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Review Article

Mosquito-borne diseases: a review of the risks to humans, Iraq

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Abstract

Mosquitoes are a major player in the spread of malaria, a parasite that killed an estimated 627,000 people in 2020 alone—as well as viruses like Zika and dengue. The Anopheles gambiae mosquito, common in rural Africa, is often called "the deadliest animal on Earth," according to a 2020 study. There are about 3,500 species of mosquito, but "only about 100 are likely to bite and spread disease to humans." The most medically important genera, Culex, Anopheles, and Aedes, carry a range of diseases, including malaria, dengue, West Nile fever, yellow fever, Zika, chikungunya, and lymphatic filariasis. Mosquito-borne diseases have been a serious scourge for humans and animals. This review aims to bring together a wealth of information and evidence about which mosquito species transmit diseases or cause health problems in Iraq. One of the most common diseases in Iraq is malaria, which is caused by the Plasmodium parasite. This disease is spread by the bite of female Anopheles mosquitoes. Anopheles mosquitoes are commonly referred to as "malaria mosquitoes" due to their association with malaria transmission. These mosquito species are best known as vectors of malaria, a life-threatening disease caused by Plasmodium parasites. They can also transmit other diseases, such as lymphatic filariasis and various forms of encephalitis. Given their role in transmitting malaria, controlling Anopheles mosquitoes is critical to preventing the spread of the disease. Strategies include residual spraying, larval control measures, and more. Understanding Anopheles mosquitoes, their association with malaria transmission, and their global distribution is essential to implementing effective control measures. Another common disease in Iraq is yellow fever. This fever is also spread by contact with mosquitoes. Although its severity varies, the mortality rate can reach significant levels.

1. Introduction

Mosquitoes are found in all parts of the world except for the Antarctic subcontinent in the Southern Ocean. Scientists and researchers have been able to identify 3,500 species of mosquitoes divided into 41 groups. For example, the Anopheles group includes more than 270 species of mosquitoes. Although the name Anopheles is associated with the transmission of malaria, only 70 species transmit malaria. There is no doubt that mosquitoes are one of the most threatening insects to human life because many species of them are able to transmit many deadly diseases and epidemics, whether from human to human or from animal to human. Among the most famous epidemics transmitted by mosquitoes are yellow fever, dengue fever, Rift Valley fever, leishmaniasis hemorrhagic kidney syndrome, and others [1].

Anopheles mosquitoes are found throughout Europe, the Middle East, Iran and Iraq. Anopheles mosquitoes are also called malaria mosquitoes because they transmit the disease. They are characterized by their spotted wings and their inclined posture when resting. The female mosquito bites a person infected with malaria and sucks the spores of the plasmodium that cause the disease with his blood. The mosquito lands on the human body and secretes saliva to moisten the skin. This saliva also causes an itchy sensation in that area,

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which requires more blood to be sucked by the piercing-sucking mouthparts [2]. Diseases and infections transmitted by different types of mosquitoes, such as malaria and viruses, have caused the death of an estimated millions of people every year worldwide, according to statistics from the World Health Organization, of whom about two million die. Malaria is one of the most prominent health problems that not only threatens the lives of the population, but also affects their living conditions due to ongoing morbidity, treatment costs, inability to work and low productivity, all of which are factors that frustrate economic and developmental progress in the country. It is necessary to look at it carefully and learn about the secrets and mysteries of its life, as this greatly helps us in our appreciation of the size and seriousness of the damage that this small insect causes to our lives [3].

Due to the spread of many diseases transmitted by different types of insects, especially flies (order Diptera) in recent years in various regions of the world in general and Iraq in particular, it has become important and necessary to pay attention to preparing modern studies that include the species belonging to this group, which facilitates their knowledge, classification and study, avoiding errors in diagnosis and knowing the correct number of these species spread in Iraq [4].

1.1. Aim of Review

The aim is to describe the role of mosquitoes in transmitting selected pathogens of medical and epidemiological importance, which pose a serious threat in Iraq, in addition to compiling the scattered information on the dipteran species that carry diseases, or those that cause health problems in Iraq, including all details related to the title of this review.

2. Historical View of Mosquitoes

Mosquitoes have evolved over millions of years to adapt and survive in many different environments and places around the world. They have developed specific characteristics that allow them to live in a variety of different places, including freshwater, rural and urban areas. Over the years, mosquito species have developed advanced systems to sense and detect hosts and prey from very long distances, have become more efficient and specific at sucking and feeding on blood, and have acquired greater resistance to insecticides [5].

Diseases caused by mosquitoes have changed the outcome of warfare. The Anopheles mosquito, which transmitted malaria to the Persian army as it moved through Greek territory, ultimately led to Greek victory during the Greco-Persian Wars. Mosquitoes helped both the Roman Empire win wars and its subsequent downfall. Noble Christians failed in their attempt to take the Holy Land during the Crusades because certain mosquitoes infected with the deadly Plasmodium parasite attacked the Crusaders [6].

European explorers brought many mosquito-borne diseases to the Americas, with the intent of destroying and eliminating all indigenous people and colonizing their lands. The spread of mosquito-borne malaria delayed the Union Army's victory in the American Civil War, contributing to President Abraham Lincoln's decision to abolish slavery, which resulted in the Emancipation Proclamation of 1863 [7].

Three species of *Anopheles* mosquitoes that transmit and cause malaria were recorded and discovered in Iraq, namely *A. superpictus, A. sacarovi and A. pulcherrimus* by Macon [8], later recorded by Manoucheri [9] in the southern, central and northern regions of Iraq.

2.1. Morphology of Mosquito

Mosquitoes have only one pair of wings, a spherical head with two compound eyes, thread-like antennae located between the eyes, and stinging and sucking organs in the form of a thin, modified proboscis. The thorax is slightly convex and compound with six long, cylindrical legs, three on each side, and two wings for flying. The abdomen contains the stomach, intestines, and other viscera. Males differ from females in that they have many cilia that increase their tentacles. The species of Anopheles, Culex, and Aedes also differ from each other in different parts of their bodies, which enables the species to be distinguished from each other. The Aedes mosquito tends to be black in color, the Anopheles tends to be gray in color, and the Culex tends to be yellow in color. The easiest way to identify the type of mosquito is to watch it when it stands on the surface. If it stands at an angle to the surface, it is the Anopheles type. If it stands parallel to the surface, it is the Culex or Aedes type [10].

