Review Article

A Checklist of Mosquitoes (Diptera: Culicidae) of Guilan Province and their Medical and Veterinary Importance

Shahyad Azari-Hamidian1,2*, Behzad Norouzi

1 Research Center of Health and Environment, Guilan University of Medical Sciences, Rasht, Iran
2 School of Health, Guilan University of Medical Sciences, Rasht, Iran

*Corresponding author: Shahyad Azari-Hamidian
Email: azari@gums.ac.ir

ABSTRACT

Background: Mosquitoes (Diptera: Culicidae) are the most important arthropods in medicine and health because of the burden of diseases which they transmit such as malaria, encephalitis, filariasis. In 2011, the last checklist of mosquitoes of Guilan Province included 30 species representing 7 genera.

Methods: Using the main data bases such as Web of Science, PubMed, Scopus, Google Scholar, Scientific Information Database (SID), IranMedex and Magiran which were searched up to August 2018 and reviewing the literature, the available data about the mosquito-borne diseases of Iran and Guilan Province were extracted and analyzed. Also the checklist of mosquitoes of Guilan Province was updated.

Results: One protozoonal disease (human malaria), two arbovirous diseases (West Nile fever, bovine ephemeral fever), two helminthic diseases (dirofilariasis, setariasis) and one bacterial disease (anthrax) have been found in Guilan Province which biologically or mechanically are assumed to transmit by mosquitoes. The updated checklist of mosquitoes of Guilan Province is presented containing 33 species representing 7 or 9 genera according different classifications of the tribe Aedini.

Conclusion: There is no information about the role of mosquitoes in the transmission of bovine ephemeral fever and anthrax in Iran and Guilan Province. Also the vectors of dirofilariasis and setariasis are not known in Guilan Province and available data belong to other provinces. It seems that the role of arthropods in the epidemiology of anthrax is not important.

Keywords: Checklist, Mosquito-borne disease, Mosquito-borne Infection, Mosquito-borne pathogen, Mosquito-borne virus, Mobovirus

Citation: Azari-Hamidian S, Norouzi B. A checklist of mosquitoes (Diptera: Culicidae) of Guilan province and their medical and veterinary importance. Caspian J Health Res. 2018;3(3):91-96.

Introduction

About 16% of the global burden of infectious and parasitic diseases belong to the vector-borne diseases. After diarrhoeal diseases, HIV/AIDS, tuberculosis, mosquito-borne malaria shows the fourth highest burden among infectious and parasitic diseases (1). The transmission of malaria as well as other diseases including filariasis, encephalitis etc. and their biting nuisance makes mosquitoes (Diptera: Culicidae) the most important arthropods in medical and health entomology (2).

Mosquitoes includes two subfamilies Anopheles and Culicinae and the latter subdivided into 11 tribes. The family Diptera contains 2 suborders, Brachycera and Cyclorrhapha, and the latter subdivided into 45 families (3).

The most important taxonomic change in the classification of mosquitoes during recent years is the elevation of many subgenera to the generic rank in the tribe Aedini by Reinert et al. (4-7), thus they included 82 genera in the tribe. However Wilkerson et al. (8) and Wilkerson and Linton (9), using the equal weighting of data set of Reinert et al. (4-7), made a different conclusion and included ten genera in the tribe Aedini. Two parallel classifications are mentioned and used in many references (e.g. 10, 11).
The present article tries to provide a comprehensive and systematic review of mosquito-borne diseases in Guilan Province and an update checklist of mosquitoes of Guilan Province in the Caspian Sea littoral of northern Iran.

