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Review Article

A review on the mosquitoes with epidemiological concern in Morocco: geographic distribution, bio-ecology, and public health risks

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Abstract. The spread and establishment of invasive mosquitoes (Diptera: Culicidae) have drawn increasing attention in recent years, particularly the introduction of *Aedes albopictus*. In Morocco, multiple species occur and are recognized as vectors or potential vectors of several arboviruses (dengue, chikungunya, Rift Valley fever virus, and West Nile virus). Some species have been established for decades (*Ae. aegypti*, *Ae. vexans*, *Ae. caspius*, *Ae. detritus*, and *Culex pipiens*), while others are invasive newcomers (*Ae. albopictus*). This review provides an overview on each mosquito species, their geographic distribution (from 1916 to 2025), bio-ecology, involvement in arbovirus transmission, and emphasizes the need for increased monitoring efforts and control.

Keywords: Vector-borne diseases, Arthropod-borne viruses, Public health, Emergence, Maps

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Introduction

Vector-borne diseases have a devastating impact on animal and human health. According to the World Health Organization (WHO), vector-borne diseases account for more than 17% of all infectious diseases and cause more than one million human deaths per year (Fournet *et al.*, 2018). These diseases are transmitted between humans or from animals to humans via a competent vector organism. The most common vectors are bloodsucking arthropods (mosquitoes, ticks, flies, etc.) that ingest pathogens (viruses, parasites, etc.) during a blood meal from an infected host and then transmit them to a new host with a subsequent blood meal (Mayer *et al.*, 2017).

In recent years, vector-borne diseases, particularly those caused by mosquito-borne arboviruses, have experienced a worrying resurgence. Since their discovery, the number of arboviruses has continued to increase and expand geographically (Gould *et al.*, 2017). Current data reports more than a hundred different types of mosquito-borne viruses are involved in human pathologies such as chikungunya (CHIKV), dengue (DENV), Zika (ZIKV), Rift Valley fever (RVFV), and West Nile virus (WNV) (Braack *et al.*, 2018).The frequency and intensity of arbovirus outbreaks are expected to increase throughout the 21st century due to globalization, human population growth, climate change, and the availability and expansion of mosquito vectors (Flores & O'Neill, 2018). It is estimated that more than 82% of the world's population already lives in areas at risk of at least one arbovirus disease, with more than half at risk of two or more (Golding *et al.*, 2015). The risk of infection is particularly high in areas where *Aedes* and *Culex* mosquitoes proliferate due to the presence of favorable habitats and close contact with humans (Liang *et al.*, 2015). Morocco's mosquito inventory includes 43 species belonging to seven genera and 18 subgenera. The most represented genera are *Aedes* and *Culex* (12 species), followed by the genera *Anopheles* (nine species) and *Culiseta* (5 species). The genera *Coquillettidia* and *Uranotaenia* are represented by only two species and the genus *Orthopodomyia* by only one species (Trari, 2017). Of these 43 species, six are implicated as the main vectors of many arboviruses: *Ae. aegypti* (Linnaeus, 1762), *Ae. albopictus* (Skuse, 1895), *Ae. vexans* (Meigen, 1830), *Ae. caspius* (Pallas, 1771), *Ae. detritus* (Haliday, 1833), and *Cx. pipiens* (Linnaeus, 1758). With increasing globalization and the landscape of emerging pathogens constantly changing, knowledge of potential vector species, their current geographic distribution, and their involvement in arbovirus transmission is essential for a thorough understanding of human health risk and for preparation for future threats.

Important mosquito-borne arboviruses detected in Morocco

Dengue virus

(DENV; Family: Flaviviridae, genus: Flavivirus) is an arbovirus ubiquitous in the tropics that is vectored to humans through the bites of infected female mosquitoes, mainly *Ae. aegypti* (Apodaca-Medina *et al.*, 2018). Other species of the genus *Aedes* may also act as vectors, such as *Ae. albopictus*, *Ae. vittatus* (Bigot, 1861), *Ae. polynesiensis* (Marks, 1951), *Ae. scutellaris* (Walker, 1859)*, and Ae. japonicus* (Theobald, 1901) (Mavale *et al.*, 1992; Carrington & Simmons, 2014; Brustolin *et al.*, 2018). Dengue virus is transmitted both in urban areas (human transmission cycle) and in forest/rural areas (sylvatic transmission cycle). These two cycles of transmission are different from an ecological and Evolutionutionary point of view. In urban areas, transmission occurs between humans, while in forested areas, transmission occurs between non-human primates with occasional spillovers into human populations (Carrington & Simmons, 2014).

The global incidence of dengue and serious clinical presentations have increased significantly over the past five decades. Approximately 50 to 200 million infections, 500,000 episodes with serious complications, and more than 20,000 dengue-related deaths occur each year (Guo *et al.*, 2017). Moreover, this disease has become endemic in more than 100 countries in Africa, the Americas, Eastern Mediterranean, Southeast Asia, and Western Pacific. It is estimated that up to 3.6 billion people now live in areas where dengue virus can be transmitted (Brady *et al.*, 2012). In Morocco, two imported cases of dengue fever were reported in 2017 in two patients, both travelling from the Ivory Coast, a Moroccan and an Ivorian who were staying in Abidjan during a 2017 outbreak (Bajjou *et al.*, 2018). A field-collected strain of *Ae. albopictus* from Morocco in 2016 was experimentally infected with dengue DENV and showed moderate transmission potential, with virus detected in saliva at day 14 post-infection. These results indicate that local DENV transmission by invasive *Ae. albopictus* in Morocco is a plausible risk (Amraoui *et al.*, 2019).

Chikungunya

(CHIKV; Family: Togaviridae, genus: Alphavirus) is an arbovirus that causes debilitating arthritis and arthralgia in infected humans (Vu *et al.*, 2017). CHIKV has caused explosive epidemics across multiple continents, including major outbreaks in the Indian Ocean (2005-2006), India (2006), and the Caribbean, demonstrating its rapid global expansion from African origins (Henry *et al.*, 2017). Similar to dengue, chikungunya virus is maintained in a sylvatic transmission cycle that occurs between various forest *Aedes* mosquitoes (*Ae. taylori* (Edwards, 1936), *Ae. luteocephalus* (Newstead, 1907), *Ae. africanus* (Theobald, 1901) and *Ae. neoafricanus* (Cornet, Valade & Dieng, 1978)) and animal reservoirs, with non-human primates being the main reservoir host (Coffey *et al.*, 2014). Urban transmission is primarily mediated by *Ae. aegypti* and *Ae. albopictus* mosquitoes and occurs in a human-mosquito-to-human transmission cycle. While enzootic forest transmission of CHIKV is well-established in Africa, outbreaks in Asia have been primarily attributed to urban transmission (Weaver *et al.*, 2020). In Morocco, only one imported case of chikungunya was reported in 2017. The case was a 37-year-old woman who returned to Morocco after 18 months in Dhaka Bangladesh where she acquired the infection (Bajjou *et al.*, 2017). The same Moroccan field-collected *Ae. albopictus* strain (2016), that showed moderate DENV transmission capacity, demonstrated high competence for CHIKV, with infectious virus detected in saliva as early as 3 days post-infection (Amraoui *et al.*, 2019).

Rift Valley Fever virus

(RVFV; Family: Phenuiviridae, genus: *Phlebovirus*) is a long-recognized disease of humans and domesticated livestock in sub-Saharan Africa but has crossed several barriers including Arabian Peninsula, and some Indian Ocean Islands (Sumaye *et al*., 2019; Ngoshe *et al*., 2020). Humans and livestock (cattle, sheep, goats, and camels) are primarily exposed to the virus through the bite of infected mosquitoes, particularly those from the genera *Aedes* and *Culex* (Tantely *et al*., 2015). The virus still circulates at common borders with Mauritania (southern Morocco) where multiple outbreaks occurred in 1987, 1993, 2003, 2010, and 2012, resulting in numerous animal deaths as well as human fatalities (Caminade *et al*., 2014). The Moroccan Veterinary Services conducted a serological study on 100 camels in 2010, and 50 of them tested positive for RVF-specific antibodies by competitive ELISA, which was later verified by virus-neutralization (El-Harrak *et al*., 2011).

West Nile virus

(WNV; Family: Flaviviridae, genus: *Flavivirus*) was initially identified in 1937 in the West Nile district of Northern Uganda from a febrile patient (Smithburn *et al*., 1940). Since then, the virus has been recorded in over 83 countries throughout the world, making it one of the most widely spread arboviruses (Chancey *et al*., 2015; Al-Jabi, 2017). A cycle of transmission between mosquitoes and birds maintains the virus in nature, whereas people and horses have been accidently infected, but are considered dead-end hosts since they do not contribute significantly to its illness spread. The main amplifying hosts and vectors that significantly contribute to the re-emergence and worldwide spread of WNV are birds and mosquitoes (*Culex* and *Aedes*) (Komar *et al*., 2003; Levine *et al*., 2017; Soltész *et al*., 2017; Rochlin *et al*., 2019). Morocco has experienced multiple outbreaks of WNV. The first one was reported in 1996 in Benslimane region and resulted in the death of 42 horses (among 94 equine confirmed cases) and one-person (Benjelloun *et al*., 2017). In the second incident, WNV spread among horses (5 deaths out of 9 equine cases) in September and October of 2003 in three locations: Mograne, Ameur Seflia, and Ouled Slama (Schuffenecker *et al*., 2005). The virus returned to the central and northwest regions (Mohammedia, Casablanca, Benslimane, and Khemisset) in 2010 and resulted in the death of eight horses and 17 confirmed cases (out of 111 suspected cases) (Benjelloun *et al*., 2016). Wild birds serosurvey (Figuerola *et al*., 2009), WNV-specific antibodies detection in camels and humans (El-Harrak *et al*., 2011; El Rhaffouli *et al*., 2012; Harrak *et al*., 2016), laboratory susceptibility and natural infection of *Cx. pipiens* (Amraoui *et al*., 2012a; Assaid *et al*., 2020), all provided evidence that WNV was widely circulating in Morocco.

Important mosquitoes found in Morocco

Aedes aegypti

Aedes aegypti (Linnaeus, 1762) is commonly referred to as the yellow fever mosquito (Reinert et al., 2004). Native to sub-Saharan Africa, its ancestral form was a sylvatic zoophilic mosquito called *Ae. aegypti formosus* which exclusively bit animals and laid eggs in tree holes (Powell & Tabachnick, 2013). *Aedes aegypti*, the domestic form, was introduced into the new world from Africa during the seventeenth century by ships and the slave trade (Brown *et al*., 2014). Since then, the species has spread globally. Currently, it is distributed in the tropical and subtropical regions of Africa and South America, the southeastern United States, the Middle East, Southeast Asia, the Pacific Islands, India, and northern Australia (Medlock *et al*., 2015).

Until the first half of the 20th century, *Ae. aegypti* was previously established in southern Europe and the Mediterranean basin (Schaffner & Mathis, 2014). It had been reported in Azerbaijan, Cyprus, France, Georgia, Greece, Italy, Malta, Portugal, southern Russia, Sardinia, Spain, Turkey, Algeria, Egypt, Libya, and Morocco (Schaffner & Mathis, 2014; Medlock *et al*., 2015). More than 50 years later and for unknown reasons, it has disappeared from most of these countries and was even presumed probably extinct (Kotsakiozi *et al*., 2018). *Aedes aegypti* was reintroduced in 2001 in the Sochi region of Russia and then in 2005 on the Portuguese island of Madeira (Iunicheva Iu *et al*., 2008; Ibañez-Justicia *et al*., 2017; Abozeid *et al*., 2018; Akıner *et al*., 2019; Seixas *et al*., 2019). In Morocco, *Ae. aegypti* was once very common throughout the Moroccan coastline (Fig. 1), especially in the cities of Rabat and Casablanca (Vialatte, 1923). This species has also been found in Tangier (Charrier, 1924), Salé, and Marrakech (Gaud, 1953). The last available notification documenting its presence in Morocco was in 1997, when its larvae were collected in the Sebkha Chemaia, central Morocco (Vialatte, 1923; Charrier, 1924; Gaud, 1953; Handaq, 1998).