2.2. Classification of Mosquito

Classification is the foundation upon which all life sciences are based. When searching for any living organism, whether animal or plant, its exact location in the world's taxonomic tree must be determined based on accurate taxonomic keys. Insects have occupied a prominent place in the taxonomic ladder due to their large numbers and great diversity, which has made taxonomists race to study them from all aspects, and among these insects are the mosquitoes that belong to the family Culicidae [11].

Mosquitoes belong to the family Culicidae, which belongs to the order Diptera, from the class Insecta, within the phylum Arthropoda. More than 3,500 species of this family are known to date, and it includes three subfamilies: the subfamily Culicinae, the subfamily Anophelinae, and the subfamily Toxorhynchitinae. The most famous mosquito genera are: the Anopheles mosquito, the Culex mosquito, and the Aedes mosquito [12].

2.3. Biology of Mosquito

Mosquito larvae play an important role in the aquatic food chain, filtering small organic particles, such as single-celled algae, from the water and converting them into tissues that make up the mosquito's body, which can then be eaten by fish and other aquatic animals, providing them with a nutrient-packed snack. The benefits of mosquitoes don't end with the larval stage; adults also serve as nutritious meals for birds, bats, and spiders. Female mosquitoes of some species only need blood to obtain the proteins they need to lay eggs. However, both male and female adult mosquitoes rely on nectar for energy. While sucking nectar from here and there, mosquitoes pollinate plants, especially the aquatic plants they spend most of their lives around, helping these plants to flourish, providing cover and shelter for animals and other organisms. Although mosquitoes are known vectors of some diseases around the world, there is some hope that mosquito saliva could be used to treat cardiovascular diseases, through the development of anticoagulant drugs [14].

Table 1: Classification of mosquitoes species [13].

Taxa	Names
Kingdom	Animalia
Phylum	Arthropoda
Class	Insecta
Order	Diptera
Suborder	Nematocera
Infraorder	Culicomorpha
Superfamily	Culicoidea
Family	Culicidea Meigen, 1818
Sub Families	Anophelinae, Culicinae
Genera (112)	Culex, Aedes, Anopheles, etc,

2.4. Life Cycle of Mosquito

Mosquitoes can be classified into groups based on several different biological and environmental factors. Examples include host type preference (the host on which the adult feeds), larval breeding areas, and egg-laying strategies. *Aedes* mosquitoes typically bite their mammalian and vertebrate hosts and lay their eggs singly in areas that would only be flooded, either on vegetation or soil. Larval breeding sources vary greatly and may include man-made hedges, tree holes, swamps, or depressions in heavily wooded areas. Most *Culex* mosquitoes prefer the blood of mammals and lay their eggs in masses, groups, or ”rafts” of 50 to 200 eggs. They prefer fresh water and can also be found in swamps and wooded areas near freshwater streams or often in backwaters. *Anopheles* mosquitoes are predators of mammals. *Culex* mosquitoes may show a broad preference for host or mammalian blood, although the majority prefer avian blood. They occasionally feed on mammals and some feed strictly on reptiles / amphibians. *Culex*, this group lays eggs in rafts. Breeding sources are very diverse and include open swamps, agricultural areas, storm drains, canals and sewage ponds [15].

The life cycle of all mosquito species consists of 4 separate stages figure 1. The mosquito life cycle include eggs, which is the first stage of the mosquito life cycle after obtaining a blood meal. The female mosquito lays eggs directly on or near water, or on moist soil that is covered with water. The eggs are laid in the form of a linked chain that floats on the surface of the water, which may reach 200 eggs, while some other species of mosquitoes lay them individually, one after the other. The eggs can survive in dry conditions for a few months, and they only hatch when exposed to water. Larvae, The second stage of the mosquito life cycle, which hangs upside down on the surface of the water, breathing air through breathing tubes, while other types of mosquito larvae lie parallel to the surface of the water; To obtain oxygen supplies through a breathing hole. Cocoon, The third stage , during this stage the mosquito turns into an adult insect capable of flying, and takes about two days to a week, and also occurs in water. This stage is a state of rest. Adulthood is the fourth stage , where the adult mosquito rests on the surface of the water for a short period after emerging from the cocoon; to allow the wings to dry, and for all parts of the body to harden, so that it can fly [5].

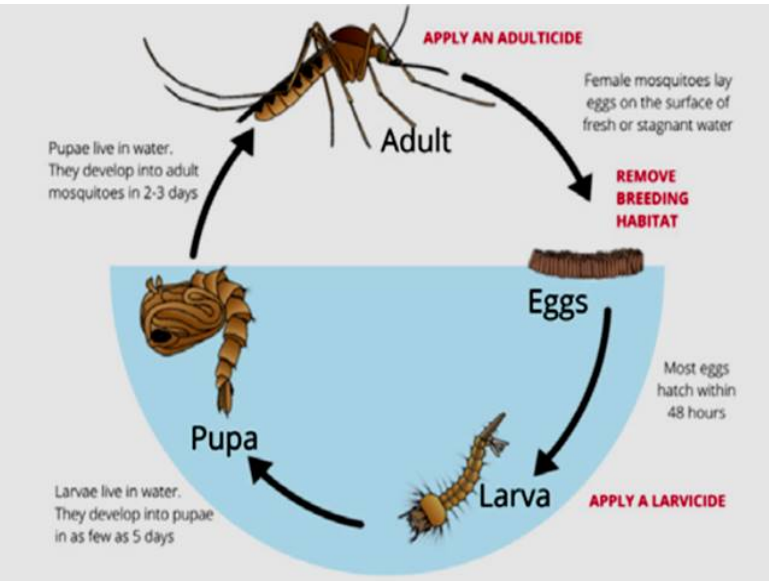

Figure 1: Life cycle of mosquito [16]

2.5. Medical Important of Mosquito

People all over the world, as well as animals, are at risk of contracting various infectious diseases transmitted by mosquitoes. In addition to being health pests, some mosquito species have the ability to transmit various pathogens from one host to another. Mosquitoes are insects of the order Diptera, directly responsible for transmitting many pathogens to animals and humans, causing vector-borne diseases, such as malaria, other types of filariasis, and various arthropod-borne viral diseases such as yellow fever and dengue. The epidemiology of diseases

transmitted by mosquitoes depends on criteria such as the competence, viability, and capacity of the vectors. Malaria was endemic until 1959, yellow fever was recorded in the 19th century, and human cases of filariasis and West Nile fever have been reported. In the face of current climate change and the threat of introducing exotic mosquito species, not only may new cases of some of these diseases occur, increasing their risks, but other mosquito-borne diseases may also be introduced that pose challenges of the 21st century and require continuous public health monitoring [17].