**Methods**

This investigation reviewed the articles indexed in Web of Science, PubMed, Scopus, Google Scholar, Scientific Information Database (SID), IranMedex and Magiran databases which were searched up to August 2018. First, the main textbooks or chapters of textbooks of medical and veterinary entomology pertaining mosquitoes (e.g. 2, 10, 12, 13) were reviewed to extract mosquito-borne diseases. Also the aforementioned databases were browsed to obtain literature that indicates mosquito-borne diseases, using keywords like “mosquito-borne diseases”, “mosquito-borne infections”, “mosquito-borne pathogens” and “mosquito-borne viruses”. Then, mosquito-borne disease names were extracted from identified literature. Afterwards, the databases were browsed to obtain literature reporting occurrence of mosquito-borne diseases in animals and humans in Guilan Province, Iran or a wider geographic range such as the Middle East, southwestern Asia or the World Health Organization Eastern Mediterranean Region. Harbach (14) and Wold Health Organization (15) were consulted for the definition of the regions. At last, the main keywords were browsed as “extracted mosquito-borne disease names, Iran, Iranian, Guilan, Gilan” and “extracted mosquito-borne pathogen names, Iran, Iranian, Guilan, Gilan”. The main mosquito-borne disease names were ‘malaria, avian malaria, bird malaria, West Nile (WN) fever, dengue (DEN) fever, Rift Valley fever (RVF), Sindbis (SIN) fever, bovine ephemeral fever (BEF), avian pox (AP), poultry pox, dirofilariasis, filariasis, lymphatic filariasis, wuchereriosis, tularemia, tularemnia, anthrax’ and the mosquito-borne pathogen generic names were ‘Plasmodium, Dirofilaria, Setaria, Deraiphotonema, Dipetalonema, Wuchereria, Francisella, Bacillus, Flavivirus, Alphavirus, Phlebovirus, Ephemeroerovirus, Orthobunyavirus, Avipoxvirus, Orbivirus, Orthonairovirus’. In addition, the references of the selected literature were also reviewed to increase the coverage of search. With few exceptions, only data from books or peer-reviewed articles were included in the final analysis. Regarding infectious agents of diseases (pathogens), mosquito-borne diseases are divided into four categories of protozoal diseases (protozooses), arboviral diseases, helminthic diseases (helminthoses) and bacterial diseases. Ashford’s article (16) was consulted for the current usage of nomenclature for some parasitic diseases especially arthropod-borne ones. Also, other names of mosquito-borne diseases (if they were applicable) were extracted and mentioned from the literature. Concerning each disease, data related to infectious agents (pathogens), distribution, reservoir or host (human and animals) and disease prevalence (if there were available) in Guilan Province were extracted and presented from the literature. At last, an update checklist of mosquitoes of Guilan Province was presented. The abbreviations of genera and subgenera of mosquitoes followed Reinert (17).

**Mosquito-Borne Diseases in Guilan Province**

**Protozoal Diseases (Protozooses)**

Malaria (Plasmodiosis or Plasmodial Infection): Human malaria causes the highest global burden of vector-borne diseases and the fourth highest burden among infectious and parasitic diseases (1). Other names of the disease are ague, paludism, marsh fever and intermittent fever (12). The disease is reported in 91 countries of the world with at least 216 million infection cases and about 445000 deaths per year with about 90% of them from tropical Africa (18). Four species of Plasmodium (P. falciparum, P. malariae, P. ovale, P. vivax) are usually responsible for human malaria and which are biologically transmitted only by some anopheline mosquitoes (10). At the present time, Iran is in the eliminating stage of the World Health Organization for malaria control. The indigenous cases of malaria have declined from 1847 to 81 between 2010 and 2016 (18). Before starting malaria control program in Iran, Caspian Sea region of northern Iran, including Guilan Province, was one of the foci of malaria in the country with meso- to hyper- endemicities. One of the first scientific investigations on malaria in Iran was carried out by Latychev in 1921 in Rasht and Bandaranazli of Guilan Province. The most prevalent Plasmodium is P. vivax in the province (19). At the present time, though, up to 6 imported human cases of malaria per year have been reported in Guilan Province in recent years, there is no indigenous case of the disease in the province from 2006 (20). So, the province is considered as the zero indigenous malaria cases (free of malaria). Out of 475 formally recognized species and more than 50 unnamed species of mosquitoes (Anopheles Meigen (3), about 70 species are known the vectors of malaria and 40 species are more important vectors (2). Seven species of the genus Anopheles (An. maculipennis Meigen s.l., An. sacharovi Favre, An. culicifacies Giles s.l., An. dhalii Patton, An. fluviatilis James s.l., An. stephensi Liston, An. superpictus Grassi s.l.) are known as malaria vectors in Iran and An. maculipennis s.l in Guilan Province (21). Also, An. hyrcanus (Pallas) was introduced as a possible vector of malaria using a nested polymerase chain reaction (PCR) assay in Fooman of Guilan Province (22).