Larval habitats

Unlike its ancestral form that laid eggs in tree holes, *Ae. aegypti* preferentially deposits its eggs in artificial larval habitats of anthropogenic origin. Most often, females do not lay their entire batch of eggs in one shot and one place, but rather choose to lay a few eggs in several separate nests (skip-oviposition), which ensures greater dispersion of offspring and reduces competition (Oliva *et al.*, 2014; Ferede *et al.*, 2018). The larval habitats are of various kinds: used tires, buckets, small plastic containers, barrels, flower pots, saucepans, jars, and even abandoned school cabinets (Ferede *et al.*, 2018). This diversity of larval sites used is a testament to its great adaptability to different environmental conditions.

Trophic behavior

Aedes aegypti mosquitoes prefer mammalian hosts and will preferentially feed on humans, even in the presence of alternative hosts (Jansen & Beebe, 2010; Cebrián-Camisón *et al.*, 2020). It prefers to enter human dwellings that offer opportunities for searching a potential target. Females appear to bite during day and night, with peak activity at dawn and dusk in warm regions (Captain-Esoah *et al.*, 2020).

Medical importance

Aedes aegypti is the main vector of yellow fever virus (YFV), DENV, CHIKV, Mayaro (MAYV), Uganda S (UGSV), and ZIKV (JPT, 1958; Lourenco-de-Oliveira *et al.*, 2002; Li *et al.*, 2012; Ferreira-de-Brito *et al.*, 2016; Guerbois *et al.*, 2016; Richard *et al.*, 2016; Costa-da-Silva *et al.*, 2017; Apodaca-Medina *et al.*, 2018; Cevallos *et al.*, 2018; da Costa *et al.*, 2018; Magalhaes *et al.*, 2018; Main *et al.*, 2018; Kantor *et al.*, 2019).

Aedes albopictus

Aedes albopictus (Skuse, 1895) is commonly referred to as the Asian tiger mosquito (Reinert *et al.*, 2004; Faraji & Unlu, 2016). It has experienced recently a dramatic global expansion facilitated by human activities, particularly the international trade in used tires and bamboo (Reiter, 1998; Hofhuis *et al.*, 2009; Bennett *et al.*, 2019). This, combined with the passive transport of eggs supporting desiccation via public and private transport, has resulted in its wide global distribution. It is now ranked among the 100 most important invasive species in the world (Amraoui *et al.*, 2019).

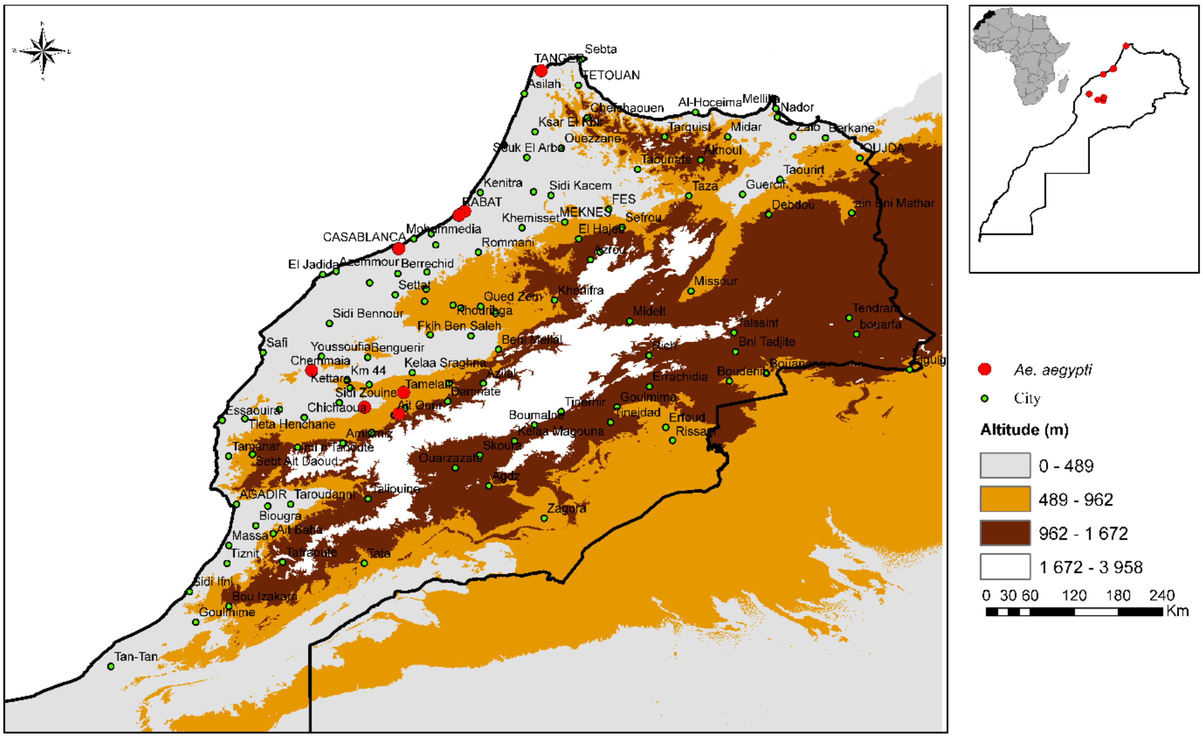

Fig. 1. Distribution of *Ae. aegypti* in Morocco

Endowed with high plasticity allowing it to adapt to various ecological conditions, this species has established itself in more than 100 countries on five continents. It has been reported so far in 25 different countries in Europe, the Middle East (Azari-Hamidian *et al.*, 2024), the Arabian Peninsula (Saudi Arabia, Yemen), South America, Central America, North America, Australia, on many islands in the Pacific and Indian Oceans, and in Africa (Cameroon, Central African Republic, Equatorial Guinea, Gabon, Madagascar, Nigeria, South Africa) (Medlock *et al.*, 2015). In Maghreb countries, this mosquito has been reported in Algeria (2010-2018), Tunisia (2018), and Morocco in Rabat in 2016 (Izri *et al.*, 2011; Benallal *et al.*, 2016; Bennouna *et al.*, 2017; Bouattour *et al.*, 2019). *Aedes albopictus* is believed to be underestimated in Morocco (Fig. 2) because it has a much larger distribution in the country, especially in the urban areas of the Orient and North, where the trade in used tires imported from abroad has been thriving in recent years.

Larval habitats

Aedes albopictus tends to proliferate in small patches of water, often artificial and surrounded by vegetation. It can thrive in cemetery flower pots, bird baths, buckets, jars, cement tanks, cans, and discarded bottles, etc (Unlu *et al.*, 2013). However, used tires remain the most frequently colonized type of sites, as they are often stored outdoors and effectively collect and retain rainwater for a long time (Abílio *et al.*, 2018; Stefopoulou *et al.*, 2018).

Trophic behavior

Although *Ae. albopictus* preferentially bites mammals (including humans), females can also feed on most groups of vertebrates, both cold-blooded and warm-blooded, including reptiles, birds, and amphibians (Kamgang *et al.*, 2012; Faraji *et al.*, 2014; Muhammad *et al.*, 2020).

Medical importance

Aedes albopictus is the world's most important vector of arboviruses. It has been found capable of transmitting up to 39 viruses: Arumowot (AMTV), Bujaru (BUJV), Bussuquara (BSQV), Cache Vallée (CVV), Chandipura (CHPV), Chilibre (CHIV), Eastern Equine Encephalomyelitis (EEEV), Getah (GETV), Icoaraci (ICOV), Ilheus (ILHV), Itaporanga (ITPV), Jamestown Canyon (JCV), Japanese Encephalitis (JEV), Karimabad (KARV), Keystone (KEYV), Kokobera (KOKV), Kunjin (KUNV), La Crosse (LACV), Mayaro (MAYV), Oropuche (OROV), Orungo (ORUV), Pacui (PACV), Potosi (POTV), Rift Valley Fever Virus (RVFV), Ross River (RRV), Salehabad (SALV), San Angelo (SA), St. Louis Encephalitis (SLEV), Tensaw (TENV), Trivittatus (TVTV), UGSV, Urucuri (URUV), Usutu (USUV), Venezuelan Equine Encephalitis (VEEV), WNV, YFV, DENV, CHIKV, and ZIKV (Pereira-Dos-Santos *et al.*, 2020).

A study tested its vector competence by infecting a local strain with DENV, CHIKV, ZIKVand YFV, revealing high transmission potential for CHIKV and lower but significant transmission for DENV, ZIKV, and YFV. Virus detection in mosquito saliva occurred as early as day 3 (CHIKV), day 14 (DENV, YFV), and day 21 (ZIKV) post-infection. These findings indicate a high risk of local arbovirus transmission by Ae. albopictus in Morocco (Amraoui *et al.*, 2019).

Aedes vexans

Aedes vexans (Meigen, 1830), or the inland floodwater mosquito, is widely distributed throughout the Holarctic region, Eastern Europe, North America, North Africa, the Arabian Peninsula, parts of East Asia as well as the Australasian and Oceanic Islands. (Birnberg *et al.*, 2019; Parry *et al.*, 2020). In Morocco, the oldest citation of this species was by Gaud in 1947 in El-Khémisset and Sidi Allal Tazi (Gaud, 1947). The species was subsequently reported on the Casablanca coast (88), el Jadida, Zemamra, and Chemaia. Then in Fez and finally in Meknes (Fig. 3) (Gaud, 1947; Metge, 1986; Handaq, 1998; El Ouali Lalami A., 2010; Handaq & Blenzar, 2017).

Larval habitats

This species thrives mainly in floodplains, rivers, and lakes. Like most floodwater mosquitoes, *Ae. vexans* lay their dessication-resistant eggs near temporary or semi-permanent ponds predisposed to seasonal flooding. Their diapause eggs survive long periods of drought and hatch massively after flood episodes (Becker *et al.*, 2020).