According to data from the World Health Organization, vector-borne diseases account for more than 17% of all infectious diseases, cause more than 700,000 deaths annually, and contribute to a heavy global burden of serious diseases. Mosquitoes, ticks, and fleas are among the arthropods responsible for transmitting various types of bacteria, viruses, and parasites that cause diseases. In terms of incidence and mortality from vector-borne diseases, mosquitoes are the most dangerous insects facing humans. They threaten more than two billion people in tropical and subtropical regions, and have had a profound impact on the development of humanity, not only socially and economically but also politically. There is no doubt that insect-borne pathogens that lead to epidemics and pandemics have played an effective role in the rise and fall of empires, for example in Greece and Rome. Malaria was the dominant health problem in the last days of the Roman Empire [18].

Human pathogens are shared with wildlife reservoirs. In addition, mosquitoes cause allergic reactions, or cause significant blood loss when present in large numbers, simply by their bites. As a group, mosquitoes inhabit all habitats where water is present, which is essential for their larval development. Mosquitoes undergo complete metamorphosis in water, and adult wings are capable of extensive flight and terrestrial activity. Females feed on blood, which they use to develop eggs, but both sexes also feed on plant sugars. Females of most species feed primarily on the blood of wild or domestic animals, and only a few feed on humans. For some, blood feeding is either facultative or absent altogether, and eggs develop spontaneously. Methods used to reduce mosquito populations and prevent transmission of pathogens are very diverse, including drug treatments, habitat modification, bed nets, insecticides, predators, and pathogens [19].

2.6. Why Mosquitoes Prefer Blood

People with blood type O are about twice as likely to be bitten by mosquitoes than people with blood type A, a study has shown. People with blood type B are usually in the middle when it comes to mosquito bites. Researchers have discovered that 85 percent of people secrete a chemical on their skin that mosquitoes use to detect their blood type. The taste of blood doesn't matter to mosquitoes. Female mosquitoes need blood protein to produce eggs after they are fertilized. So they have to bite us to have offspring. Mosquitoes are also attracted to the smell of ammonia, lactic acid and urine, which are released from humans through the skin through decomposing sweat. Also, the smell that women emit during a certain stage of their menstrual cycle is attractive to mosquitoes [20].

Mosquitoes are more attracted to certain people than others, and the secret lies in a puzzling mix of chemicals. Researchers found that people with higher levels of certain acids on their skin were up to 100 times more attractive to female Aedes aegypti, a mosquito species responsible for spreading diseases like dengue, chikungunya, yellow fever and Zika. The researchers also found that women become more attractive to mosquitoes during pregnancy. Scientists aren't entirely sure whether mosquitoes actually know a person's blood type before they bite. What we do know is that about 80-87% of people secrete chemicals through their skin that indicate their blood type. In these people, sometimes called secretors, the same antigens found on red blood cells are also found in their tears. Adult female mosquitoes also need the proteins in blood to produce eggs. In a pure taste test — that is, blood provided by nutrients rather than humans — mosquitoes chose type O blood over other types, according to a 2019 study. That may be because the lack of antigens makes it easier for mosquitoes to break down blood cells and absorb the protein. Among secretions, mosquitoes preferred people with type O blood over those with type A blood, according to a 2004 study. In the same study, mosquitoes also preferred blood from type A over blood from type B [21].

Some humans are known to secrete blood group oligosaccharides on the skin, and soluble blood group antigens A, B, and H have been shown to be present in human skin. These substances may influence mosquitoes' choice of human hosts. Blood group O secretions have been reported to be preferred over non-O secretions by *A. aegypti,* and non-A secretions were preferred over A secretions. Given the high prevalence of blood group O in malaria-endemic populations, we hypothesized that malaria vectors may play an indirect role in the genetic makeup of the host population. Available research suggests that mosquitoes may prefer individuals with blood group O. However, it is likely that many other additional factors also play a role in a person's attractiveness to mosquitoes [22].

2.7. Mosquito Control

Mosquito control relies on managing and regulating mosquito populations in order to reduce and eliminate their harm to human life, health, and economy. Mosquito control is a necessary and vital public health practice worldwide, especially in tropical areas, because mosquitoes spread and transmit many diseases, such as malaria and *Zika virus* [23].

Mosquito control methods, based on the life cycle stage of the mosquito, include two important stages. The first method is larval mosquito control methods, which is one of the effective methods of mosquito control, in finding the larval habitat to eliminate them, which will have a significant impact on mosquito control, as mosquito groups are concentrated and immobile, and can be reached before they mature into adult mosquitoes and spread. This approach increases the effectiveness of applying mosquito control pesticides, and reduces their widespread use. The second method is adult mosquito control methods, and in this method, adult mosquito control methods vary greatly, starting from the use of insecticides to the use of various mosquito control devices, with some special home measures to control the matter tightly [24].

2.8. Mosquito Species

There are more than 3,500 species of mosquitoes on Earth, each with its own unique characteristics and different ability to transmit diseases. The most common types of mosquitoes include the Culex mosquito, which bites both humans and birds, and is usually seen at night, both indoors and outdoors. Diseases it can transmit include West Nile fever. Another type of mosquito is the Anopheles mosquito, which bites humans and mammals, and is also seen at night, both indoors and outdoors. It is the type responsible for transmitting malaria. The last type is the Aedes mosquito, which is seen during the day, and humans are its favorite. It transmits a number of serious diseases, including Zika virus, chikungunya, and dengue fever. In Iraq, about 37 species have been recorded during the last years. There are differences between

species and geographical distribution of each species as well as the density of Anopheles mosquitoes between Iraqi governorates, while Culex mosquitoes are widely distributed throughout Iraq. All mosquito species figure 2 show a clear difference in seasonal density [25].