**Arboviral Diseases**

Mosquito-Borne Viral Infections (Mosquito-Borne Viruses or Moboviruses)

West Nile Fever: West Nile virus and its subtype Kunjin, a member of the Japanese encephalitis (JE) serogroup (Flaviviridae: Flavivirus), is distributed in Eurasia, Africa, North and Central America and Australia. Mosquitoes, especially ornithophilic species including different species of Anopheles, Aedes, Culex, Drosophila, Musca domestica, Tsetse fly, etc., are the principal vectors of the virus and some virus isolations have been reported from soft and hard ticks (Parasitiformes: Ixodidae: Argasidae and Ixodidae). Wild birds, especially wetland species, are the principal vertebrate hosts. The virus has also been isolated from mammals and frogs. Rabensburg virus is the synonym of WNV (23-26). Guilan Province, with vast wetlands, is one of the foci of WNV where infections are found in humans (1.4–10%) (27–29), horses (2.2-25%) (29, 30) and birds (especially the common coot, the main reservoir) (62.7%) (31). Recently, Shahhosseini et al. (32) found the virus in Cx. pipiens Linnaeus in Guilan Province.
Bovine Ephemeral Fever: Bovine ephemeral fever virus (Rhabdoviridae: Ephemerovirus) infects a wide range of wild and domestic ruminants especially cattle and water buffalo in Africa, Asia and Australia. Other names of the disease are three-day sickness, stiff sickness, dengue fever of cattle, bovine epizootic fever and lazy man’s disease. Mosquitoes of the genera *Anopheles*, *Aedes* and *Culex* and biting midges (Diptera: Ceratopogonidae) are probably the main vectors (33-35). In Iran, bovine ephemeral fever virus is found in cattle and water buffalo using molecular sequence and serological assay in different provinces such as Razavi Khorasan (36) Khuzistan (37), Fars, Tehran, West Azerbaijan (38) and Qazvin (39). Also, there is unpublished data about the occurrence of BEF in the provinces of Bushehr, Guilan, Ilam, Mazandaran, Qom, Semnan and Yazd (39, 40). There is no information about the vectors of BEF in Iran.

**Helminthic Diseases (Helminthoses)**

Mosquito-Borne Filariases

Dirofilariasis (Dirofilariosis): Dirofilariasis is a disease caused by at least 27 species of the nematode genus *Dirofilaria* (Spirurida: Onchocercidae), especially *D. immitis* (canine or dog heartworm) and *D. repens*, which are transmitted by mosquitoes. The disease is cosmopolitan. The reservoirs of the nematodes are many different mammals (at least 111 species), especially canids. Currently human dirofilariasis is classified as an emerging disease in some areas because of dramatic increases in the number of reported cases (41-43). More than 77 species of *Anopheles*, *Aedes*, *Culex*, *Coquillettidia*, *Mansonia*, *Psorophora* Robineau-Desvoidy and *Culiseta* Felt are assumed to play a role in transmission of dirofilariasis (44). Azari-Hamidian et al. (45) reviewed all published documents on dirofilariasis in Iran by 2005. Thus the review included references that have not been cited herein. It seems that Guilan Province is one of the foci of dirofilariasis, where *D. repens* infection is found in humans (Three cases) (45, 46) and *D. immitis* found in 4.4% (47) to 51.4% of local dogs (48, 49). *Culex theileri* Theobald is a known vector of *D. immitis* in Ardebil Province (44), but there is no information about the vector of infection in Guilan Province.

