



Review Paper

The Invasive *Aedes* Mosquitoes (Diptera: Culicidae) and Their Medical and Veterinary Importance: A Mini Review



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ABSTRACT

The present article briefly introduces and describes the terminology which is used for 'non-native' and 'invasive' species. Also, six invasive *Aedes* species (Diptera: Culicidae) in which two species, *Ae. aegypti* and *Ae. albopictus*, are recorded in Iran and their medical and veterinary importance are discussed.

Keywords: *Aedes aegypti*, *Aedes albopictus*, *Georgecraigius*, *Hulecoeteomyia*, *Rampamyia*, *Stegomyia*

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The biting nuisance of mosquitoes (Diptera: Culicidae) and their transmission of different pathogens makes them the most important arthropods in medical entomology and public health [1].

The family Culicidae includes two subfamilies, Anophelinae and Culicinae, and the latter is subdivided into 11 tribes. The family consists of 41 or 113 genera, depending on the classification of the tribe Aedini, with a total of 3,719 species [2]. The most recent major change in the mosquito taxonomy is the removal of the subspecies from culicid classification [3]. Some 170 species of mosquitoes (about 5% of formally recognized species) are pests, invasive or medically important [4].

At least 37 species of mosquitoes (about 1% of recognized species) are 'non-native', of which 12 are 'invasive' species [5-11]. Juliano & Lounibos [5] listed 31 'non-native' species in which nine were 'invasive'. After that publication, three additional 'non-native' species, *Aedes flavopictus* Yamada [8], *Ae. triseriatus* (Say) [6, 7] and *Ae. vittatus* (Bigot) [9, 12], and three 'invasive' species, *Ae. koreicus* (Edwards) [6, 7], *Anopheles stephensi* Liston [11, 13, 14] and *Culex coronator* Dyar & Knab [10], were added to the list.

In general, the 'introduced' species, which have entered a new region beyond their native range via a 'route' or 'pathway' and become 'established', but have neither 'spread' rapidly and widely nor have important 'impact' on humans, are known as 'alien', 'colonizer', 'exotic', 'naturalised', 'non-native' or 'nonindigenous' species [5, 15-17]. Because of a lack of consensus on the use of the aforementioned terms, Lounibos [15] and Juliano & Lounibos [5] preferred using 'nonindigenous' and 'non-native', respectively, and avoided the other terms. In contrast, 'invasive' species, or 'invaders', are those 'introduced' and 'established' species that 'spread' rapidly and widely and have important 'impacts' (especially in a negative way) on other species, ecosystems, environments, human and animal health and economy. Those impacts are primarily through biotic interactions, including predation, parasitism, interspecific competition and ecosystem engineering [5, 15-17].

A biological invasion is characterized by three stages: 'arrival' or 'introduction', 'establishment' and 'spread' [5, 15]. The main 'routes' or 'pathways' of invasion of 'non-native' *Aedes* species are: The used tire trade, lucky bamboo trade, public/private passive transportation (by aircraft, ground vehicle or maritime sea traffic) and (active) natural dispersal [6, 18-20].

Juliano & Lounibos [5] studied some main characteristics of 'non-native' and 'invasive' mosquito species. They found that 'desiccant-resistant eggs' and 'development in small man-made containers, tree holes, bromeliads or rock pools' are common among 'non-native' species, but are not significantly associated with becoming 'invasive'. In contrast, 'occupying human-dominated habitats (urban, suburban and domestic)' is significantly more common among 'invasive' than 'non-native' mosquitoes.

Six main known invasive *Aedes* species include *Ae. (Georgecraigius) atropalpus* (Coquillett), *Ae. (Hulecoeteomyia) japonicus* (Theobald), *Ae. (Hulecoeteomyia) koreicus*, *Ae. (Rampamyia) notoscriptus* (Skuse), *Ae. (Stegomyia) aegypti* (Linnaeus) and *Ae. (Stegomyia) albopictus* (Skuse) [5-7]. More information for these species follows.

Aedes (Georgecraigius) atropalpus, the American rock pool mosquito or black-lipped American pointy mosquito (Type locality: Plummers Island, Montgomery County, Maryland, United States) is native to the eastern United States and Canada and has invaded Europe (France, Italy, Switzerland and the Netherlands) [4, 21]. However, the rapid intervention of control treatments avoided the establishment of the species and today there are no known established populations of *Ae. atropalpus* in Europe [22]. Females bite different species of mammals, including humans, and birds [21]. This species is a vector of eastern equine encephalomyelitis, Japanese encephalitis, La Crosse, Murray Valley encephalitis, St. Louis encephalitis, Venezuelan equine encephalitis, western equine encephalitis and West Nile viruses [4].

Aedes (Hulecoeteomyia) japonicus, the Japanese bush mosquito, Asian rock pool mosquito or Tokyo Japanese pointy mosquito (Type locality: Tokyo, Japan) is a highly 'invasive' species which has extended its distribution from its native range (Korea and Japan) to many Asian, European and North American countries [4, 23, 24]. Females bite different species of mammals and birds, with preference for mammals, and humans represent some 36% of the source of blood for females of this species [25]. This species is a known vector of dengue, chikungunya, Cache Valley, eastern equine encephalomyelitis, Japanese encephalitis, La Crosse, Orungo, Rift Valley fever, St. Louis encephalitis, western equine encephalitis and West Nile viruses [4]. Additionally, laboratory studies have demonstrated some vector competence for Usutu and Zika viruses and the microfilariae of *Dirofilaria immitis* and *D. repens* [24].