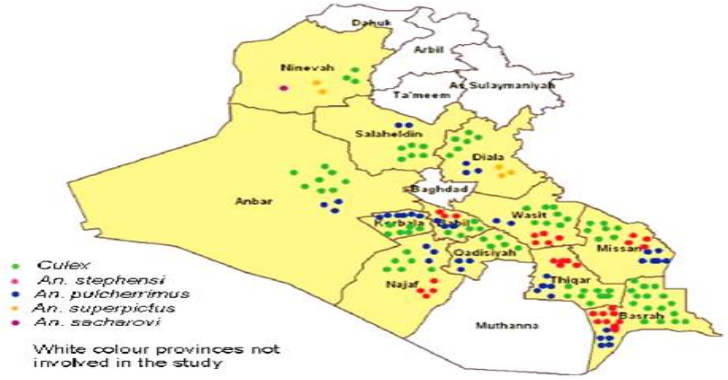

Figure 2: Map showing distribution of mosquito species in Iraq [25]

Aedes

A mosquito characterized by its black color and transparent wings, with white dots on the body and head, and white rings on the legs figure 3. It is active during the day, especially two hours after sunrise and in the evening two hours before sunset. The female of this type of mosquito feeds on human and animal blood to obtain the blood necessary for the maturation of its eggs. By biting humans, it transmits some diseases to them, including the Zika virus, dengue fever, and yellow fever. The female Aedes aegypti mosquito is considered the carrier of the Zika virus, just like the dengue and yellow fever viruses. The Zika virus lives in the blood of a sick person for 5 to 10 days, and if this person is bitten by a female Aedes aegypti mosquito during this period, the mosquito transmits the disease from him to dozens of other people by biting them. This mosquito remains a carrier of the disease throughout its life span, which ranges from 15 to 65 days. The virus remains in the mosquito's salivary glands, and when it bites, the virus comes out with the mosquito's saliva, which contains substances that prevent blood clotting, making it easier for it to absorb blood when it injects its saliva [26].

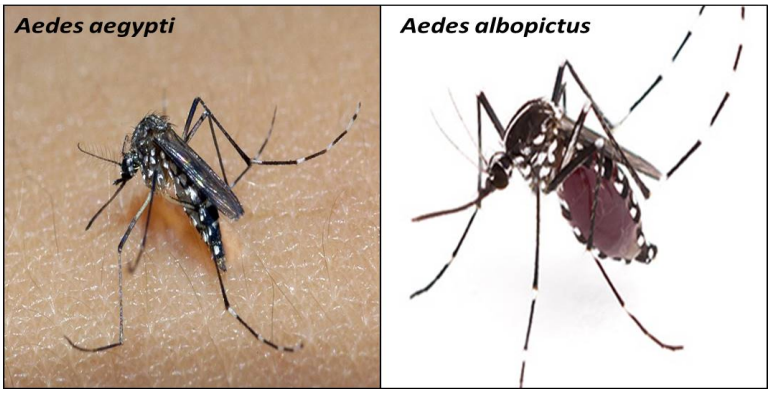

Figure 3: Aedes species [5]

Effective mosquito control requires a comprehensive technological approach that includes both public and individual practices. Mosquito control requires controlling mosquitoes at their source by controlling the larval stage. Mosquito control mechanisms may include, but are not limited to, metabolic resistance, target site resistance, penetration resistance, and behavioral adaptation Figure 4, [27].

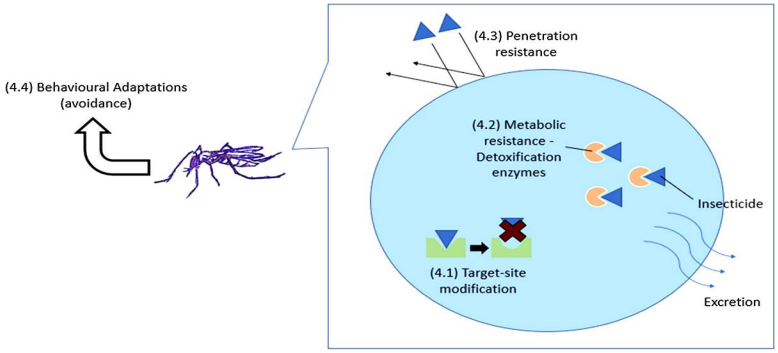

Figure 4: Mosquito control mechanisms : (4.1) target site resistance, (4.2) metabolic resistance, (4.3) penetration resistance, (4.4) behavioural adaptation [27]

Culex

In Iraq, about 37 species have been identified. There are very clear differences in the geographical distribution of mosquitoes, while Cx. pipiens is widespread throughout Iraq figure 5. All mosquito genera show clear differences in seasonal density. The Culex mosquito is characterized by feeding on blood and often attacks at night, biting the victim in exposed parts such as the legs and arms, especially groups with low immunity such as children and the elderly, which often causes swelling of their extremities. These bites result in allergic symptoms such as redness of the skin, swelling of the affected area and high temperature, and the infection may be severe, leading to skin deformities that are difficult to heal [28].

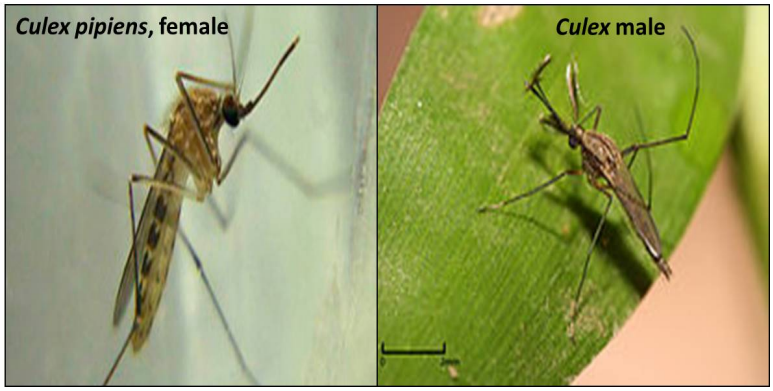

Figure 5: Culex species (female and male) [5]

For each mosquito species, five life history traits that can be directly measured by experimental values at different temperatures were studied. The traits examined were:
- Immature development (time in days to reach the next life stage
- Survival to adulthood (proportion of eggs that become adults
- Oviposition (number of eggs, either per egg raft or per female
- Egg survivability (proportion of eggs that hatch
- Adult lifespan (time in days that an adult mosquito survives Figure 6, [29].