Setariasis (Setariosis): Setariasis caused by 43 species of *Setaria* (Nematoda: Onchocercidae: Setariinae) is a worldwide disease and infects a wide range of ruminants. Setariasis is transmitted by the mosquito genera of *Anopheles*, *Aedes*, *Armigeres* Theobald, *Culex* and *Mansonia* and probably stable-fly (Diptera: Muscidae) (41, 50). Five species of Setaria (*S. digitata*, *S. equina*, *S. labiatopapillosa*, *S. marshali*, *S. cervi*) have been reported in Iran using Knott’s method and microscope observation. They are found in horse, cattle, water buffalo, sheep, goat, donkey and wild sheeps in the provinces of East Azerbaijan, Guilan, Hamedan, Khuzistan, Mazandaran, Qazvin, Sistan and Baluchistan, Tehran, West Azerbaijan and Zanjan (51-62). Baharsetaf et al. (52) reported lumbar paralysis (cerebrospinal nematodiases) in sheep due to *S. labiatopapillosa* in Guilan Province for the first time in Iran. *Anopheles maculipennis* is known the vector of *Setaria* in Ardebil Province (44), but there is no information about the vector of infection in Guilan Province.

**Bacterial Diseases**

Anthrax: anthrax is a worldwide infection caused by the bacterium *Bacillus anthracis*. Other names of the disease are charbon, malignant pustule, malignant carbuncle, splenic fever, milizbrand and woolsorter’s disease. The main ways of transmission to human are direct contact of infected carcasses or the handling of contaminated products from morbid animals. Horseflies, stable-fly and mosquitoes (experimentally in *Aedes*) mechanically transmit the bacterium. Also, ants, coprophagous and necrophagous beetles (e.g. Dermestidae), blow-flies (Diptera: Calliphoridae) and house-fly (Diptera: Muscidae) are believed to be implicated in transferring spores. But it seems that arthropods have a minor importance in the epidemiology of the disease (13, 63, 64). Human cases of anthrax have been reported from 106 to 179 per year during 2006-2011 from at least 25 Iranian provinces (20). One rare case of human cutaneous anthrax was found in Guilan Province (65). During 2006-2011, from 4 to 21 cases of human anthrax were reported from Guilan Province. The province as well as Chishmehal and Bakhtiari, Fars, Isfahan, Kurdistan, Razavi Khorasan and West Azerbaijan Provinces show high rate of human cases in Iran (20). There is no information about the role of arthropods in transmission of anthrax in the country.

**A checklist of mosquitoes (Diptera: Culicidae) of Guilan Province**

In 2007, the most recent checklist of Iranian mosquitoes included 64 species representing seven genera (66). After that, four minor modifications were carried out in the nomenclature of Iranian mosquitoes which were noted during providing keys to them (67). Those two aforementioned articles listed most of the literature that pertained to the records of mosquitoes in Iran by 2007. After that five species were added to the Iranian mosquito fauna (22, 68-71).

The last checklist of Iranian mosquitoes (66) included the species of tribe Aedini in two genera of *Aedes* and *Ochlerotatus* Lynch Arribalzaga according to elevation of subgenus *Ochlerotatus* to generic rank by Reinert (72). At the present time, based on the system of classification of aedine species, 12 verified species of Iranian Aedini (66, 69, 71) are classified in one genus (with five subgenera) (8, 9) or five genera (4-7). So, the checklist of Iranian species includes 69 species representing seven or eleven genera. Azari-Hamidian (73) listed 30 species of mosquitoes representing seven genera in Guilan Province. Since, two species new to the province fauna, *Ae. pulcitarsis* (Rondani) and *Cx. perexiguus* Theobald, and a genus and species *Orthopodomia pulcipalpis* (Rondani)] new to Iranian fauna were reported from Guilan Province (70, 74), thus there are 33 species representing seven or nine genera in the province. A checklist of mosquitoes of Guilan Province is presented as follow:

