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Special Collection: Emerging and Lesser-Known Arboviruses Impacting Animal and Human Health

Emerging and lesser-known arboviruses impacting animal and human health

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Arboviruses (arthropod-borne viruses) are a class of viral pathogens that are transmitted by arthropod vectors in nature. They are responsible for many vector-borne diseases that continue to plague humans and animals and impact the health of ecosystems globally. The biological transmission of arboviruses generally occurs in nature between susceptible vertebrate hosts and hematophagous insects such as biting midges, mosquitoes, and ticks. The morbidity and mortality associated with vector-borne diseases have not lessened in recent years but continue to rise as a result of changes in climate, land use patterns, rapidity and frequency of worldwide human travel, increases in animal migrations and trade, and the continuing geographic range expansion of insect vector species.

In the United States, vector-borne diseases continue to increase annually, with the vast majority of reported cases being attributed to tick- and mosquito-borne pathogens (Rosenberg et al. 2018). Leading the number of reported cases are Lyme disease and West Nile virus (WNV) infections; however, it has been reported that the number of documented cases of these well-known pathogens is grossly underreported in the United States (Beard et al. 2019). According to the Centers for Disease Control and Prevention (CDC) the total number of Lyme disease cases may be 7 times higher than actually reported, and WNV infections may be underreported by a factor of 30–70 (Beard et al. 2019). Reasons for this discrepancy may range from a lack of familiarity with vector-borne diseases by clinicians, specific case definitions for disease (fever versus neuroinvasive), availability or desire for diagnostic tests, an arduous process for reporting cases, or simply the failure of patients to seek health care because of cost or severity of the disease.

If the most prevalent vector-borne diseases in the United States, such as Lyme disease and WNV, are underreported, it is almost certain that lesser-known arboviral diseases also suffer the same fate. Healthcare professionals have undoubtedly been exposed to at least a few facts about Lyme and WNV, but the etiological agents of diseases such as Bourbon, Cache Valley, Everglades, La Crosse, and Powassan, among many others, may be completely intangible. Furthermore, recent outbreaks of exotic pathogens in nonendemic locales have further exacerbated public health security and exposed socioeconomic gaps within public health infrastructures. The occurrence of exotic and resurgence of endemic vector-borne pathogens have been predicted to further rise in the coming decades. In an effort to address problems surrounding vector-borne pathogens, we have dedicated a series of Forum Articles for a special issue of the *Journal of Medical Entomology* titled "Emerging and Lesser-Known Arboviruses Impacting Animal and Human Health". It is our hope that this series of articles written by subject matter experts will further contribute to our understanding of these lesser-known arboviruses for the benefit of vector control personnel, clinicians, and public health stewards within a One Health approach. This issue will encompass some of the lesser-known arboviruses transmitted by biting midges (Diptera: Ceratopogonidae), mosquitoes (Diptera: Culicidae), and hard ticks (Ixodida: Ixodidae).

We start our special issue with an article by Hudson et al. (2023) on orbiviruses transmitted by Culicoides biting midges (Diptera: Ceratopogonidae) that impact the health of wildlife and domestic animals, including bluetongue virus, epizootic hemorrhagic disease virus, and African horse sickness virus. The authors provide a brief overview of the viruses, vectors, and hosts in light of global climate change and potential changes that may alter vector competence, viral genomes, incubation periods, dispersal, range expansion, and overall epidemiological impact. They end the article with a call for action, which will require an interdisciplinary approach to assess and mitigate future outbreak threats posed by these unique biting insects and the pathogens that they transmit.

Our next series of articles focuses on lesser-known arboviruses transmitted by mosquitoes (Diptera: Culicidae). We start this section with an article by Hughes et al. (2023) on Cache Valley virus (Peribunyaviridae), which is widely distributed in North America and is known to cause severe disease in animals and occasional illness in humans, yet little is known about the pathogen. The authors provide an overview of available virology, ecology, clinical disease in animals and humans, diagnostic techniques, and culminate by discussing gaps in current understandings of this pathogen and considerations