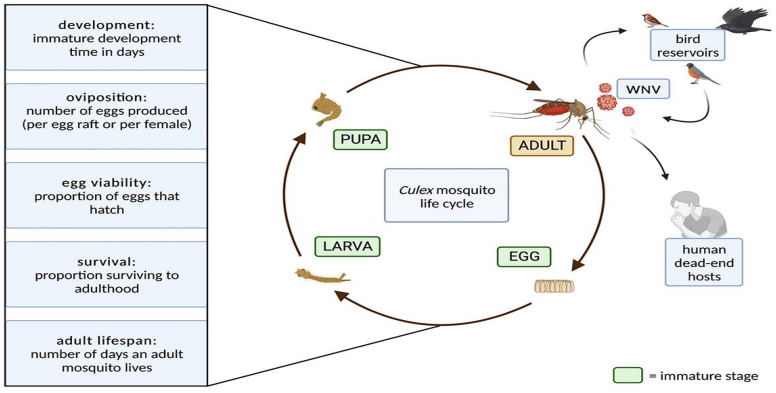

Figure 6: Genetic cycle between mosquitoes and birds (top right), mosquito life cycle (middle) with definitions of life cycle traits (left)[29]

2.9. Anopheles

There are more than 3,500 species of mosquitoes distributed into 41 different genera, and the only genus that transmits malaria is the Anopheles mosquito, of which there are 430 species, only 40 of which transmit malaria. This mosquito is found everywhere on the globe except Antarctica, and the remaining species, even if they bite humans repeatedly, cannot support the growth of malaria parasites. Male mosquitoes live for a week, feeding on flower nectar and other sugar sources, while females live longer, ranging from a week to a month, feeding on nectar in addition to blood. The female Anopheles mosquito needs blood to form eggs, and after the female consumes a full meal of the victim's blood, she rests for several days during which the blood is digested and the eggs are formed. After this process is complete, the female resumes searching for another source of blood. The life cycle of this mosquito consists of four stages. First, the female lays between fifty and two hundred eggs at a time on the surface of the water, where the eggs float . Within two to three days, the egg hatches and a larva emerges from it, thus completing the first stage of its life [30].

The female Anopheles mosquito carries the parasite responsible for malaria, Plasmodium, but does not show any symptoms and is not affected by it. That is, the Plasmodium parasite does not cause the death or weakness of the mosquito, but rather uses it as a vector to reach humans [31], figure 7.

Also known as the swamp mosquito. The most prominent species are Anopheles gambiae, known for transmitting malaria in Africa, and Anopheles freeborn in North America. For the disease to occur, three factors must be present: Plasmodium, a female Anopheles mosquito, and a human being bitten by the mosquito. When a mosquito carrying Plasmodium bites a healthy human, the mosquito injects the parasite

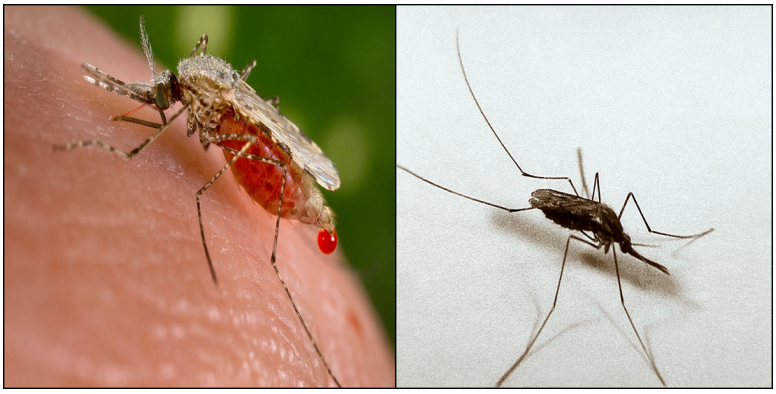

Figure 7: Anopheles species [31]

into the victim through its saliva. In the human body, the parasite grows and multiplies in liver cells and red blood cells, destroying them and releasing new parasites that attack other cells [32].

Diseases Transmitted by Mosquitoes

Vector-borne diseases account for more than 17% of all infectious diseases, causing more than 700,000 deaths annually. They can be caused by parasites, bacteria, or viruses. Focusing on mosquitoes as the primary vector for disease ignores the dynamic biological interactions between the pathogen, vector, host, and environment in which they are transmitted. Different pathogens are transmitted within a complex and organized ecosystem. The system consists of many integrated factors, including hosts, primary vectors, pathogens, important social factors, and other environmental factors Figure 8, [33].

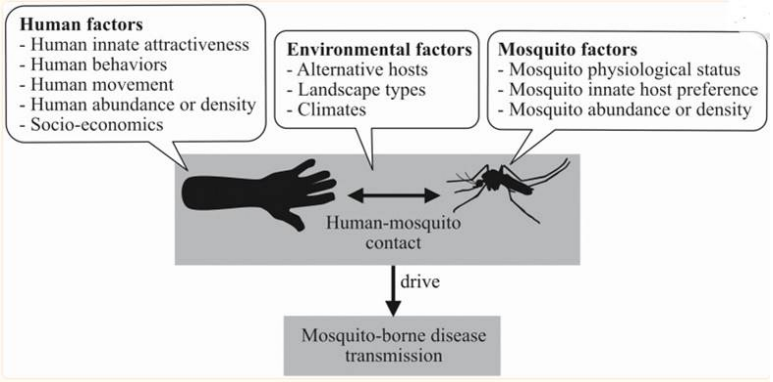

Figure 8: Human–mosquito contact [33]

When a mosquito bites, it uses its proboscis to suck blood and pierce the skin. The mosquito injects saliva into the skin as it feeds. The body's reaction to the saliva causes swelling and itching. Some people's bodies react only slightly to the bite or bites, while others react more strongly, resulting in swelling, pain, and redness. Many people are exposed to mosquito bites. Mosquito bites affect everyone in different ways. When a mosquito bites, it draws blood from the host and injects some of its saliva into the host. The mosquito's saliva contains anticoagulants and foreign proteins. These foreign proteins stimulate the body's immune system. As a result, the body's immune system releases histamine, a substance that helps white blood cells reach the affected area. Although histamine is necessary for the body to fight foreign substances, it is a substance that causes itching, inflammation, and swelling [34].