Aedes (Hulecoeteomyia) koreicus, the Korean bush mosquito or Joseon Korean pointy mosquito (Type locality: Korea), native to eastern Asia (northeastern China, southern Russia, the Korean Peninsula and Japan), has invaded other Asian (Kazakhstan) and European countries (Austria, Belgium, European Russia, Germany, Hungary, Italy, Slovenia, Switzerland and the Netherlands) [4, 26, 27]. It is shown that females bite dogs, cows and humans, but human blood represents over 90% of blood meals [25]. In contrast, in a study in Europe, blood meals were mostly taken from roe deer (63.2%) in forested areas and from humans (15.4%) in urban areas, and fewer blood meals from avian and lizard hosts [28]. This species is a vector of Japanese encephalitis virus and the microfilariae of *Brugia malayi* and *Dirofilaria immitis* [4]. Additionally, it has been experimentally demonstrated that the species can vector chikungunya and Zika viruses [27].

Aedes (Rampamyia) notoscriptus, the Australian backyard mosquito or scriptwriting Australian pointy mosquito (Type locality: Sydney, New South Wales, Australia) is an Australasian species which has been introduced into New Zealand and the United States as an 'invasive' species [4, 5, 29]. This species is an aggressive biter and bites different species of mammals (brush-tail possums, cats, dogs, flying foxes and humans) and birds [4]. The species is a known vector of Barmah Forest, chikungunya, dengue, Ross River and Whataroa viruses and the microfilariae of *Dirofilaria immitis* [4]. Also, various degrees of vector competency have been demonstrated for Japanese encephalitis, Rift Valley fever, West Nile and yellow fever viruses [29].

Aedes (Stegomyia) aegypti, the yellow fever mosquito or yellow fever Malaysian pointy mosquito (Type locality: Kuala Lumpur, Selangor, Malaysia) is cosmopolitan. It originated in Africa but it is now firmly established in many parts of the world as a known 'invasive' mosquito [4]. Females bite different species of mammals and birds, with preference for mammals, but humans represent the most important source of blood meals (93%) for this species [25]. *Aedes aegypti* is the primary vector of yellow fever, dengue fever, chikungunya, West Nile, Zika and many other viruses [4]. Also, *Plasmodium gallinaceum* and *P. lophurae* have been isolated from this species [4]. It is also a known vector of microfilariae of *Dirofilaria immitis* [30].

Aedes (Stegomyia) albopictus, the Asian tiger mosquito (Type locality: Calcutta, India) is cosmopolitan and a known 'invasive' mosquito, although originally confined to the Oriental Region [1]. Females bite many

different species of amphibians, birds, fishes, mammals and turtles, with preference for mammals, and humans represent about 60% of the blood meals [25]. It is of significant medical and veterinary importance as a vector of at least 22 arboviruses, the most important of which are chikungunya, dengue, Japanese encephalitis, Sindbis, West Nile, yellow fever and Zika viruses [31]. Additionally, *Dirofilaria immitis*, *Plasmodium gallinaceum*, *P. fallax* and *P. lophurae* have been isolated from this species [4].

There are two old records of *Ae. aegypti* in southern Iran, including Kuzistan Province [32], as *Stegomyia fasciata*, and Bushehr Province [33]. Recently, the species was reported in Hormozgan Province and Sistan and Baluchistan Province of southern Iran (Nejati, personal communication).

Aedes albopictus was recorded in Sistan and Baluchistan Province of southeastern Iran, based on six adults and five larvae [34]. However, since then the species has not been collected in the province or other areas of southern Iran [35-38]. Therefore, it seems that the species was not established in that region. Another hypothesis might be misidentification. Recently, the species has been found in Guilan Province of northern Iran (Azari-Hamidian et al. in press). The mosquito fauna of Guilan Province includes 33 species representing seven genera [39]. Thus, the culicid fauna of the province increases to 34 species.

It is noteworthy that two species of the subgenus *Stegomyia* occur in Iran and/or the western Palearctic Region that are not 'invasive'. *Aedes cretinus* Edwards occurs in Cyprus, Georgia, Greece, Lebanon, Macedonia, Turkey, Russia and Ukraine [4]. The females of *Ae. cretinus* are distinguished from those of *Ae. albopictus* using the ornamentation of the thorax [40]. *Aedes cretinus* is not a medically important species. Another species, *Aedes unilineatus* (Theobald), is distinguished from *Ae. albopictus* using characters of the thorax and legs [41]. This species is found in the Afrotropical, Oriental and Palearctic Regions [1]. In the Middle East, it occurs in Iran and Saudi Arabia [1, 4]. *Aedes unilineatus* is a potential vector of Zika virus [42]. Damaged specimens of the two aforementioned species may be misidentified as *Ae. albopictus*. Additionally, there are some similarities between *Ae. albopictus* and the other invasive species mentioned above (*Ae. aegypti*, *Ae. japonicus* and *Ae. koreicus*), but well-preserved specimens can be morphologically distinguished using available identification keys.

In view of the recent finding of two very important invasive *Aedes* mosquitoes in both northern and southern areas of Iran, it is essential to engage the national surveillance program for monitoring their populations and interventions for their control.

Ethical Considerations

Compliance with ethical guidelines

This article is a narrative mini-review with no human or animal sample. There were no ethical considerations to be considered in this work.

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Conflict of interest

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