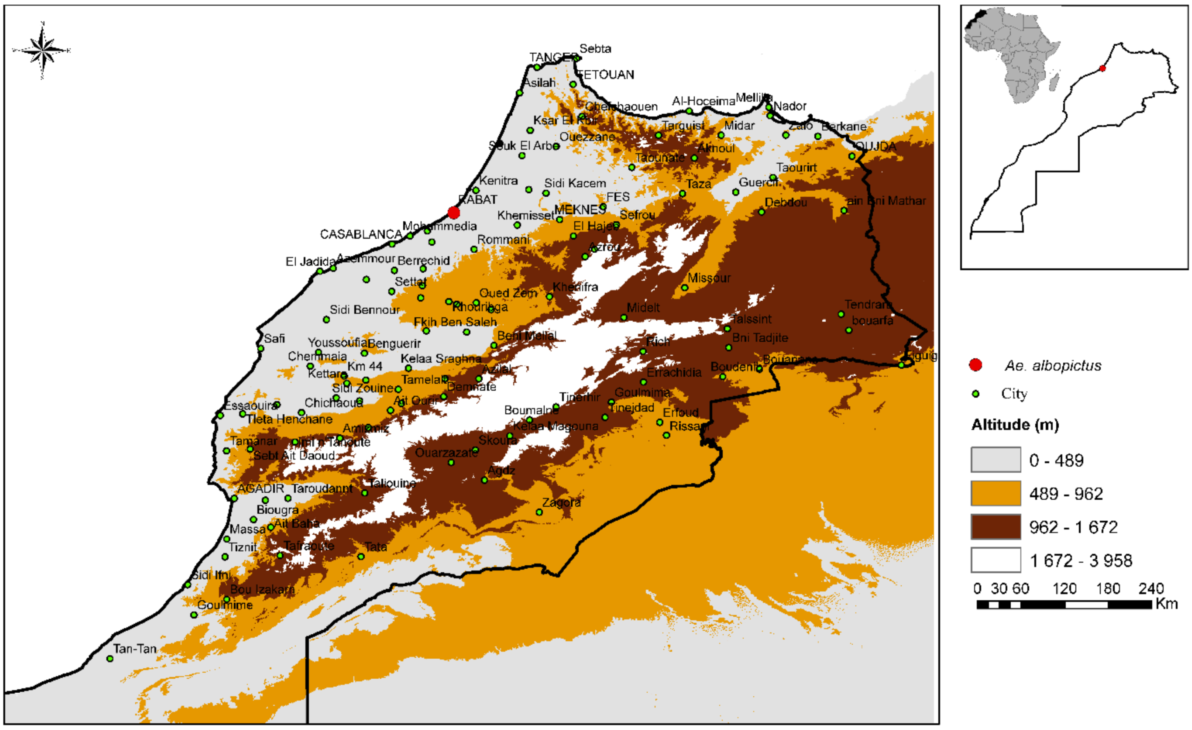

Fig. 2. Distribution of *Ae. albopictus* in Morocco

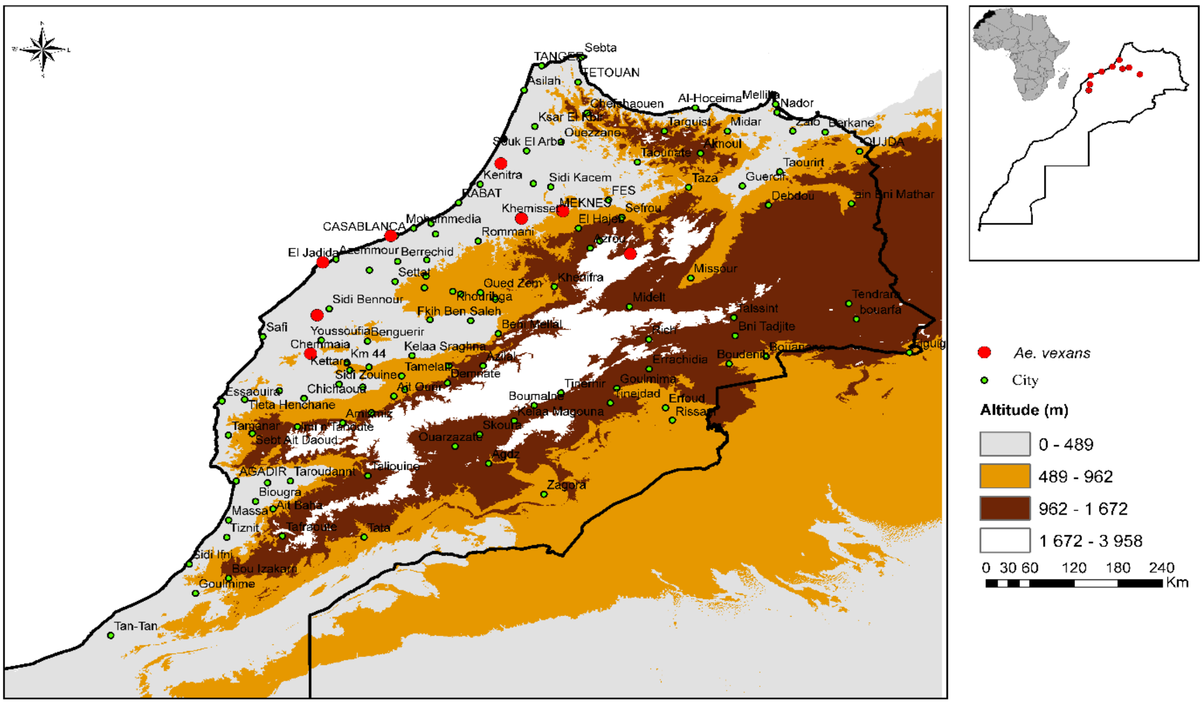

Fig. 3. Distribution of *Ae. vexans* in Morocco

Trophic behavior

Females are aggressive with low host specificity in mammals and humans, which is relevant for the potential transmission of pathogens. In Europe, female bite rates are so high that staying outdoors becomes virtually impossible, especially during the evening hours (Becker & Lüthy, 2017).

Medical importance

In North America and Europe, several arboviruses, such as WNV, Snowshoe hare virus (SSHV), Jamestown Canyon virus (JCV) (Gligic & Adamovic, 1976; Medlock *et al.*, 2017; Sang *et al.*, 2017), Batai virus (BATV) (Elizondo-Quiroga *et al.*, 2018; Scheuch *et al.*, 2018; Karliuk *et al.*, 2021) were isolated from *Ae. vexans*. In Africa, it is considered one of the main vectors of the RVFV *(Miller et al., 2002; Ndiaye et al., 2016; Sang et al.*, 2017).

Aedes caspius

Aedes caspius (Pallas, 1771) is a species with a very wide Palearctic distribution; extending from Europe to Central Asia. It is also well-established in Russia and the Middle East(Robert *et al.*, 2019; ECDC, 2020) In the European continent, its presence generates mainly nuisance especially around the Mediterranean along the coast. It has been reported in Italy (Veronesi *et al.*, 2012), France (Balenghien *et al.*, 2008; Carron *et al.*, 2008), Belgium (Boukraa *et al.*, 2015), Spain (Gutierrez-Lopez *et al.*, 2019), etc. In Morocco, it occurs both in coastal wetlands and in the interior of the country (Fig. 4) (Handaq, 1998; Handaq & Blenzar, 2017).

Larval habitats

The female of *Ae. caspius* lays eggs on moist soil, at the base of clumps of vegetation, the watering of which causes the eggs to hatch. Larvae develop in most cases in brackish water but can also be found in freshwater (Bellini *et al.*, 1997).

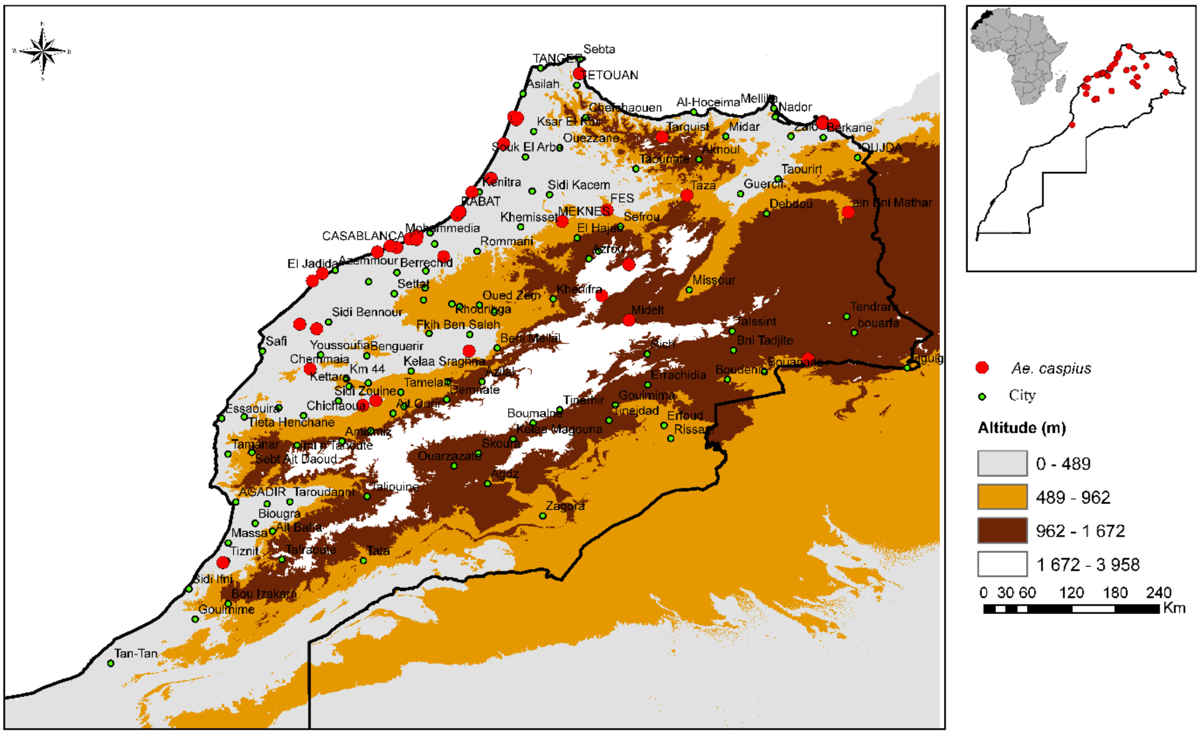

Fig. 4. Distribution of *Ae. caspius* in Morocco

Trophic behavior

Aedes caspius is an anthropophilic species preferably known to bite during the day and night, with a peak of activity at dusk. It usually feeds aggressively inside and outside homes (Veronesi *et al.*, 2012).

Medical importance

Most studies dealing with the vector role of this mosquito concern arboviruses and more specifically the Tahyna virus (Pilaski & Mackenstein, 1985), WNV (Orshan *et al.*, 2008; Ergunay *et al.*, 2014), and RVFV (Turell *et al.*, 1996; Tantely *et al.*, 2015). It may also be involved in the transmission of Sindbis (Lundstrom, 1999) and Usutu viruses (Cook *et al.*, 2018).

Aedes detritus

Aedes detritus (Haliday, 1833) is a Palearctic species that occurs throughout the European coast, the Baltic Sea as well as the Atlantic Ocean, and around the Mediterranean basin. It is a common species that is more abundant in southern and dry regions, i.e., in the United Kingdom (Blagrove *et al.*, 2016), Italy *(Mancini et al.*, 2017), Belgium (Boukraa *et al.*, 2015), France (Brengues *et al.*, 2014) and Spain (Ruiz-Arrondo *et al.*, 2019). In addition, it has a dispersed distribution in the inland saline areas of Europe, North Africa, and Southwest Asia.

In North Africa, it was detected in Egypt (Abdel-Hamid *et al.*, 2011), Tunisia (Ben Ayed *et al.*, 2019), Algeria (Metge & Hassaïne, 1998), etc. In Morocco, *Ae. detritus* is very well represented in coastal areas (Fig. 5), where they are found on a fairly regular strip from Tangier to Tantan (Atlantic coast), and on a less regular strip from Tangier to Saïdia (Mediterranean coast) (Trari, 2017).

Larval habitats

It is a typically halophilic species and the larvae are found almost exclusively in habitats with an exceptionally high salinity content; and are found only occasionally in freshwater (Blagrove *et al.*, 2016). Larvae can be found in semi-permanent ponds in open marshes and drainage channels or stagnant lagoons, with little aquatic vegetation. They are sometimes found with larvae of *Ae. caspius*, but most often, due to tolerance to extreme salinity, the species occurs alone in its aquatic habitats and does not co-occur with other species *(Becker et al.*, 2020).

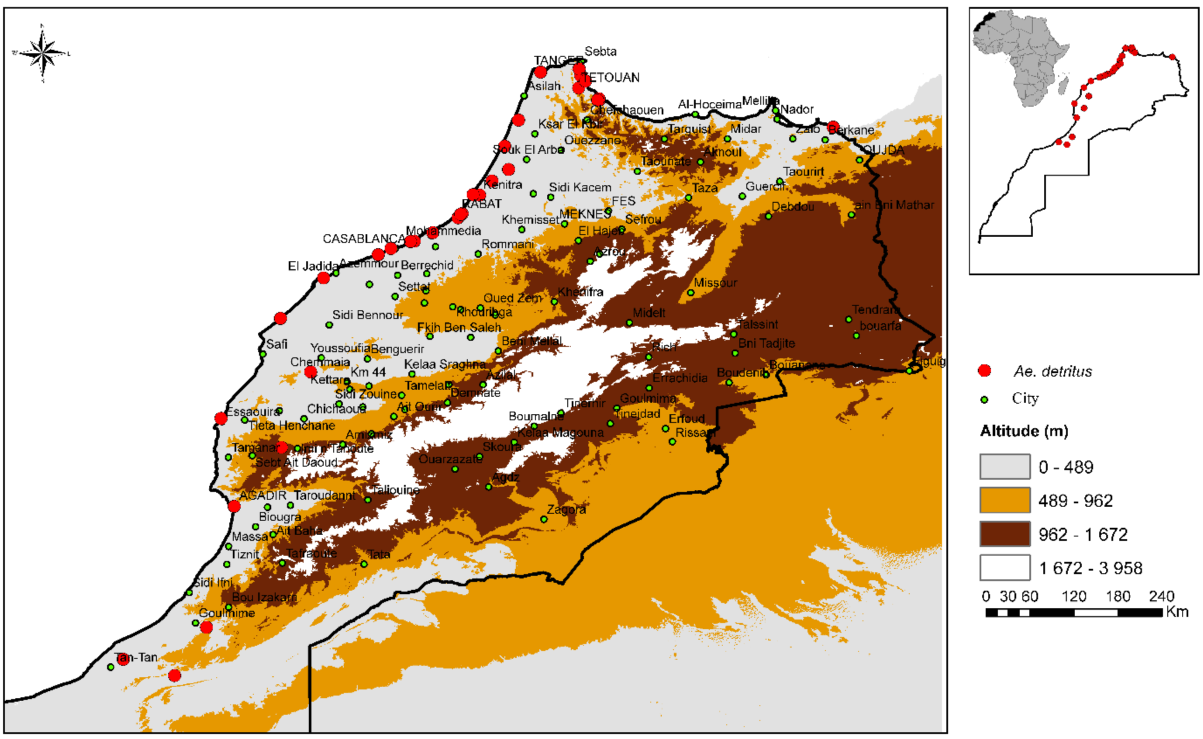

Fig. 5. Distribution of *Ae. detritus* in Morocco

Trophic behavior

Females are aggressive, persistent and easily attack humans, often in large numbers. They can feed during the day but are mainly active at dusk. *Aedes detritus* is a typical exophilic species that enters buildings only occasionally. Having a large flight capacity, they can travel more than 10 km to fetch their blood meal and thus constitute a significant nuisance at a great distance from emergence areas (Becker *et al.*, 2020).

