarus emphasizes the escalating risk of anaplasmosis spread.

Acknowledgments
The article was prepared in accordance with the research plan for the program of fundamental scientific research of the Russian Academy of Sciences (No. 121042000066-6 “Study and analysis of the epizootic state of diseases of invasive etiology of agricultural and unproductive animals, bees and birds, changes in the species composition and bioecological patterns of the development cycle of parasites in conditions of displacement of boundaries their ranges”).

Conflict of Interest
Authors declare that there is no conflict of interest.

Financial Disclosure
The article was prepared in accordance with the research plan for the program of fundamental scientific research of the Russian Academy of Sciences (No. 121042000066-6 “Study and analysis of the epizootic state of diseases of invasive etiology of agricultural and unproductive animals, bees and birds, changes in the species composition and bioecological patterns of the development cycle of parasites in conditions of displacement of boundaries their ranges”)

Contribution to authors:
Elena Sivkova was involved in manuscript writing and data analysis; Vladimir Domatskiy involved in literature search, data collection; Elena Sivkova and Vladimir Domatskiy involved in revision of manuscript**.** All the authors reviewed and approved the final manuscript.

Data Availability
Any questions regarding the availability of the study's supporti ng data should be addressed to the corresponding author, who can provide it upon justifiable request.

Ethics Approval and Consent to Participate
Not Applicable

How to cite this article: Sivkova E, Domatskiy V. Innovative Approaches for Ecological Monitoring Disease Outbreaks Carried by Horseflies (Diptera, Tabanidae): A Systematic Review Bangladesh J Infect Dis 2023;10(2):x-x

ORCID
Elena Sivkova: https://orcid.org/0000-0002-2837-7235
Vladimir Domatskiy: https://orcid.org/0000-0002-3944-0121

Article Info
Received on: 7 November 2023
Accepted on: 21 November 2023
Published on: 1 December 2023

References

1. Sivkova EI. Veterinary and Medical Significance of Horseflies (Diptera, Tabanidae) (Review). In: Conceptual and Applied Aspects of Scientific Research and Education in the Field of Invertebrate Zoology; 2020 Oct 26-28; Tomsk, Russia. Tomsk: National Research Tomsk State University; 2020. p. 304-7
2. Sivkova EI, Domatskiy VN. Influence of Environmental Factors on the Fauna of the Blood-Sucking Horseflies (Diptera, Tabanidae). Int J Ecosyst Ecol Sci. 2022;12(4):251-8.
3. Domatsky VN, Fedorova OA, Siben AN. Epizootological and Epidemiological Significance of Blood-Sucking Diptera Insects in the Conditions of the Far North (Review). Russ Parasitol J. 2018;12(4):73-6.
4. Domatsky VN, Gavrichkin AA, Gavrichkina AA. Factors Influencing the Prevalence of Anthrax. In: Proceedings of the All-Russian Research Institute of Veterinary Entomology and Arachnology. Tyumen: Mayak; 2016;53:68-77.
5. Trojan P. Tabanidae Ocolic Warszawy (Diptera). Fragmenta Faunistica. 1955;7(4):199-207