The number of researches focusing on various diseases transmitted by mosquitoes has increased in recent years. We conducted a descriptive review of mosquito vectors and some different diseases and their associations with environmental factors in countries around the world, especially Iraq. This review aims to identify and analyze the existing literature on the transmission of various diseases transmitted by mosquitoes and the increasing factors that may affect the risk of their transmission in Iraq. Below we present some of these diseases.

Malaria

Malaria was recorded in Iraq in previous years, with (11,878) cases reported in 1965. The outbreaks also increased in Iraq in 1995, with a peak of only (39,000) reported cases. Malaria can be prevented and eliminated in any country in the world through effective planning and appropriate preventive measures. In this regard, the Iraqi Ministry of Health and Environment clearly declared in 2009 that Iraq is free of malaria after a complex and long battle with the disease [35].

The most important symptoms of jungle malaria fever are shivering and chills that last for about 1-2 hours normal for severe, then profuse sweating where the body temperature reaches or below normal. The occurrence of its poisoning with Plasmodium falciparum is repeated completely (48 hours) Figure 9, [36].

Malaria is one of the world's oldest and deadliest diseases, perpetuating the cycle of poverty in many communities and countries and destroying families. According to the World Malaria Report 2021 by the World Health Organization, there were 247 million cases of malaria

and more than 619,000 deaths, with three out of four deaths being in children under five years of age [37].

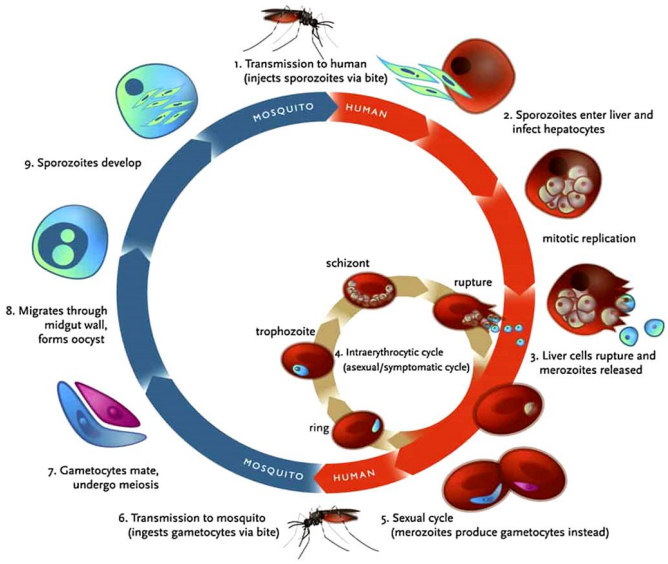

Figure 9: Life Cycle of the Malarie [38]

Chikungunya

Chikungunya virus CHIK has been reported in several neighboring countries to Iran such as Iraq, Turkey, Yemen, Russia, Saudi Arabia, Pakistan, Oman, and Qatar. Moreover, Chikungunya virus (CHIK) has been reported in several countries neighboring Iran, including Iraq, Turkey, Yemen, Russia, Saudi Arabia, Pakistan, Oman, and Qatar. Chikungunya virus is transmitted by mosquitoes, most commonly Aedes aegypti (Stegomyia) and Aedes (Stegomyia) albopictus, which can also transmit dengue and Zika viruses. These mosquitoes bite primarily during daylight hours. They lay eggs in containers with standing water. Both species feed outdoors, but Ae. aegypti also feeds indoors [39].

Chikungunya typically begins in patients who develop symptoms 4 to 8 days (range 2 to 12 days) after being bitten by an infected mosquito. It is characterized by a sudden onset of fever, often accompanied by severe joint pain. The joint pain is often debilitating and usually lasts a few days but can persist for weeks, months, or even years. Other common signs and symptoms include joint swelling, muscle aches, headache, vomiting, fatigue, and rash. Because these symptoms overlap with other infections, including dengue and Zika viruses, cases can be misdiagnosed. In the absence of significant joint pain, infected individuals often have mild symptoms and the infection may go unrecognized [40].

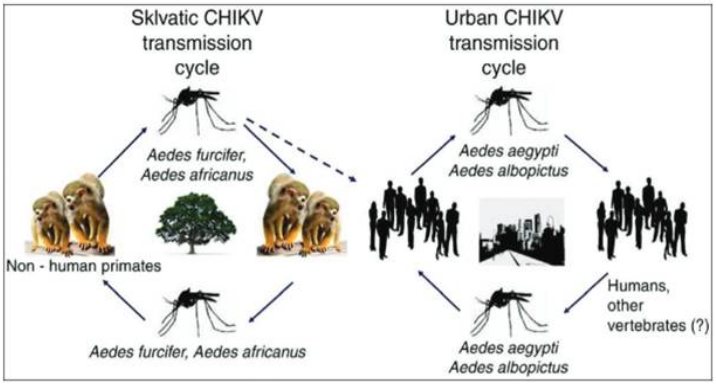

Figure 10: Life cycle of Chikungunya virus [41]

When an uninfected mosquito feeds on a person with chikungunya virus in their blood, the mosquito can ingest the virus. The virus then replicates in the mosquito over several days, reaches the salivary glands, and can be transmitted to a new human host when the mosquito bites the person. The virus begins to replicate again in this newly infected person and reaches high concentrations in their blood, at which point it can infect another mosquito and perpetuate the transmission cycle. When an uninfected mosquito feeds on a person with chikungunya virus in their blood, the mosquito can ingest and pick up the virus. The virus then replicates in the mosquito over several days, reaches the salivary glands, and can be transmitted to a new human host when the mosquito bites the person. The virus begins its replication cycle again in this newly infected person and reaches high levels in their blood Figure 10, [42].

Zika

Zika virus is a viral infection, first identified in rhesus macaques in Uganda in 1947. Infection in humans emerged in other African countries in the 1950s. Zika virus is transmitted by the bites of the virus-carrying Aedes aegypti mosquito, which is most active during the day,

especially in the mid-morning and late afternoon hours [43].