Medical importance

Aedes detritus is a competent vector for ZIKV transmission, JEV, WNV, and RVFV (Vazeille *et al.*, 2008; Mackenzie-Impoinvil *et al.*, 2015; Tantely *et al.*, 2015; Blagrove *et al.*, 2016; Lumley *et al.*, 2018; Blagrove *et al.*, 2020).

Culex pipiens

In temperate regions, especially in the Mediterranean basin, *Cx. pipiens* (Linnaeus, 1758) is recognized as one of the most widespread cosmopolitan species (Amraoui *et al.*, 2012a; Brugman *et al.*, 2018). It is also found in temperate regions of Africa, Asia, Australia, Europe, and North and South America. *Culex pipiens* exists in two morphologically identical forms or biotypes, the *pipiens* form and the *molestus* form (Farajollahi *et al.*, 2011). The *pipiens* form is anautogenous, eurygamous (mates in the open air), and enters diapause during the winter (heterodynamic). The *molestus* form is autogenous, stenogamous (can mate in confined spaces) and remains active during the winter period (homodynamic). In Morocco, *Cx. pipiens* is a very common and ubiquitous species (Fig. 6) (Amraoui *et al.*, 2012b; Bkhache *et al.*, 2016; Aboulfadl *et al.*, 2020).

Larval habitats

Larvae of *Cx. pipiens* can be found in temporary or semi-permanent water sources, ponds with vegetation, rice fields, along rivers, in flood-prone areas, in puddles and ruts, sometimes even in water-filled tree holes (Müller *et al.*, 2012; Liu *et al.*, 2019; Becker *et al.*, 2020). They are also frequently present in artificial water bodies, such as flooded cellars, construction sites, road drains and pits, water barrels, metal tanks, ornamental ponds, and any type of container (Becker *et al.*, 2020). They can thrive in clear water but also in water polluted by organic matter (wastewater), and can even tolerate a small amount of salinity (Kengne *et al.*, 2019; Marini *et al.*, 2020).

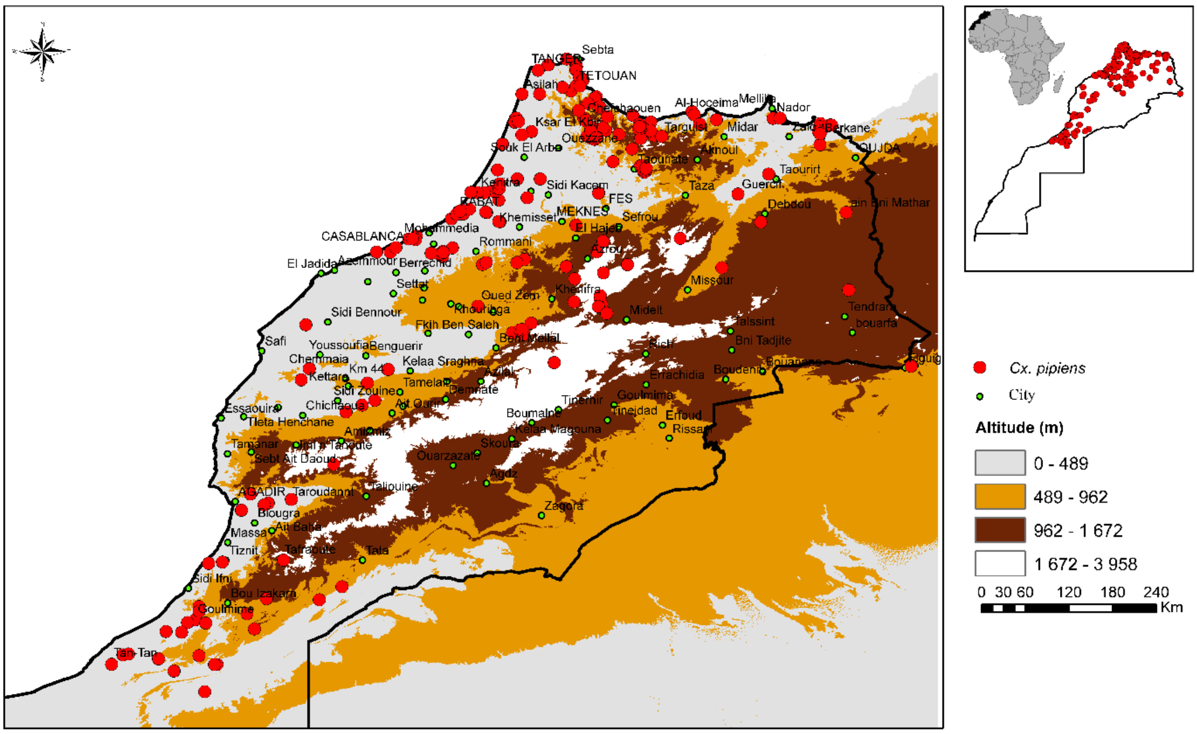

Fig. 6. Distribution of *Cx. pipiens* in Morocco

Trophic behavior

Females bite all warm-blooded vertebrates at night and eat their meals mostly indoors. *Culex pipiens* mosquitoes bite humans, but can also bite mammals (horses) and birds (Becker *et al.*, 2020). The *pipiens* form feeds preferably on birds while the *molestus* form mainly on mammals (Amraoui *et al.*, 2012b; Shahhosseini *et al.*, 2018).

Medical importance

Culex pipiens is a competent vector of several pathogens infecting animals and humans, including WNV (Meegan *et al.*, 1980; Calzolari *et al.*, 2010; Mavridis *et al.*, 2018). In 2012, several populations of *Cx. pipiens* from different distinct habitats (urban and suburban) in Morocco and other countries in the Maghreb region were experimentally infected with WNV and RVFV (Amraoui *et al.*, 2012a). About 69.2% of mosquitoes developed a disseminated Infection of RVFV and of these, 77.8% transmitted the virus through saliva. All mosquitoes developed a highly disseminated infection with and excreted infectious saliva.

Conclusion

Currently, mosquito-borne pathogens pose one of the greatest public health challenges. Knowledge of mosquitoes of Morocco, their geographical distribution, bioecology, as well as their involvement in the transmission of diseases is essential for a good understanding of the current risk and preparing for future threats. The epidemiology of arboviruses has undergone significant changes throughout the world over the past thirty years, in connection with the intercontinental dissemination of the main vector species *Ae. albopictus* and *Ae. aegypti*, favored by human activities and current climatic changes. *Aedes albopictus*, recently found in Algeria and in Morocco, is a mosquito that spreads rapidly and the epidemiological consequences of its invasion and establishment are disastrous and well known throughout the world. Since the current knowledge of the Moroccan distribution of these two vectors remains incomplete and scattered, monitoring of their establishment is highly recommended. The recent reporting of *Ae. albopictus* in Morocco and the increase in the number of international travelers to the country could be one of the determining factors in the establishment of an autochthonous transmission cycle of arboviruses.

Author's Contributions

Outammassine Abdelkrim: Conceptualizing, data curation, data analyzing, writing and reviewing the manuscript. **Daoudi Mohamed**: writing and reviewing the manuscript. **Loqman Souad**: supervision, writing, review and editing. **Zouhair Said**: supervision, conceptualization, writing - review and editing, project administration, resources.

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This review does not contain any studies with human participants performed by any of the authors.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Generative AI statement

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REFERENCES

Abdel-Hamid, Y. M., Soliman, M. I., & Kenawy, M. A. (2011). Mosquitoes (Diptera: Culicidae) in relation to the risk of disease transmission in El Ismailia Governorate, Egypt. *Journal of the Egyptian Society of Parasitology*, *41*(2), 347-356.

Abílio, A. P., Abudasse, G., Kampango, A., Candrinho, B., Sitoi, S., Luciano, J., Tembisse, D., Sibindy, S., de Almeida, A. P. G., Garcia, G. A., David, M. R., Maciel-de-Freitas, R., & Gudo, E. S. (2018). Distribution and breeding sites of *Aedes aegypti* and *Aedes albopictus* in 32 urban/peri-urban districts of Mozambique: implication for assessing the risk of arbovirus outbreaks. *PLoS Neglected Tropical Diseases*, *12*(9), e0006692. https://doi.org/10.1371/journal.pntd.0006692

Aboulfadl, S., Mellouki, F., Aouinty, B., & Faraj, C. (2020). Susceptibility status of *Culex pipiens* larvae (Diptera: Culicidae) to the main insecticides used in larval control in the regions of Rabat and Casablanca in Morocco. *International Journal of Pest Management*, 1-7. https://doi.org/10.1080/09670874.2020.1818869

Abozeid, S., Elsayed, A. K., Schaffner, F., & Samy, A. M. (2018). Re-emergence of *Aedes aegypti* in Egypt. *The Lancet Infectious Diseases*, *18*(2), 142-143. https://doi.org/10.1016/s1473-3099(18)30018-5

Akıner, M. M., Öztürk, M., Başer, A. B., Günay, F., Hacıoğlu, S., Brinkmann, A., Emanet, N., Alten, B., Özkul, A., Nitsche, A., Linton, Y.-M., & Ergünay, K. (2019). Arboviral screening of invasive *Aedes* species in northeastern Turkey: West Nile virus circulation and detection of insect-only viruses. *PLoS Neglected Tropical Diseases*, *13*(5), e0007334. https://doi.org/10.1371/journal.pntd.0007334

Al-Jabi, S. W. (2017). Global research trends in West Nile virus from 1943 to 2016: a bibliometric analysis. *Global Health*, *13*(1), 55-55. https://doi.org/10.1186/s12992-017-0284-y

Amraoui, F., Ben Ayed, W., Madec, Y., Faraj, C., Himmi, O., Btissam, A., Sarih, M., & Failloux, A. B. (2019). Potential of *Aedes albopictus* to cause the emergence of arboviruses in Morocco. *PLoS Neglected Tropical Diseases*, *13*(2), e0006997. https://doi.org/10.1371/journal.pntd.0006997

Amraoui, F., Krida, G., Bouattour, A., Rhim, A., Daaboub, J., Harrat, Z., Boubidi, S. C., Tijane, M., Sarih, M., & Failloux, A. B. (2012a). *Culex pipiens*, an experimental efficient vector of West Nile and Rift Valley fever viruses in the Maghreb region. *PloS One*, *7*(5), e36757. https://doi.org/10.1371/journal.pone.0036757

Amraoui, F., Tijane, M., Sarih, M., & Failloux, A. B. (2012b). Molecular evidence of *Culex pipiens* form *molestus* and hybrids *pipiens*/*molestus* in Morocco, North Africa. *Parasites & Vectors*, *5*, 83-83. https://doi.org/10.1186/1756-3305-5-83

Apodaca-Medina, A. I., Torres-Avendano, J. I., Rendon-Maldonado, J. G., Torres-Montoya, E. H., Flores-Lopez, B. A., Del Angel, R. M., Velarde-Felix, J. S., Salomon-Soto, V. M., & Castillo-Ureta, H. (2018). First Evidence of Vertical Infection of Dengue Virus 2 in *Aedes aegypti* Mosquitoes from Sinaloa, Mexico. *Vector-Borne and Zoonotic Diseases*, *18*(4), 231-233. https://doi.org/10.1089/vbz.2017.2202