**Family Culicidae Meigen, 1818**

Subfamily Anophelinae

1) Genus *Anopheles* Meigen, 1818
Subgenus Anopheles Meigen, 1818
1- An. (Ano.) algeriensis Theobald, 1903
2- An. (Ano.) claviger (Meigen, 1804)
Maculipennis Group
3- An. (Ano.) atroparvus Van Thiel, 1927
4- An. (Ano.) labranchiae Falleri, 1926
5- An. (Ano.) maculipennis Meigen, 1818
6- An. (Ano.) melanoon Hackett, 1934
7- An. (Ano.) messee Falleri, 1926
8- An. (Ano.) persiensis Linton, Sedaghat and Harbach, 2003
9- An. (Ano.) sacharovi Favre, 1903
10- An. (Ano.) plumbeus Stephens, 1828

Azari

Hyrcanus Group
11- An. (Ano.) hyrcanus (Pallas, 1771)
12- An. (Ano.) pseudopictus Grassi, 1899
Subgenus Cellia Theobald, 1902
13- An. (Cel.) superpictus Grassi, 1899
Subfamily Culicinae

Tribe Aedini
II) Genus Aedes Meigen, 1818
Subgenus Aedimorphus Theobald, 1903
14- Ae. (Adm.) vexans (Meigen, 1830) [Aedimorphus vexans]
Subgenus Dahliana Reinert, Harbach and Kitching, 2006
15- Ae. (Dah.) echinus (Edwards, 1920) [Dahliana echinus]
16- Ae. (Dah.) genicalatus (Olivier, 1791) [Dahliana geniculata]
Subgenus Ochlerotatus Lynch Arribalzaga, 1891
17- Ae. (Och.) caspius (Pallas, 1771) s.l. [Oc. caspius s.l.]
18- Ae. (Och.) pulcritarsis (Rondani, 1872) [Oc. pulcritarsis]
Tribe Culicini
III) Genus Culex Linnaeus, 1758
Subgenus Culex Linnaeus, 1758
19- Cx. (Cax.) pipiens Linnaeus, 1758
20- Cx. (Cax.) torrentium Martini, 1925
21- Cx. (Cax.) perexiguus Theobald, 1903
22- Cx. (Cax.) theileri Theobald, 1903
23- Cx. (Cax.) mimetica Noe, 1899
24- Cx. (Cax.) tritaeniorynchus Giles, 1901
Subgenus Maillotia Theobald, 1907
25- Cx. (Mai.) hortensis Ficalbi, 1889
Subgenus Neoculex Dyar, 1905
26- Cx. (Ncx.) territans Walker, 1856
Tribe Culiseta
IV) Genus Culiseta Felt, 1904
Subgenus Allotheobaldia Broelemann, 1919
27- Cs. (All.) longiareolata (Macquart, 1838)
Subgenus Culicella Felt, 1904
28- Cs. (Cuc.) morsitans (Theobald, 1901)
Subgenus Culicella Felt, 1904
29- Cs. (Cas.) annulata (Schrank, 1776)
30- Cs. (Cas.) subochrea (Edwards, 1921)
Tribe Mansonini
V) Genus Coquillettidia Dyar, 1905
Subgenus Coquillettidia Dyar, 1905
31- Cq. (Cq.) richardi (Ficalbi, 1889)
Tribe Orthopodomyini
VI) Genus Orthopodomyia Theobald, 1904
32- Or. pulcripalpis (Rondani, 1872)
Tribe Uranotanemini
VII) Genus Uranotaenia Lynch Arribalzaga, 1891
Subgenus Pseudosalbia Theobald, 1912
33- Ur. (Pfc.) unguiculata Edwards, 1913

Acknowledgements
The authors are grateful to Shadi Azari-Hamidian for reviewing the manuscript.

Ethical consideration
None.

Conflicts of interests
Authors declared no conflict of interest.

Funding
None.

References
Azari-Hamidian and Norouzi