Zika virus disease cases have declined worldwide since 2017; however, Zika virus transmission and spread continue at very low levels in many other affected countries and areas. Zika virus is a member of the Flaviviridae family, the same genus as yellow fever, dengue, and West Nile virus. Zika virus can be transmitted through mosquito bites. People infected with Zika virus have a fever and may also have a rash, joint pain, and red eyes. Symptoms are usually mild and resolve within a few days. Seriously ill patients are rare. Hospitalization may be required [44].

Zika virus attaches to the surface of a host cell and enters the cell through a process called phagocytosis. Once inside the cell, the virus fuses with the inner membrane and is released into the cytoplasm. The virus particle releases the viral genome Figure 11. In general, about 1 in 5 people infected with Zika virus become ill and develop symptoms. The incubation period for the disease is not yet certain. But it should be about the same as the flu, which is 2–3 days to a week. Symptoms are similar to those of the flu, including fever, rash, joint pain, and red eyes. Some people may experience headaches. Patients who become seriously ill may need to be hospitalized. The mortality rate remains low [45].

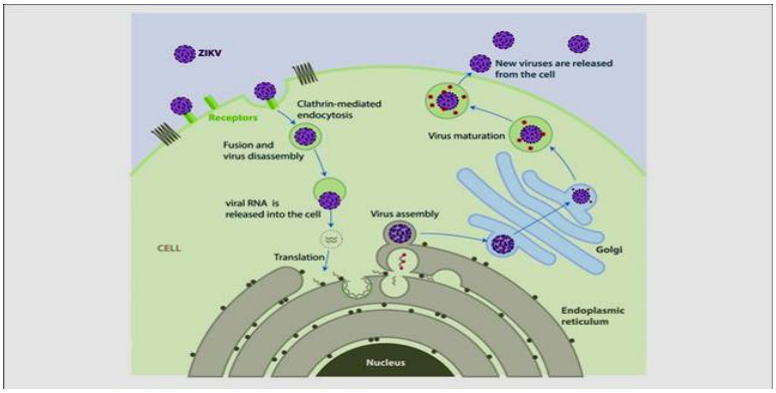

Figure 11: Zika virus life cycle [46]

Yellow Fever

Yellow fever is transmitted by mosquitoes that receive the disease virus from monkeys or humans infected with yellow fever. After an incubation period of 1–14 days, the patient becomes yellow, as the name of the disease indicates, and develops fever and bleeding, especially from the stomach Figure 12. Yellow fever is caused by a virus that is spread by mosquitoes. These mosquitoes breed in human habitations and even in clean water. Humans and monkeys are most commonly infected with the yellow fever virus. The mosquito transmits the virus back and forth between monkeys, humans, or both. When the mosquito bites a human or monkey infected with yellow fever, the virus enters the mosquito's bloodstream and circulates before settling in the salivary glands. When the infected mosquito bites another monkey or human, the virus then enters the host's bloodstream, where it can cause disease. Risk factors for yellow fever include traveling to an area where mosquitoes continue to carry the yellow fever virus, including sub-Saharan Africa and tropical South America [47].

Yellow fever is a viral infection spread by mosquitoes. It is caused by the bite of an infected mosquito. Mosquitoes in tropical areas of central Africa, Central America, and South America carry yellow fever. It causes headache, dizziness, muscle aches, and fever. Sometimes the skin and eyes turn yellow (jaundice) because the disease affects the liver. Yellow fever can be fatal if it severely affects internal organs. The best ways to prevent yellow fever are to get vaccinated and avoid mosquito bites [48].

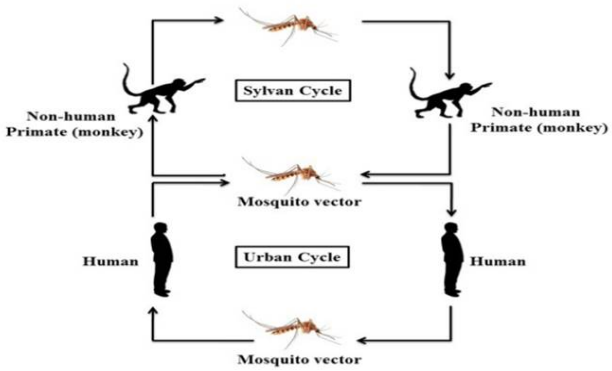

Figure 12: life cycle of the yellow fever virus [49]

Dengue

"Dengue is a type of hemorrhagic fever currently prevalent in Iraq, and this fever (dengue) occurs in poor and tropical areas of the world, due to the prevalence of the primary causative mosquito." The main vector for the disease is the Aedes aegypti mosquito, and to a lesser extent the Aedes albopictus mosquito [50]. Although many cases of dengue virus infection are asymptomatic or cause only mild illness,

dengue virus can sometimes cause more severe cases, even death, according to the World Health Organization. ”All people are susceptible to infection, but the disease becomes more serious after 10 to 14 days, as is the case with children under 10 years of age, because their blood vessels are soft, and thus bleeding occurs through the nose, eyes or inside the body, leading to dehydration or death [51].

Dengue fever is a viral infection transmitted by mosquitoes, causing mild flu-like symptoms, but in some cases it can be severe and life-threatening Figure 13. The primary vectors that transmit the disease are the Aedes aegypti mosquito and, to a lesser extent, the Aedes albopictus mosquito. The incubation period, which is the period from the time of infection until the onset of symptoms, is about 4 to 10 days after transmission, during which no symptoms appear. The period of onset of symptoms, which lasts 2-7 days, during which a person is able to transmit the infection by infecting a healthy mosquito with the virus and transmitting it to others [52].

The best prevention method is to control the vector mosquito by eliminating its breeding sites in freshwater pools such as swimming pools, reservoirs, and water left after rains, and in small pools of water in and around homes [53]. After the mosquito feeds on the blood of a person infected with the dengue virus, the virus multiplies in the mosquito’s midgut before spreading to secondary tissues, including the salivary glands. The mosquito can then transmit the virus for the rest of its life [54].

