1. Introducing the role of mosquitoes in the transmission of pathogens to wildlife

Rafael Gutiérrez-López[1,2], James Logan[3,4] and Josué Martínez-de la Puente[5,6]*
[1]Animal Health Research Center, National Food and Agriculture Research and Technology Institute (INIA-CISA-CSIC), Valdeolmos, 28130, Madrid, Spain; [2]Applied Zoology and Animal Conservation research group, University of the Balearic Islands, C/Valldemossa km 7.5, 07122 Palma, Spain; [3]Department of Disease Control, Faculty of Infectious and Tropical Diseases, London School of Hygiene and Tropical Medicine, Keppel Street, London, WC1E 7HT, United Kingdom; [4]Arctech Innovation, The cube, Londoneast-UK Business and Technical Park, Yew Tree Avenue, Dagenham RM10 7FN, United Kingdom; [5]Departament of Parasitology, University of Granada, Campus Universitario de Cartuja, 18071 Granada, Spain; [6]Centro de Investigación Biomédica en Red de Epidemiología y Salud Pública (CIBERESP), Madrid, Spain; rafael.gutierrez@inia.csic.es

Abstract

Mosquitoes play a central role in the transmission of pathogens causing important diseases to humans and other animals. The incidence of zoonotic diseases has increased in recent decades, many of them caused by pathogens transmitted by mosquitoes. Due to the relevance of these diseases in public and animal health, medical and veterinary entomologists have traditionally focused their studies on the impact of mosquitoes, among other vectors, in diseases such as malaria, West Nile fever or dengue. However, the relevance of mosquitoes in the transmission of pathogens affecting wildlife have been comparatively neglected. The current volume of *Ecology and Control of Vector-Borne Diseases* series highlights significant and novel aspects of the ecology of diseases transmitted by mosquitoes to wildlife, contributing to the better understanding of their epidemiology. We hope this volume will influence to improve our understanding of the dynamics of transmission of mosquito-borne diseases in the wild and provide updated information on the surveillance, control and epidemiology of mosquito-borne zoonotic diseases.

Keywords: arbovirus, One Health perspective, parasites, vector-borne diseases

The incidence of emerging infectious diseases (EIDs) has increased in the past three decades. Nearly 75% of these EIDs have a zoonotic origin, with pathogens naturally circulating in animal reservoirs and, accidentally, infecting humans (Taylor *et al.* 2001). Many of these zoonotic diseases are transmitted by insect-vectors, with mosquitoes playing a central role in their transmission (Pereira-dos Santos *et al.* 2020). Different factors affected by global change have been highlighted as relevant to explain the increase in the incidence of EIDs. The improved efficiency of transportation of materials and people worldwide, together with the introduction of invasive species and processes affected by the habitat anthropization, such as the land use change by deforestation and urbanisation, are driving the emergence of zoonotic diseases, most of them strongly affecting the life cycle, distribution and populations of mosquitoes involved in their transmission (Ferraguti *et al.* 2016).

Globalisation has favoured changes in the natural distribution of pathogens and animals, including mosquitoes, where their introduction or reintroduction may represent a risk to human and environmental health. Animals may carry pathogens and introduce them into new ecosystems with consequent deleterious effects on wildlife/domestic populations and changing the ecological

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balance in an area. In the case of mosquitoes, their introduction in new areas could produce human disturbances due to their bites, but more importantly, may affect the epidemiological scenario of different pathogens allowing their transmission in areas where competent vectors were previously absent. One of the main examples of that is the introduction of the avian malaria parasite *Plasmodium relictum* and their mosquito vectors in Hawaiian Islands, allowing their circulation in the area which highly contributed to the decline of native bird species (Atkinson *et al.* 2010). Imported materials such as tires and/or bamboo, have been recognised as a major factor determining the global spread of *Aedes albopictus* mosquitoes where it plays a key role in the transmission of pathogens in introduced areas. In Europe, *Ae. albopictus* contributed to the transmission of locally circulating parasites, such as *Dirofilaria immitis* in Italy (Cancrini *et al.* 2003), and imported pathogens affecting humans including Dengue virus (Aranda *et al.* 2018), Zika virus (Brady and Hay 2019) and Chikungunya virus (Watson 2007).

One of the main factors affecting the transmission dynamics of pathogens by mosquitoes is their blood feeding patterns (Takken and Verhulst 2013). The blood feeding habits of mosquitoes have been known since, at least, the Middle Eocene, as supported by the use of non-destructive mass-spectrometry analysis to identify the host´s oxygen-carrying group of haemoglobin present in the abdomen of fossil mosquitoes (Greenwalt *et al.* 2013). Nowadays, the use of molecular techniques applied to the study of recently engorged females have revealed the ability of mosquitoes to feed on blood from a diversity of animals, from ectotherms including amphibians and fishes to birds and mammals, including humans. For example, *Ae. albopictus* females feed on blood from fish, birds and mammals with, at least, 20 mammal and 5 bird host species identified in their blood meals (Cebrián-Camisón *et al.* 2020). Consequently, mosquitoes are able to transmit pathogens to different taxa. For instance, in addition to the previously mentioned avian malaria parasites, birds are common hosts of mosquito-borne pathogens including nematodes and viruses, some of them considered zoonotic. Amphibians and reptiles also harbour a wide variety of vector-borne pathogens with mosquitoes playing a key role as vectors involved in their transmission (Matta *et al*. 2022; Chapter 3 of this book).

The ability of mosquitoes to feed on different vertebrate species further supports their role in the ability of transmission of pathogens between them, affecting the epidemiology of different diseases. Zoos and wildlife parks are excellent scenarios to study the patterns of parasite transmission, as they host animals maintained in captivity, native wild animals and human visitors. In addition, they provide suitable environments for the breeding and maintenance of mosquito populations potentially favouring the transmission of mosquito-borne pathogens (Heym *et al.* 2019). Penguins are common hosts of mosquitoes, including those carrying avian *Plasmodium* parasites (Martínez-de la Puente *et al.* 2020) which produce deleterious effects on these animals supporting the necessity to develop treatment protocols (Grilo *et al.* 2016).

Altogether, these examples represent the necessity to improve our knowledge on the ecology of mosquito-borne diseases that affect wildlife which is the main aim of the chapters included in this seventh volume of *Ecology and control of vector-borne diseases*. This volume uses a multidisciplinary approach to provide a general overview of the importance of diseases affecting wildlife from different disciplines from conservation biology to public health, considering the *One Health* paradigm.

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