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for future research. The next article by Burkett-Cadena et al. (2023) discusses Everglades virus (Togaviridae), an alphavirus included in the Venezuelan equine encephalitis virus complex. The pathogen is currently only endemic to Florida within the United States, and muroid rodents are important vertebrate hosts. Although human infections from this arbovirus are currently rare, the authors discuss important topics surrounding virus evolution and future disease transmission cycles as impacted by the establishment and expansion of invasive mosquito species, habitat restoration, human land use alterations, climate change, and mammal community declines due to the invasive Burmese python (cover photograph for this special issue). Our next article takes us to a review of the epidemiology, ecology, and evolution of Jamestown Canyon virus (Peribunyaviridae), a largely underrecognized pathogen with a wide distribution throughout much of North America (Shepard and Armstrong 2023). This pathogen is primarily maintained in a mosquito-deer transmission cycle, but it also frequently infects humans, and disease cases appear to be on the rise, primarily in the north-central and northeastern United States. The authors discuss vector biology, virology, epidemiology, and ecology of the virus to better understand transmission cycles and the emergence of Jamestown Canyon virus as an agent of arboviral disease while posing remaining questions and debating future research directions. The next article by Day et al. (2023) provides an overview of La Crosse virus (Peribunyaviridae) and the longstanding deficiencies in disease surveillance, clinical diagnostics and therapeutics, actionable entomologic and environmental risk indices, public health response, and overall awareness. The authors argue that the virus is the most common cause of pediatric neuroinvasive mosquito-borne disease in the United States, yet little information is available to truly impact the morbidity and mortality associated with this pathogen. The authors provide an overview of the vector, virus, epidemiology, and discourse on current gaps and future opportunities, with a special emphasis on public health policy and action. The next article in the series is provided by Gibson et al. (2023) on the increasing threats from the Rift Valley fever virus (Phenuiviridae), a viral disease of humans and livestock that can cause mild to severe symptoms. Although the pathogen is currently endemic to Africa because of changing climate regimes, viral evolution, global commerce, and human/animal movement, the risk of introduction and potential impact from this lesser-known arbovirus are tremendous for the United States. The authors discuss current understandings surrounding the virus, vectors, hosts, epidemiology, modeling, and risk assessment and provide a crucial call to arms for sustained vigilance for the protection of public and veterinary health. Our last article on mosquito-borne transmitted arboviruses is presented by Walker and Yuill (2023) on snowshoe hare virus (Peribunyaviridae), which occurs primarily in the northern latitudes of North America. This enigmatic pathogen is primarily found in snowshoe hares; however, antibodies have been detected in other mammals, including humans. Additionally, encephalitis cases have also been reported in humans from Canada, but the potential role of this pathogen in human disease remains largely unknown. The authors provide a review of the mosquito vectors, viruses, and transmission cycles and conclude by drawing special attention to viral reassortment and a call for proactive surveillance measures to mitigate public, veterinary, and wildlife health implications.

Our last series of articles concentrates on the topics of lesser-known tick-borne viruses. Although tick-borne bacterial infections including Lyme disease, ehrlichiosis, Rocky Mountain spotted fever, and tularemia are generally well known, many other arboviruses transmitted by ticks remain elusive, despite recent recognition of increases in their prevalence. The first article by Dupuis et al. (2023) highlights 2 relatively new tick-borne viruses transmitted primarily by the lone star tick, *Amblyomma americanum* (L.) (Ixodida: Ixodidae). The authors provide an overview of Bourbon virus (Orthomyxoviridae) and Heartland virus (Phenuiviridae) which are both transmitted by *A. americanum*, cause similar disease manifestations and have been detected in the lower midwestern United States. The authors provide an overview of both viruses, discuss their ecology, epidemiology, virology, and further highlight current challenges for surveillance and control noting future direction needs for these 2 emerging tick-borne arboviruses. The next article by Harris et al. (2023) provides a review of Colorado tick fever virus (Spinareoviridae), an understudied tick-borne arbovirus of medical importance that can lead to severe infections in humans. The primary vector is the Rocky Mountain wood tick, *Dermacentor andersoni* Stiles (Ixodida: Ixodidae), which primarily occurs in the western United States and southern Canada. The authors provide an overview of the current known vector and virus information and identify vacancies in current research for the modern era. The last article on tick-borne arboviruses is provided by Brackney and Vogels (2023) on Powassan virus (Flaviviridae), a rare flaviviral pathogen also transmitted by hard ticks (Ixodida: Ixodidae). The authors highlight the recent increases in the incidence of this arbovirus and the high rates of morbidity and mortality associated with the disease. The manuscript reviews current knowledge of Powassan virus surveillance, ecology, and epidemiology and discusses major gaps in knowledge and alternative hypotheses about transmission dynamics, reservoir hosts in the wild, and spatial focality.

We hope that this special issue sheds additional light on some of the lesser-known arboviruses that may be increasing in incidence, distribution, and human or animal health impact. Our sincere objective in putting this special issue together was to provide additional information for vector control specialists, public health stewards, and clinicians on these pathogens and their vectors, with the ultimate aim of lessening their overall impact and reversing alarming trends associated with arboviral infections.

Author Contributions

Ary Faraji (Data curation [Equal], Writing—original draft [Equal], Writing—review & editing [Equal]), Goudarz Molaei (Writing—original draft [Equal], Writing—review & editing [Equal]), and Theodore Andreadis (Writing—original draft [Equal], Writing—review & editing [Equal])

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