6. Lelep PP. On the Question of the Importance of Horseflies in the Spread of Anthrax. Coll Sci Works Omsk Vet Inst. 1936;2:70-98
7. Olsufyev NG, Lelep PP. On the Importance of Horseflies in the Spread of Anthrax. In: Parasites, Vectors and Poisonous Animals. Moscow-Leningrad: All-Union Inst Exp Med; 1935. p. 145-97
8. Pavlova RP. Bioecological Foundations of Protection of Cattle from Horseflies (Diptera, Tabanidae). [dissertation]. Tyumen: All-Russian Research Institute of Veterinary Entomology and Arachnology; 2000. 38
9. Samko KP. Small Entomological Notes. Bull Soc Study Region Museum Tobolsk North. 1929;4:31-4
10. Palazzo L, De Carlo E, Santagada G, Serrecchia L, Aceti A, Guarino A, et al. Recent Epidemic-Like Anthrax Outbreaks in Italy: What Are the Probable Causes? Open J Vet Med. 2012;2(2):74-6
11. Titova LV, Samodova OV, Krieger EA, Gordienko TA, Kruglova NV, Shchepina IV, et al. Tularemia in the Arkhangelsk Region: Clinical and Epidemiological Characteristics. J Infectol. 2016;8(2):78-84
12. Tarasov MA, Porshakov AM, Kazakova LV, Kresova UA, Romanov RA, Sludsky AA. Modern Cadastre of Carrier Species of Tularemia Microbe in Foci of Different Types on the Territory of Russia. News Saratov Univ New Ser Ser Chem Biol Ecol. 2019;19(1):70-8
13. Pokrovsky VI. Guide to Zoonoses. Moscow: Medicine; 1983
14. Tarasov VV. Epidemiology of Vector-Borne Diseases. Moscow: Publ House Moscow State Univ; 2002
15. Yasyukevich VV, Titkina SN, Popov IO, Davidovich EA, Yasyukevich NV. Climate-Dependent Diseases and Arthropod Vectors: Possible Impact of Climate Change Observed in Russia. Probl Ecol Monit Ecosyst Model. 2013;25:375-94
16. Popov IO, Titkina SN, Semenov SM, Yasyukevich VV. Model Estimates of the Spread of Vectors of Some Human Diseases in the XXI Century in Russia and Neighboring Countries. Probl Ecol Monit Ecosyst Model. 2013;25:395-427
17. Lviv DK. Viruses and Viral Infections of Humans and Animals. Moscow: MIA; 2013
18. Nikiforov VV, Karetkina GN. Tularemia: From Discovery to the Present Day. Infect Dis. 2007;5(1):67-76
19. Isakov YA, Sazonova ON. On Some Patterns of Transmissible Outbreaks of Tularemia in Western Siberia. Med Parasitol Parasit Dis. 1946;15(1):75-83
20. Afset JE, Larssen KW, Bergh K, Larkeryd A, Sjodin A, Johansson A, et al. Phylogeographical Pattern of Francisella Tularensis in a Nationwide Outbreak of Tularaemia in Norway, 2011. Euro Surveill. 2015;20(19):21125
21. Gurycova D, Tinakova K, Vyrostekova V, Gacikova E. The Incidence of Tularemia in Slovakia in 1997-2008. Epidemiologie Mikrobiologie Imunologie. 2020;59(1):39-44
22. Popov VA, Samarina IV, Binatova VV. Leptospirosis. In: Laboratory Diagnostics of Pathogens of Dangerous Infectious Diseases. Saratov: Inst "Microbe"; 1998
23. Mezentsev VM, Kovalev NG. Outbreak of Leptospirosis in the Krasnogvardeysky District of the Stavropol Territory in 2001. In: Efremenko VI, editor. Actual Problems of Epidemiological Safety: Materials of the Anniversary Scientific and Practical Conference "Epidemiological Safety in the Caucasus. Results and Prospects." Stavropol: Stavropol Research Anti-Plague Inst; 2002. p. 173-7
24. Ministry of Agriculture and Food of the Russian Federation. Leptospirosis. In: Prevention and Control of Infectious Diseases Common to Humans and Animals: Collection of Sanitary and Veterinary Rules. Moscow: Goskomsanepidnadzor of Russia, Ministry of Agriculture and Food of Russia; 1996. p. 136-47
25. Toporkov VP, Velichko LN. Dynamics of the Incidence of Leptospirosis in the Federal Districts of the Russian Federation. Probl Particularly Dangerous Infect. 2008;2(96):22-5
26. Chirov PA. Slepni (Diptera, Tabanidae) of Kyrgyzstan (Ecological and Faunal Characteristics, Epizootological Significance, Control Measures). [dissertation]. Frunze: Kyrgyz Agricultural Inst named after K. I. Skryabin; 1986
27. Afrosina RV, Markosian NS. Epidemiological Features of Leptospirosis in the Republic of Mordovia. Sci Almanac. 2016;4-3(18):278-80
28. Abramov IV, Stepanova NI, Deacon LP, Grobov OF. Anaplasmosis of Animals. In: Anaplasmosis of Animals. Moscow: Kolos; 1965. p. 15-41
29. Krasikov AP, Rudakov NV. Epidemiological and Epizootological Features of Anaplasmosis in the Regions of Russia. In: Questions of Veterinary Surgery: International Scientific and Practical Conference Dedicated to the Day of Russian Science of the Omsk State Agrarian Univ named after P.A. Stolypin. Omsk: Litera; 2016. p. 87-96
30. Kazakov NA, Idina MF. Anaplasmosis of Cattle in the Tver Region. Vet Pathol. 2009;2:72-5
31. Tsvil EP. The Spread of Anaplasmosis Vector Ticks in the Minsk Region. In: Gusakov VG, editor. Youth in Science. Minsk: Izdatel'skiy dom “Belorusskaya nauka”; 2021. p. 120-2
32. Hristofis G, Belimenko VV. Anaplasmosis of Cattle. Russ Vet J. 2015;1:5-7
33. Kazakov NA. Sheep Anaplasmosis, Prevention and Control Measures. Vet Pathol. 2003;1(5):124-8