Assaid, N., Mousson, L., Moutailler, S., Arich, S., Akarid, K., Monier, M., Beck, C., Lecollinet, S., Failloux, A. B., & Sarih, M. (2020). Evidence of circulation of West Nile virus in *Culex pipiens* mosquitoes and horses in Morocco. *Acta Tropica*, *205*, 105414. https://doi.org/10.1016/j.actatropica.2020.105414

Azari-Hamidian, S., Norouzi, B., Maleki, H., Rezvani, S. M., Pourgholami, M. & Oshaghi, M. A. (2024) First record of a medically important vector, the Asian tiger mosquito Aedes albopictus (Skuse, 1895) (Diptera: Culicidae), using morphological and molecular data in northern Iran. Journal of Insect Biodiversity and Systematics, 10 (4), 953–963. https://doi.org/10.61186/jibs.10.4.953

Bajjou, T., Akhouad, Y., Hilali, F., Elkochri, S., Laraqui, A., Touil, N., Lahlou Amine, I., Mahassine, F., & Sekhsokh, Y. (2018). Dengue fever in Morocco: result of surveillance during the year 2017 and first imported cases. *International Journal of Research in Medical Sciences*, *6*(3), 1029. https://doi.org/10.18203/2320-6012.ijrms20180633

Bajjou, T., Reggad, A., Hilali, F., Elkochri, S., Laraqui, A., Touil, N., Lahlou Amine, I., Sekhsokh, Y., & Mahassine, F. (2017). Chikungunya infection confirmed in a Moroccan traveller returning from Bangladesh. *International Journal of Research in Medical Sciences*, *6*(1), 343. https://doi.org/10.18203/2320-6012.ijrms20175746

Balenghien, T., Vazeille, M., Grandadam, M., Schaffner, F., Zeller, H., Reiter, P., Sabatier, P., Fouque, F., & Bicout, D. J. (2008). Vector Competence of Some French *Culex* and *Aedes* Mosquitoes for West Nile Virus. *Vector-Borne and Zoonotic Diseases*, *8*(5), 589-596. https://doi.org/10.1089/vbz.2007.0266

Becker, N., & Lüthy, P. (2017). Chapter 26 - Mosquito Control With Entomopathogenic Bacteria in Europe. In L. A. Lacey (Ed.), *Microbial Control of Insect and Mite Pests* (pp. 379-392). Academic Press. https://doi.org/https://doi.org/10.1016/B978-0-12-803527-6.00026-3

Becker, N., Petrj , D., Zgomba, M., Boase, C., Madon, M., Dahl, C., & Kaiser, A. (2020). *Mosquitoes and Their Control* (3 ed.). Springer

Bellini, R., Veronesi, R., Draghetti, S., & Carrieri, M. (1997). Study on the flying height of *Aedes caspius* and *Culex pipiens* females in the Po Delta area, Italy. *Journal of the American Mosquito Control Association*, *13*(4), 356-360.

Ben Ayed, W., Amraoui, F., M'Ghirbi, Y., Schaffner, F., Rhaim, A., Failloux, A. B., & Bouattour, A. (2019). A survey of *Aedes* (Diptera: Culicidae) mosquitoes in Tunisia and the potential role of *Aedes detritus* and *Aedes caspius* in the Transmission of Zika Virus. *Journal of Medical Entomology*, *56*(5), 1377-1383. https://doi.org/10.1093/jme/tjz067

Benallal, K. E., Allal-Ikhlef, A., Benhamouda, K., Schaffner, F., & Harrat, Z. (2016). First report of *Aedes* (*Stegomyia*) *albopictus* (Diptera: Culicidae) in Oran, West of Algeria. *Acta Tropica*, *164*, 411-413. https://doi.org/10.1016/j.actatropica.2016.09.027

Benjelloun, A., El Harrak, M., & Belkadi, B. (2016). West Nile disease epidemiology in North-West Africa: bibliographical review [https://doi.org/10.1111/tbed.12341]. *Transboundary and Emerging Diseases*, *63*(6), e153-e159. https://doi.org/https://doi.org/10.1111/tbed.12341

Benjelloun, A., El Harrak, M., Calistri, P., Loutfi, C., Kabbaj, H., Conte, A., Ippoliti, C., Danzetta, M. L., & Belkadi, B. (2017). Seroprevalence of West Nile virus in horses in different Moroccan regions. *Veterinary Medicine and Science*, *3*(4), 198-207. https://doi.org/10.1002/vms3.71

Bennett, K. L., Gómez Martínez, C., Almanza, A., Rovira, J. R., McMillan, W. O., Enriquez, V., Barraza, E., Diaz, M., Sanchez-Galan, J. E., Whiteman, A., Gittens, R. A., & Loaiza, J. R. (2019). High infestation of invasive *Aedes* mosquitoes in used tires along the local transport network of Panama. *Parasites & Vectors*, *12*(1), 264. https://doi.org/10.1186/s13071-019-3522-8

Bennouna, A., Balenghien, T., El Rhaffouli, H., Schaffner, F., Garros, C., Gardes, L., Lhor, Y., Hammoumi, S., Chlyeh, G., & Fassi Fihri, O. (2017). First record of *Stegomyia albopicta* (= *Aedes albopictus*) in Morocco: a major threat to public health in North Africa? *Medical and Veterinary Entomology*, *31*(1), 102-106. https://doi.org/10.1111/mve.12194

Birnberg, L., Talavera, S., Aranda, C., Núñez, A. I., Napp, S., & Busquets, N. (2019). Field-captured *Aedes vexans* (Meigen, 1830) is a competent vector for Rift Valley fever phlebovirus in Europe. *Parasites & Vectors*, *12*(1), 484. https://doi.org/10.1186/s13071-019-3728-9

Bkhache, M., Tmimi, F.-Z., Charafeddine, O., Faraj, C., Failloux, A.-B., & Sarih, M. h. (2016). First report of L1014F-kdr mutation in *Culex pipiens* complex from Morocco. *Parasites & Vectors*, *9*(1), 644. https://doi.org/10.1186/s13071-016-1931-5

Blagrove, M. S. C., Caminade, C., Diggle, P. J., Patterson, E. I., Sherlock, K., Chapman, G. E., Hesson, J., Metelmann, S., McCall, P. J., Lycett, G., Medlock, J., Hughes, G. L., Torre, A. d., & Baylis, M. (2020). Potential for Zika virus transmission by mosquitoes in temperate climates. *Proceedings of the Royal Society B: Biological Sciences*, *287*(1930), 20200119. https://doi.org/doi:10.1098/rspb.2020.0119

Blagrove, M. S. C., Sherlock, K., Chapman, G. E., Impoinvil, D. E., McCall, P. J., Medlock, J. M., Lycett, G., Solomon, T., & Baylis, M. (2016). Evaluation of the vector competence of a native UK mosquito *Ochlerotatus detritus* (*Aedes detritus*) for dengue, chikungunya and West Nile viruses. *Parasites & Vectors*, *9*(1), 452. https://doi.org/10.1186/s13071-016-1739-3

Bouattour, A., Khrouf, F., Rhim, A., & M'Ghirbi, Y. (2019). First detection of the Asian tiger mosquito, *Aedes* (*Stegomyia*) *albopictus* (Diptera: Culicidae), in Tunisia. *Journal of Medical Entomology*, *56*(4), 1112-1115. https://doi.org/10.1093/jme/tjz026

Boukraa, S., Dekoninck, W., Versteirt, V., Schaffner, F., Coosemans, M., Haubruge, E., & Francis, F. (2015). Updated checklist of the mosquitoes (Diptera: Culicidae) of Belgium. *Journal of Vector Ecology*, *40*(2), 398-407. https://doi.org/10.1111/jvec.12180

Braack, L., Gouveia de Almeida, A. P., Cornel, A. J., Swanepoel, R., & de Jager, C. (2018). Mosquito-borne arboviruses of African origin: review of key viruses and vectors. *Parasites & Vectors*, *11*(1), 29. https://doi.org/10.1186/s13071-017-2559-9

Brady, O. J., Gething, P. W., Bhatt, S., Messina, J. P., Brownstein, J. S., Hoen, A. G., Moyes, C. L., Farlow, A. W., Scott, T. W., & Hay, S. I. (2012). Refining the global spatial limits of dengue virus transmission by evidence-based consensus. *PLoS Neglected Tropical Diseases*, *6*(8), e1760. https://doi.org/10.1371/journal.pntd.0001760

Brengues, C., Ferré, J. B., Le Goff, G., Lami, P., Pratlong, F., Pasteur, N., Lagneau, C., Simard, F., & Robert, V. (2014). A multiplex PCR to differentiate the two sibling species of mosquitoes *Ochlerotatus detritus* and *Oc. coluzzii* and evidence for further genetic heterogeneity within the Detritus complex. *Infection, Genetics and Evolution*, *28*, 676-680. https://doi.org/10.1016/j.meegid.2014.07.010

Brown, J. E., Evans, B. R., Zheng, W., Obas, V., Barrera-Martinez, L., Egizi, A., Zhao, H., Caccone, A., & Powell, J. R. (2014). Human impacts have shaped historical and recent evolution in *Aedes aegypti*, the dengue and yellow fever mosquito. *Evolution*, *68*(2), 514-525. https://doi.org/10.1111/evo.12281

Brugman, V. A., Hernández-Triana, L. M., Medlock, J. M., Fooks, A. R., Carpenter, S., & Johnson, N. (2018). The Role of *Culex pipiens* L. (Diptera: Culicidae) in Virus Transmission in Europe. *International Journal of Environmental Research and Public Health*, *15*(2), 389. https://doi.org/10.3390/ijerph15020389

Brustolin, M., Santamaria, C., Napp, S., Verdun, M., Rivas, R., Pujol, N., Talavera, S., & Busquets, N. (2018). Experimental study of the susceptibility of a European *Aedes albopictus* strain to dengue virus under a simulated Mediterranean temperature regime. *Medical and Veterinary Entomology*, *32*(4), 393-398. https://doi.org/10.1111/mve.12325

Calzolari, M., Bonilauri, P., Bellini, R., Albieri, A., Defilippo, F., Maioli, G., Galletti, G., Gelati, A., Barbieri, I., Tamba, M., Lelli, D., Carra, E., Cordioli, P., Angelini, P., & Dottori, M. (2010). Evidence of simultaneous circulation of West Nile and Usutu viruses in mosquitoes sampled in Emilia-Romagna region (Italy) in 2009. *PloS One*, *5*(12), e14324. https://doi.org/10.1371/journal.pone.0014324

Caminade, C., Ndione, J. A., Diallo, M., MacLeod, D. A., Faye, O., Ba, Y., Dia, I., & Morse, A. P. (2014). Rift Valley Fever outbreaks in Mauritania and related environmental conditions. *International Journal of Environmental Research and Public Health*, *11*(1), 903-918. https://doi.org/10.3390/ijerph110100903

Captain-Esoah, M., Kweku Baidoo, P., Frempong, K. K., Adabie-Gomez, D., Chabi, J., Obuobi, D., Kwame Amlalo, G., Balungnaa Veriegh, F., Donkor, M., Asoala, V., Behene, E., Adjei Boakye, D., & Dadzie, S. K. (2020). Biting behavior and molecular identification of *Aedes aegypti* (Diptera: Culicidae) subspecies in some selected recent yellow fever outbreak communities in Northern Ghana. *Journal of Medical Entomology*, *57*(4), 1239-1245. https://doi.org/10.1093/jme/tjaa024

Carrington, L. B., & Simmons, C. P. (2014). Human to mosquito transmission of dengue viruses. *Frontiers in Immunology 5*, 290-290. https://doi.org/10.3389/fimmu.2014.00290

Carron, A., Bichaud, L., Platz, N., & Bicout, D. J. (2008). Survivorship characteristics of the mosquito *Aedes caspius* adults from southern France under laboratory conditions. *Medical and Veterinary Entomology*, *22*(1), 70-73. https://doi.org/10.1111/j.1365-2915.2008.00718.x

Cebrián-Camisón, S., Martínez-de la Puente, J., & Figuerola, J. (2020). A literature review of host feeding patterns of invasive *Aedes* mosquitoes in Europe. *Insects*, *11*(12), 848. https://www.mdpi.com/2075-4450/11/12/848

Cevallos, V., Ponce, P., Waggoner, J. J., Pinsky, B. A., Coloma, J., Quiroga, C., Morales, D., & Cardenas, M. J. (2018). Zika and Chikungunya virus detection in naturally infected *Aedes aegypti* in Ecuador. *Acta Tropica*, *177*, 74-80. https://doi.org/10.1016/j.actatropica.2017.09.029

Chancey, C., Grinev, A., Volkova, E., & Rios, M. (2015). The global ecology and epidemiology of West Nile virus. *Biomed Research International*, *2015*, 376230-376230. https://doi.org/10.1155/2015/376230

Charrier, H. (1924). Le *Stegomyia fasciata* dans la région de Tanger (Maroc). *Bulletin de la Société de Pathologie Exotique 17*, 137-142.

Coffey, L. L., Failloux, A.-B., & Weaver, S. C. (2014). Chikungunya virus-vector interactions. *Viruses*, *6*(11), 4628-4663. https://doi.org/10.3390/v6114628

Cook, C. L., Huang, Y. S., Lyons, A. C., Alto, B. W., Unlu, I., Higgs, S., & Vanlandingham, D. L. (2018). North American *Culex pipiens* and *Culex quinquefasciatus* are competent vectors for Usutu virus. *PLoS Neglected Tropical Diseases*, *12*(8), e0006732. https://doi.org/10.1371/journal.pntd.0006732

Costa-da-Silva, A. L., Ioshino, R. S., Petersen, V., Lima, A. F., Cunha, M. D. P., Wiley, M. R., Ladner, J. T., Prieto, K., Palacios, G., Costa, D. D., Suesdek, L., Zanotto, P. M. A., & Capurro, M. L. (2017). First report of naturally infected *Aedes aegypti* with chikungunya virus genotype ECSA in the Americas. *PLoS Neglected Tropical Diseases*, *11*(6), e0005630. https://doi.org/10.1371/journal.pntd.0005630

da Costa, C. F., da Silva, A. V., do Nascimento, V. A., de Souza, V. C., Monteiro, D., Terrazas, W. C. M., Dos Passos, R. A., Nascimento, S., Lima, J. B. P., & Naveca, F. G. (2018). Evidence of vertical transmission of Zika virus in field-collected eggs of *Aedes aegypti* in the Brazilian Amazon. *PLoS Neglected Tropical Diseases*, *12*(7), e0006594. https://doi.org/10.1371/journal.pntd.0006594

ECDC. (2020). *Aedes caspius - current known distribution: May 2020*. Retrieved 01/11 from Mosquito maps [internet]. Stockholm: ECDC; 2020. Available from: https://ecdc.europa.eu/en/disease-vectors/surveillance-and-disease-data/mosquito-maps

El-Harrak, M., Martín-Folgar, R., Llorente, F., Fernández-Pacheco, P., Brun, A., Figuerola, J., & Jiménez-Clavero, M. A. (2011). Rift Valley and West Nile virus antibodies in camels, North Africa. *Emerging Infectious Diseases*, *17*(12), 2372-2374. https://doi.org/10.3201/eid1712.110587

El Ouali Lalami A., H. T., Azzouzi A., Elghadraoui L., Maniar S., Faraj C., Adlaoui E., Ameur I. & Ibnsouda Koraichi S. (2010). Inventaire et répartition saisonnière des Culicidae dans le centre du Maroc. *Entomologie Faunistique*, *62*(4), 131-138.

El Rhaffouli, H., El Harrak, M., Lotfi, C., El Boukhrissi, F., Bajjou, T., Laraqui, A., Hilali, F., Kenfaoui, M., & Lahlou-Amine, I. (2012). Serologic evidence of West Nile virus infection among humans, Morocco. *Emerging Infectious Diseases*, *18*(5), 880-881. https://doi.org/10.3201/eid1805.110826

Elizondo-Quiroga, D., Medina-Sanchez, A., Sanchez-Gonzalez, J. M., Eckert, K. A., Villalobos-Sanchez, E., Navarro-Zuniga, A. R., Sanchez-Tejeda, G., Correa-Morales, F., Gonzalez-Acosta, C., Arias, C. F., Lopez, S., Del Angel, R. M., Pando-Robles, V., & Elizondo-Quiroga, A. E. (2018). Zika Virus in salivary glands of five different species of wild-caught mosquitoes from Mexico. *Scientific Reports*, *8*(1), 809. https://doi.org/10.1038/s41598-017-18682-3

Ergunay, K., Gunay, F., Erisoz Kasap, O., Oter, K., Gargari, S., Karaoglu, T., Tezcan, S., Cabalar, M., Yildirim, Y., Emekdas, G., Alten, B., & Ozkul, A. (2014). Serological, molecular and entomological surveillance demonstrates widespread circulation of West Nile virus in Turkey. *PLoS Neglected Tropical Diseases*, *8*(7), e3028. https://doi.org/10.1371/journal.pntd.0003028

Faraji, A., Egizi, A., Fonseca, D. M., Unlu, I., Crepeau, T., Healy, S. P., & Gaugler, R. (2014). Comparative host feeding patterns of the Asian tiger mosquito, *Aedes albopictus*, in urban and suburban Northeastern USA and implications for disease transmission. *PLoS Neglected Tropical Diseases*, *8*(8), e3037. https://doi.org/10.1371/journal.pntd.0003037

Faraji, A., & Unlu, I. (2016). The eye of the tiger, the thrill of the fight: effective larval and adult control measures against the Asian Tiger Mosquito, *Aedes albopictus* (Diptera: Culicidae), in North America. *Journal of Medical Entomology*, *53*(5), 1029-1047. https://doi.org/10.1093/jme/tjw096

Farajollahi, A., Fonseca, D. M., Kramer, L. D., & Marm Kilpatrick, A. (2011). "Bird biting" mosquitoes and human disease: a review of the role of *Culex pipiens* complex mosquitoes in epidemiology. *Infection, Genetics and Evolution*, *11*(7), 1577-1585. https://doi.org/10.1016/j.meegid.2011.08.013

Ferede, G., Tiruneh, M., Abate, E., Kassa, W. J., Wondimeneh, Y., Damtie, D., & Tessema, B. (2018). Distribution and larval breeding habitats of *Aedes* mosquito species in residential areas of northwest Ethiopia. *Epidemiology and Health*, *40*, e2018015-e2018015. https://doi.org/10.4178/epih.e2018015

Ferreira-de-Brito, A., Ribeiro, I. P., Miranda, R. M., Fernandes, R. S., Campos, S. S., Silva, K. A., Castro, M. G., Bonaldo, M. C., Brasil, P., & Lourenco-de-Oliveira, R. (2016). First detection of natural infection of *Aedes aegypti* with Zika virus in Brazil and throughout South America. *Memórias do Instituto Oswaldo Cruz* *111*(10), 655-658. https://doi.org/10.1590/0074-02760160332

Figuerola, J., Baouab, R. E., Soriguer, R., Fassi-Fihri, O., Llorente, F., & Jímenez-Clavero, M. A. (2009). West Nile virus antibodies in wild birds, Morocco, 2008. *Emerging Infectious Diseases*, *15*(10), 1651-1653. https://doi.org/10.3201/eid1510.090340

Flores, H. A., & O'Neill, S. L. (2018). Controlling vector-borne diseases by releasing modified mosquitoes. *Nature Reviews Microbiology*, *16*(8), 508-518. https://doi.org/10.1038/s41579-018-0025-0

Fournet, F., Jourdain, F., Bonnet, E., Degroote, S., & Ridde, V. (2018). Effective surveillance systems for vector-borne diseases in urban settings and translation of the data into action: a scoping review. *Infectious Diseases of Poverty*, *7*(1), 99-99. https://doi.org/10.1186/s40249-018-0473-9

Gaud, J. (1947). Contribution à l'étude des Culicides au Maroc, quatre espèces nouvelles pour la faune locale. *Bulletin de la Société des Sciences Naturelles du Maroc*, *25-27*, 204-206.

Gaud, J. (1953). Notes biogéographiques sur les Culicides du Maroc. In A. d. l. I. P. d. Maroc (Ed.), (Vol. 4, pp. 443-490).

Gligic, A., & Adamovic, Z. (1976). Isolation of Tahyna virus from *Aedes vexans* mosquitoes in Serbia. *Mikrobiologija*, *13*(2), 19–291.

Golding, N., Wilson, A. L., Moyes, C. L., Cano, J., Pigott, D. M., Velayudhan, R., Brooker, S. J., Smith, D. L., Hay, S. I., & Lindsay, S. W. (2015). Integrating vector control across diseases. *BMC Medicine*, *13*(1), 249. https://doi.org/10.1186/s12916-015-0491-4

Gould, E., Pettersson, J., Higgs, S., Charrel, R., & de Lamballerie, X. (2017). Emerging arboviruses: Why today? *One Health*, *4*, 1-13. https://doi.org/https://doi.org/10.1016/j.onehlt.2017.06.001

Guerbois, M., Fernandez-Salas, I., Azar, S. R., Danis-Lozano, R., Alpuche-Aranda, C. M., Leal, G., Garcia-Malo, I. R., Diaz-Gonzalez, E. E., Casas-Martinez, M., Rossi, S. L., Del Rio-Galvan, S. L., Sanchez-Casas, R. M., Roundy, C. M., Wood, T. G., Widen, S. G., Vasilakis, N., & Weaver, S. C. (2016). Outbreak of Zika Virus infection, Chiapas State, Mexico, 2015, and first confirmed transmission by *Aedes aegypti* mosquitoes in the Americas. *The Journal of Infectious Diseases*, *214*(9), 1349-1356. https://doi.org/10.1093/infdis/jiw302

Guo, C., Zhou, Z., Wen, Z., Liu, Y., Zeng, C., Xiao, D., Ou, M., Han, Y., Huang, S., Liu, D., Ye, X., Zou, X., Wu, J., Wang, H., Zeng, E. Y., Jing, C., & Yang, G. (2017). Global epidemiology of Dengue outbreaks in 1990-2015: A systematic review and meta-analysis. *Frontiers in Cellular and Infection Microbiology*, *7*, 317-317. https://doi.org/10.3389/fcimb.2017.00317

Gutierrez-Lopez, R., Bialosuknia, S. M., Ciota, A. T., Montalvo, T., Martinez-de la Puente, J., Gangoso, L., Figuerola, J., & Kramer, L. D. (2019). Vector competence of *Aedes caspius* and *Ae. albopictus m*osquitoes for Zika Virus, Spain. *Emerging Infectious Diseases*, *25*(2), 346-348. https://doi.org/10.3201/eid2502.171123

Handaq, N. (1998). *Les moustiques du Maroc: écologie et biogéographie des peuplements culicidiens dans les régions montagneuses, semi arides et arides du Maroc occidental : Essai de biotypologie des gîtes larvaires et étude comparative de la dynamique des populations marocaines et tunisiennes.* [Thèse de Doctorat de 3e cycle, Université Cadi Ayad, Faculté de Sciences Semlalia Marrakech].

Handaq, N., & Blenzar, A. (2017). Impact des eaux usées et des aménagements urbains sur la répartition des espèces de Culicidae (Diptera Nematocera) dans la ville de Meknès (Maroc). *European Scientific Journal*, *13*(27). https://doi.org/10.19044/esj.2017.v13n27p184

Harrak, Y., Kasouati, J., Loutfi, C., Benjelloun, A., Harrak, M. E., Hadef, R., Touil, N., & Mrabet, M. (2016). Anticipating West Nile virus transmission risk from the Moroccan blood donation. *European Journal of Public Health*, *26*.

Henry, M., Francis, L., Asin, V., Polson-Edwards, K., & Olowokure, B. (2017). Chikungunya virus outbreak in Sint Maarten, 2013-2014. *Revista Panamericana de Salud Pública*, *41*, e61. https://doi.org/10.26633/rpsp.2017.61

Hofhuis, A., Reimerink, J., Reusken, C., Scholte, E. J., Boer, A., Takken, W., & Koopmans, M. (2009). The hidden passenger of lucky bamboo: do imported *Aedes albopictus* mosquitoes cause dengue virus transmission in the Netherlands? *Vector-Borne and Zoonotic Diseases*, *9*(2), 217-220. https://doi.org/10.1089/vbz.2008.0071

Ibañez-Justicia, A., Gloria-Soria, A., den Hartog, W., Dik, M., Jacobs, F., & Stroo, A. (2017). The first detected airline introductions of yellow fever mosquitoes (*Aedes aegypti*) to Europe, at Schiphol International airport, the Netherlands. *Parasites & Vectors*, *10*(1), 603-603. https://doi.org/10.1186/s13071-017-2555-0

Iunicheva Iu, V., Riabova, T. E., Markovich, N., Bezzhonova, O. V., Ganushkina, L. A., Semenov, V. B., Tarkhov, G. A., Vasilenko, L. E., Guzeeva, T. M., Shevereva, T. V., & Sergiev, V. P. (2008). [First evidence for breeding *Aedes aegypti* L in the area of Greater Sochi and in some towns of Abkhasia]. *Meditsinskaya Parazitologiya i Parazitarnye Bolezni (Moscow)*(3), 40-43.

Izri, A., Bitam, I., & Charrel, R. N. (2011). First entomological documentation of *Aedes* (*Stegomyia*) *albopictus* (Skuse, 1894) in Algeria. *Clinical Microbiology and Infection*, *17*(7), 1116-1118. https://doi.org/10.1111/j.1469-0691.2010.03443.x

Jansen, C. C., & Beebe, N. W. (2010). The dengue vector *Aedes aegypti*: what comes next. *Microbes and Infection*, *12*(4), 272-279. https://doi.org/10.1016/j.micinf.2009.12.011

JPT., B. (1958). Transmission of Uganda S virus by *Aedes* (*Stegomyia*) *aegypti* Linn. . *Transactions of the Royal Society of Tropical Medicine and Hygiene*, *52*(4), 383–388.

Kamgang, B., Nchoutpouen, E., Simard, F., & Paupy, C. (2012). Notes on the blood-feeding behavior of *Aedes albopictus* (Diptera: Culicidae) in Cameroon. *Parasites & Vectors*, *5*, 57-57. https://doi.org/10.1186/1756-3305-5-57

Kantor, A. M., Lin, J., Wang, A., Thompson, D. C., & Franz, A. W. E. (2019). Infection pattern of Mayaro Virus in *Aedes aegypti* (Diptera: Culicidae) and transmission potential of the virus in mixed infections with Chikungunya Virus. *Journal of Medical Entomology*, *56*(3), 832–843. https://doi.org/10.1093/jme/tjy241

Karliuk, Y., Vom Hemdt, A., Wieseler, J., Pfeffer, M., & Kümmerer, B. M. (2021). Characterization and vector competence studies of Chikungunya virus lacking repetitivemMotifs in the 3' untranslated region of the genome. *Viruses*, *13*(3). https://doi.org/10.3390/v13030403

Kengne, P., Charmantier, G., Blondeau-Bidet, E., Costantini, C., & Ayala, D. (2019). Tolerance of disease-vector mosquitoes to brackish water and their osmoregulatory ability. *Ecosphere*, *10*(10), e02783. https://doi.org/https://doi.org/10.1002/ecs2.2783

Komar, N., Langevin, S., Hinten, S., Nemeth, N., Edwards, E., Hettler, D., Davis, B., Bowen, R., & Bunning, M. (2003). Experimental infection of North American birds with the New York 1999 strain of West Nile virus. *Emerging Infectious Diseases*, *9*(3), 311-322. https://doi.org/10.3201/eid0903.020628

Kotsakiozi, P., Gloria-Soria, A., Schaffner, F., Robert, V., & Powell, J. R. (2018). *Aedes aegypti* in the Black Sea: recent introduction or ancient remnant? *Parasites & Vectors*, *11*(1), 396. https://doi.org/10.1186/s13071-018-2933-2

Levine, R. S., Hedeen, D. L., Hedeen, M. W., Hamer, G. L., Mead, D. G., & Kitron, U. D. (2017). Avian species diversity and transmission of West Nile virus in Atlanta, Georgia. *Parasites & Vectors*, *10*(1), 62. https://doi.org/10.1186/s13071-017-1999-6

Li, M. I., Wong, P. S., Ng, L. C., & Tan, C. H. (2012). Oral susceptibility of Singapore *Aedes* (*Stegomyia*) *aegypti* (Linnaeus) to Zika virus. *PLoS Neglected Tropical Diseases*, *6*(8), e1792. https://doi.org/10.1371/journal.pntd.0001792

Liang, G., Gao, X., & Gould, E. A. (2015). Factors responsible for the emergence of arboviruses; strategies, challenges and limitations for their control. *Emerging Microbes and Infection*, *4*(3), e18. https://doi.org/10.1038/emi.2015.18

Liu, X., Baimaciwang, Wu, H., Pengcuociren, Guo, Y., Cirenwangla, Ren, D., Danzenggongga, Dazhen, Yang, J., Zhaxisangmu, Li, J., Cirendeji, Zhao, N., Sun, J., Li, J., Wang, J., Cirendunzhu, & Liu, Q. (2019). Breeding site characteristics and associated factors of *Culex pipiens* complex in Lhasa, Tibet, P. R. China. *International Journal of Environmental Research and Public Health*, *16*(8), 1407. https://doi.org/10.3390/ijerph16081407

Lourenco-de-Oliveira, R., Vazeille, M., Bispo de Filippis, A. M., & Failloux, A. B. (2002). Oral susceptibility to yellow fever virus of *Aedes aegypti* from Brazil. *Memórias do Instituto Oswaldo Cruz*, *97*(3), 437-439. http://www.ncbi.nlm.nih.gov/pubmed/12048581

Lumley, S., Hernández-Triana, L. M., Horton, D. L., Fernández de Marco, M. D. M., Medlock, J. M., Hewson, R., Fooks, A. R., & Johnson, N. (2018). Competence of mosquitoes native to the United Kingdom to support replication and transmission of Rift Valley fever virus. *Parasites & Vectors*, *11*(1), 308. https://doi.org/10.1186/s13071-018-2884-7

Lundstrom, J. O. (1999). Mosquito-borne viruses in western Europe: a review. *Journal of Vector Ecology*, *24*(1), 1-39. http://www.ncbi.nlm.nih.gov/pubmed/10436876

Mackenzie-Impoinvil, L., Impoinvil, D. E., Galbraith, S. E., Dillon, R. J., Ranson, H., Johnson, N., Fooks, A. R., Solomon, T., & Baylis, M. (2015). Evaluation of a temperate climate mosquito, *Ochlerotatus detritus* (=*Aedes detritus*), as a potential vector of Japanese encephalitis virus. *Medical and Veterinary Entomology*, *29*(1), 1-9. https://doi.org/10.1111/mve.12083

Magalhaes, T., Robison, A., Young, M. C., Black, W. C. t., Foy, B. D., Ebel, G. D., & Ruckert, C. (2018). Sequential infection of *Aedes aegypti* mosquitoes with Chikungunya virus and Zika virus enhances early Zika virus transmission. *Insects*, *9*(4). https://doi.org/10.3390/insects9040177

Main, B. J., Nicholson, J., Winokur, O. C., Steiner, C., Riemersma, K. K., Stuart, J., Takeshita, R., Krasnec, M., Barker, C. M., & Coffey, L. L. (2018). Vector competence of *Aedes aegypti*, *Culex tarsalis*, and *Culex quinquefasciatus* from California for Zika virus. *PLoS Neglected Tropical Diseases*, *12*(6), e0006524. https://doi.org/10.1371/journal.pntd.0006524

Mancini, G., Montarsi, F., Calzolari, M., Capelli, G., Dottori, M., Ravagnan, S., Lelli, D., Chiari, M., Santilli, A., Quaglia, M., Quaglia, M., Federici, V., Monaco, F., Goffredo, M., & Savini, G. (2017). Mosquito species involved in the circulation of West Nile and Usutu viruses in Italy. *Veterinaria Italiana*, *53*(2), 97-110. https://doi.org/10.12834/VetIt.114.933.4764.2

Marini, A. G., Lieberthal, B. A., & Gardner, A. M. (2020). Production of *Culex pipiens* in stormwater and combined Sewer Catch Basins. *Journal of the American Mosquito Control Association*, *36*(4), 249-252. https://doi.org/10.2987/20-6934.1

Mavale, M. S., Ilkal, M. A., & Dhanda, V. (1992). Experimental studies on the susceptibility of *Aedes vittatus* to dengue viruses. *Acta Virologica*, *36*(4), 412-416. http://www.ncbi.nlm.nih.gov/pubmed/1362325

Mavridis, K., Fotakis, E. A., Kioulos, I., Mpellou, S., Konstantas, S., Varela, E., Gewehr, S., Diamantopoulos, V., & Vontas, J. (2018). Detection of West Nile virus - Lineage 2 in *Culex pipiens* mosquitoes, associated with disease outbreak in Greece, 2017. *Acta Tropica*, *182*, 64-68. https://doi.org/10.1016/j.actatropica.2018.02.024

Mayer, S. V., Tesh, R. B., & Vasilakis, N. (2017). The emergence of arthropod-borne viral diseases: A global prospective on dengue, chikungunya and zika fevers. *Acta Tropica*, *166*, 155-163. https://doi.org/10.1016/j.actatropica.2016.11.020

Medlock, J. M., Cull, B., Vaux, A. G. C., & Irwin, A. G. (2017). The mosquito *Aedes vexans* in England. *Veterinary Record*, *181*(9), 243. https://doi.org/10.1136/vr.j4048

Medlock, J. M., Hansford, K. M., Versteirt, V., Cull, B., Kampen, H., Fontenille, D., Hendrickx, G., Zeller, H., Van Bortel, W., & Schaffner, F. (2015). An entomological review of invasive mosquitoes in Europe. *Bulletin of Entomological Research*, *105*(6), 637-663. https://doi.org/10.1017/s0007485315000103

Meegan, J. M., Khalil, G. M., Hoogstraal, H., & Adham, F. K. (1980). Experimental transmission and field isolation studies implicating *Culex pipiens* as a vector of Rift Valley fever virus in Egypt. *The American Journal of Tropical Medicine and Hygiene*, *29*(6), 1405-1410. https://doi.org/10.4269/ajtmh.1980.29.1405

Metge, G. (1986). *Étude des écosystèmes hydromorphes (Daya et Merja) de la Meseta occidentale marocaine. Typologie et synthèse cartographique à objectif sanitaire, appliquée aux populations d'Anopheles labranchiae (Falleroni, 1926) (Diptera, Culicidae, Anophelinae)* Université Aix-Marseille].

Metge, G., & Hassaïne, K. (1998). Study of the environmental factors associated with oviposition by *Aedes caspius* and *Aedes detritus* along a transect in Algeria. *Journal of the American Mosquito Control Association*, *14*(3), 283-288.

Miller, B. R., Godsey, M. S., Crabtree, M. B., Savage, H. M., Al-Mazrao, Y., Al-Jeffri, M. H., Abdoon, A. M., Al-Seghayer, S. M., Al-Shahrani, A. M., & Ksiazek, T. G. (2002). Isolation and genetic characterization of Rift Valley fever virus from *Aedes vexans arabiensis*, Kingdom of Saudi Arabia. *Emerging Infectious Diseases*, *8*(12), 1492-1494. https://doi.org/10.3201/eid0812.020194

Muhammad, N. A. F., Abu Kassim, N. F., Ab Majid, A. H., Abd Rahman, A., Dieng, H., & Avicor, S. W. (2020). Biting rhythm and demographic attributes of *Aedes albopictus* (Skuse) females from different urbanized settings in Penang Island, Malaysia under uncontrolled laboratory conditions. *PloS One*, *15*(11), e0241688. https://doi.org/10.1371/journal.pone.0241688

Müller, G. C., Kravchenko, V. D., Junnila, A., & Schlein, Y. (2012). Tree-hole breeding mosquitoes in Israel. *Journal of Vector Ecology*, *37*(1), 102-109. https://doi.org/10.1111/j.1948-7134.2012.00206.x

Ndiaye, e. H., Fall, G., Gaye, A., Bob, N. S., Talla, C., Diagne, C. T., Diallo, D., B, A. Y., Dia, I., Kohl, A., Sall, A. A., & Diallo, M. (2016). Vector competence of *Aedes vexans* (Meigen), *Culex poicilipes* (Theobald) and *Cx. quinquefasciatus* Say from Senegal for West and East African lineages of Rift Valley fever virus. *Parasites & Vectors*, *9*, 94. https://doi.org/10.1186/s13071-016-1383-y

Ngoshe, Y. B., Avenant, A., Rostal, M. K., Karesh, W. B., Paweska, J. T., Bagge, W., Jansen van Vuren, P., Kemp, A., Cordel, C., Msimang, V., & Thompson, P. N. (2020). Patterns of Rift Valley fever virus seropositivity in domestic ruminants in central South Africa four years after a large outbreak. *Scientific Reports*, *10*(1), 5489. https://doi.org/10.1038/s41598-020-62453-6

Oliva, L. O., Correia, J. C., & Albuquerque, C. M. R. (2014). How Mosquito Age and the Type and Color of Oviposition Sites Modify Skip-Oviposition Behavior in *Aedes aegypti* (Diptera: Culicidae)? *Journal of Insect Behavior*, *27*(1), 81-91. https://doi.org/10.1007/s10905-013-9407-3

Orshan, L., Bin, H., Schnur, H., Kaufman, A., Valinsky, A., Shulman, L., Weiss, L., Mendelson, E., & Pener, H. (2008). Mosquito vectors of West Nile Fever in Israel. *Journal of Medical Entomology*, *45*(5), 939-947. https://doi.org/10.1603/0022-2585(2008)45[939:mvownf]2.0.co;2

Parry, R., Naccache, F., Ndiaye, E. H., Fall, G., Castelli, I., Lühken, R., Medlock, J., Cull, B., Hesson, J. C., Montarsi, F., Failloux, A.-B., Kohl, A., Schnettler, E., Diallo, M., Asgari, S., Dietrich, I., & Becker, S. C. (2020). Identification and RNAi profile of a novel Iflavirus infecting senegalese *Aedes vexans arabiensis* Mosquitoes. *Viruses*, *12*(4), 440. https://doi.org/10.3390/v12040440

Pereira-Dos-Santos, T., Roiz, D., Lourenço-de-Oliveira, R., & Paupy, C. (2020). A Systematic review: Is *Aedes albopictus* an efficient bridge vector for zoonotic Arboviruses? *Pathogens*, *9*(4), 266. https://doi.org/10.3390/pathogens9040266

Pilaski, J., & Mackenstein, H. (1985). [Isolation of Tahyna virus from mosquitoes in 2 different European natural foci]. *Bacteriology, Microbiology, and Hygiene Series B*, *180*(4), 394-420. http://www.ncbi.nlm.nih.gov/pubmed/2860760 (Nachweis des Tahyna-Virus bei Stechmucken in zwei verschiedenen europaischen Naturherden.)

Powell, J. R., & Tabachnick, W. J. (2013). History of domestication and spread of *Aedes aegypti*--a review. *Memórias do Instituto Oswaldo Cruz*, *108 Suppl 1*(Suppl 1), 11-17. https://doi.org/10.1590/0074-0276130395

Reinert, J. F., Harbach, R., & Kitching, I. (2004). Phylogeny and classification of *Aedini* (Diptera: Culicidae), based on morphological characters of all life stages. *Zoological Journal of the Linnean Society*, *142*, 289-368.

Reiter, P. (1998). *Aedes albopictus* and the world trade in used tires, 1988-1995: the shape of things to come? *Journal of the American Mosquito Control Association*, *14*(1), 83-94.

Richard, V., Paoaafaite, T., & Cao-Lormeau, V. M. (2016). Vector Competence of French Polynesian *Aedes aegypti* and *Aedes polynesiensis* for Zika Virus. *PLoS Neglected Tropical Diseases*, *10*(9), e0005024. https://doi.org/10.1371/journal.pntd.0005024

Robert, V., Gunay, F., Goff, G. L., Boussès, P., Sulesco, T., Khalin, A., Medlock, J., Kampen, H., Petrj , D., & Schaffner, F. (2019). Distribution chart for Euro-Mediterranean mosquitoes (western Palaearctic region).

Rochlin, I., Faraji, A., Healy, K., & Andreadis, T. G. (2019). West Nile Virus Mosquito Vectors in North America. *Journal of Medical Entomology*, *56*(6), 1475-1490. https://doi.org/10.1093/jme/tjz146

Ruiz-Arrondo, I., McMahon, B. J., Hernández-Triana, L. M., Santibañez, P., Portillo, A., & Oteo, J. A. (2019). Surveillance of Mosquitoes (Diptera, Culicidae) in a Northern Central Region of Spain: Implications for the Medical Community. *Frontiers in Veterinary Science*, *6*, 86-86. https://doi.org/10.3389/fvets.2019.00086

Sang, R., Arum, S., Chepkorir, E., Mosomtai, G., Tigoi, C., Sigei, F., Lwande, O. W., Landmann, T., Affognon, H., Ahlm, C., & Evander, M. (2017). Distribution and abundance of key vectors of Rift Valley fever and other arboviruses in two ecologically distinct counties in Kenya. *PLoS Neglected Tropical Diseases*, *11*(2), e0005341. https://doi.org/10.1371/journal.pntd.0005341

Schaffner, F., & Mathis, A. (2014). Dengue and dengue vectors in the WHO European region: past, present, and scenarios for the future. *The Lancet Infectious Diseases*, *14*(12), 1271-1280. https://doi.org/10.1016/s1473-3099(14)70834-5

Scheuch, D. E., Schäfer, M., Eiden, M., Heym, E. C., Ziegler, U., Walther, D., Schmidt-Chanasit, J., Keller, M., Groschup, M. H., & Kampen, H. (2018). Detection of Usutu, Sindbis, and Batai Viruses in Mosquitoes (Diptera: Culicidae) Collected in Germany, 2011-2016. *Viruses*, *10*(7), 389. https://doi.org/10.3390/v10070389

Schuffenecker, I., Peyrefitte, C. N., el Harrak, M., Murri, S., Leblond, A., & Zeller, H. G. (2005). West Nile virus in Morocco, 2003. *Emerg Infect Dis*, *11*(2), 306-309. https://doi.org/10.3201/eid1102.040817

Seixas, G., Salgueiro, P., Bronzato-Badial, A., Gonçalves, Y., Reyes-Lugo, M., Gordicho, V., Ribolla, P., Viveiros, B., Silva, A. C., Pinto, J., & Sousa, C. A. (2019). Origin and expansion of the mosquito *Aedes aegypti* in Madeira Island (Portugal). *Scientific Reports 9*(1), 2241. https://doi.org/10.1038/s41598-018-38373-x

Shahhosseini, N., Friedrich, J., Moosa-Kazemi, S. H., Sedaghat, M. M., Kayedi, M. H., Tannich, E., Schmidt-Chanasit, J., & Lühken, R. (2018). Host-feeding patterns of *Culex* mosquitoes in Iran. *Parasites & Vectors*, *11*(1), 669. https://doi.org/10.1186/s13071-018-3237-2

Smithburn, K. C., Hughes, T. P., Burke, A., & Paul, J. (1940). A neurotropic virus isolated from the blood of a native of Uganda. *The American Journal of Tropical Medicine and Hygiene*, *20*, 471-492.

Soltész, Z., Erdélyi, K., Bakonyi, T., Barna, M., Szentpáli-Gavallér, K., Solt, S., Horváth, É., Palatitz, P., Kotymán, L., Dán, Á., Papp, L., Harnos, A., & Fehérvári, P. (2017). West Nile virus host-vector-pathogen interactions in a colonial raptor. *Parasites & Vectors*, *10*(1), 449. https://doi.org/10.1186/s13071-017-2394-z

Stefopoulou, A., Balatsos, G., Petraki, A., LaDeau, S. L., Papachristos, D., & Michaelakis, A. (2018). Reducing *Aedes albopictus* breeding sites through education: A study in urban area. *PloS one*, *13*(11), e0202451-e0202451. https://doi.org/10.1371/journal.pone.0202451

Sumaye, R., Jansen, F., Berkvens, D., De Baets, B., Geubels, E., Thiry, E., & Krit, M. (2019). Rift Valley fever: An open-source transmission dynamics simulation model. *PloS one*, *14*(1), e0209929-e0209929. https://doi.org/10.1371/journal.pone.0209929

Tantely, L. M., Boyer, S., & Fontenille, D. (2015). A review of mosquitoes associated with Rift Valley fever virus in Madagascar. *The American Journal of Tropical Medicine and Hygiene*, *92*(4), 722-729. https://doi.org/10.4269/ajtmh.14-0421

Trari, B. (2017). *Les moustiques (insectes, diptères) du maroc: atlas de répartition et études épidémiologiques* (Publication Number 2970) [Thèse de doctorat d'état, Université Mohammed V Faculté des sciences de Rabat].

Turell, M. J., Presley, S. M., Gad, A. M., Cope, S. E., Dohm, D. J., Morrill, J. C., & Arthur, R. R. (1996). Vector competence of Egyptian mosquitoes for Rift Valley fever virus. *The American Journal of Tropical Medicine and Hygiene*, *54*(2), 136-139. https://doi.org/10.4269/ajtmh.1996.54.136

Unlu, I., Farajollahi, A., Strickman, D., & Fonseca, D. M. (2013). Crouching tiger, hidden trouble: urban sources of *Aedes albopictus* (Diptera: Culicidae) refractory to source-reduction. *PloS One*, *8*(10), e77999. https://doi.org/10.1371/journal.pone.0077999

Vazeille, M., Jeannin, C., Martin, E., Schaffner, F., & Failloux, A. B. (2008). Chikungunya: a risk for Mediterranean countries? *Acta Tropica*, *105*(2), 200-202. https://doi.org/10.1016/j.actatropica.2007.09.009

Veronesi, R., Gentile, G., Carrieri, M., Maccagnani, B., Stermieri, L., & Bellini, R. (2012). Seasonal pattern of daily activity of *Aedes caspius*, *Aedes detritus*, *Culex modestus*, and *Culex pipiens* in the Po Delta of northern Italy and significance for vector-borne disease risk assessment. *Journal of Vector Ecology*, *37*(1), 49-61. https://doi.org/10.1111/j.1948-7134.2012.00199.x

Vialatte, C. (1923). Contribution à la recherche de l'aire de dispersion de *Stegomyia fasciata*. Son existence à Marrakech. *Archives de l'Institut Pasteur d'Algérie*, *1*, 688-690.

Vu, D. M., Jungkind, D., & Angelle Desiree, L. (2017). Chikungunya virus. *Clinics in Laboratory Medicine*, *37*(2), 371-382. https://doi.org/10.1016/j.cll.2017.01.008

Weaver, S. C., Chen, R., & Diallo, M. (2020). Chikungunya virus: role of vectors in emergence from enzootic cycles. *Annual Review of Entomology*, *65*, 313-332. https://doi.org/10.1146/annurev-ento-011019-025207

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Review Article

مروری بر پشه‌های دارای اهمیت اپیدمیولوژیک در مراکش: توزیع جغرافیایی، زیست‌بوم‌شناسی و خطرات بهداشت عمومی

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چکیده: گسترش و استقرار گونه‌های مهاجم پشه (Diptera: Culicidae) بخصوص ورود گونه *Aedes albopictus* در سال‌های اخیر، توجه فزاینده‌ای را به خود جلب کرده است. در مراکش، گونه‌های متعددی از پشه‌ها وجود دارند که به عنوان ناقل یا ناقل بالقوه چندین آربوویروس (دنگو، چیکونگونیا، ویروس تب دره ریفت و ویروس نیل غربی) شناخته می‌شوند. برخی از گونه‌ها، دهه‌هاست که در این کشور مستقر شده‌اند (*Ae. aegypti*، *Ae. vexans*، *Ae. caspius*، *Ae. detritus* و *Culex pipiens*)، در حالی که برخی دیگر، مهاجمینی تازه وارد هستند (*Ae. albopictus*). نوشتار حاضر، مروری بر گونه های پشه در مراکش، پراکنش جغرافیایی آنها (از ۱۹۱۶ تا ۲۰۲۵)، زیست بوم شناسی و نقش آنها در انتقال آربوویروس ارائه می‌دهد و بر ضرورت افزایش تلاش‌های نظارتی و راهکارهای کنترل تأکید می‌کند.

کلمات کلیدی: بیماری‌های منتقله از طریق ناقلین، ویروس‌های منتقله از طریق بندپایان، بهداشت عمومی، ظهور، نقشه‌ها

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