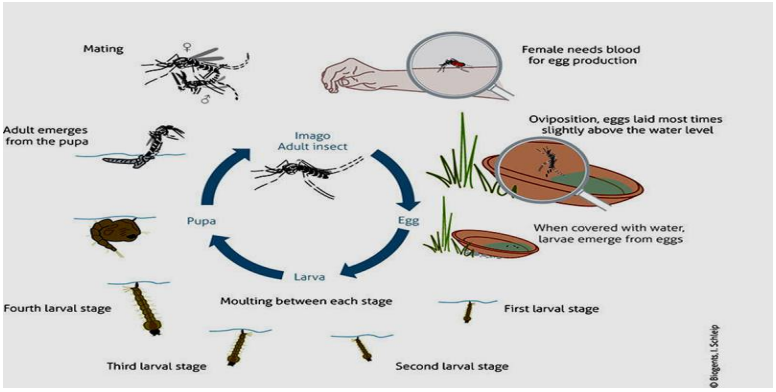

Figure 13: Dengue virus life cycle [54]

Dog Heartworm (Dirofilaria immitis)

Canine heartworm disease is one of the most common parasitic diseases in temperate countries, which has had significant public health impacts and can also infect humans. In Iraq, the disease was detected in dogs using SNAP ELISA technique. The overall seroprevalence rate of (172) shepherd dogs subjected to this study was (40.12%), including (42.48%) and (35.59%) in Al-Qadisiyah and Thi-Qar governorates, respectively [55].

Filaria worms depend on both mammals and mosquitoes to complete their life cycle Figure 14. Heartworm larvae float in the dog’s blood and tissues until they eventually settle in the heart and pulmonary arteries. They then develop into adult heartworms (Dirofilaria immitis). Adult worms cause respiratory problems, and can result in heart difficulties, including complete heart failure. Canine heartworm infection is a filarial worm infection that rarely infects humans because these worms cannot complete their life cycle in humans and do not survive very long in humans. Canine heartworm infection can be transmitted when an infected mosquito bites a person and deposits worm larvae at the site of the bite. The larvae usually die in the skin. However, sometimes the larvae live long enough to travel through the blood to the lungs, where they die, forming a mass (nodule). Rarely, the larvae travel to the eye, brain, or testicles and form masses there [56].

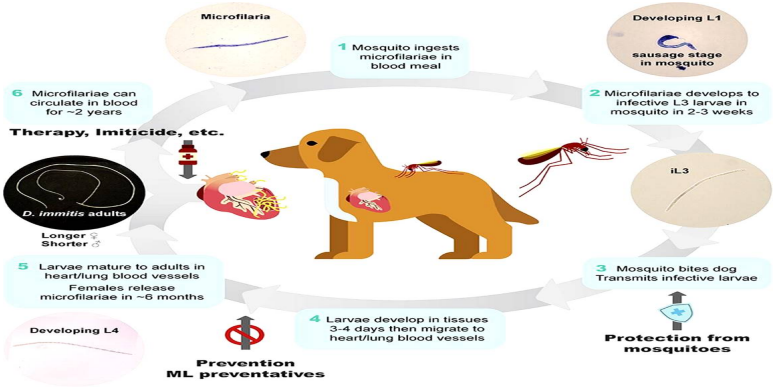

Figure 14: Heart cycle (dog) [57]

West Nile Virus

West Nile virus is the virus responsible for West Nile fever and is transmitted to humans through the bites of infected mosquitoes. It can cause serious neurological disease in humans, but 80% of cases are asymptomatic. Some studies have reported a high prevalence of mosquito-borne flaviviruses and sandfly-borne viruses in southern Iraq. The primary host of West Nile virus is birds, which become infected through the bite

of infected mosquitoes and then transmit the disease to uninfected mosquitoes when they bite them. Some birds, such as vultures or crows, also become infected by eating other infected birds or a dead bird infected with the virus [58].

The virus is also transmitted by some types of birds of prey such as vultures or crows, which become infected by eating other infected birds or a dead bird that was infected with the virus. These mosquitoes acquire the virus by feeding on infected birds, i.e. those that carry the West Nile virus Figure 15 [59]. The virus is also transmitted by some types of birds of prey such as vultures or crows, which become infected by eating other infected birds or a dead bird that was infected with the virus. These mosquitoes acquire the virus by feeding on infected birds, i.e. those that carry the West Nile virus Figure 15, [60].

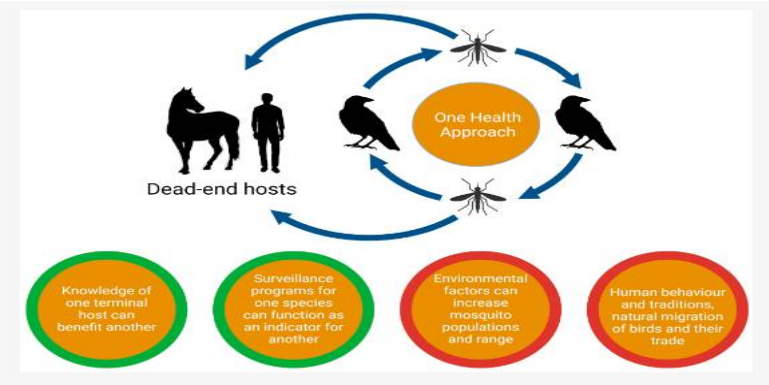

Figure 15: West Nile virus (WNV) lifecycle [60]

Eastern Equine Encephalitis (EEE)

Eastern equine encephalitis (EEE) is a rare but serious viral disease. The virus that causes EEE is spread through the bite of an infected mosquito. EEE primarily infects birds, often with no evidence of disease in birds. Mosquitoes become infected when they bite infected birds. Although humans and other mammals, particularly horses, can become infected, they do not spread the disease. EEE is a very rare disease. Since the virus was first identified in Massachusetts in 1938, there have been just over 110 cases. The first symptoms of EEE are fever (often 103 to 106 degrees Fahrenheit), neck stiffness, headache, and lack of energy. These symptoms appear three to ten days after the bite of an infected mosquito. Inflammation and swelling of the brain, called encephalitis, is the most serious and common complication. The disease progresses rapidly and some patients may fall into a coma within a week. It has a complex life cycle Figure 16 that involves birds and a variety of mosquitoes. These mosquitoes feed on infected birds, become carriers of the disease, and then feed on humans, horses, and other mammals [61].

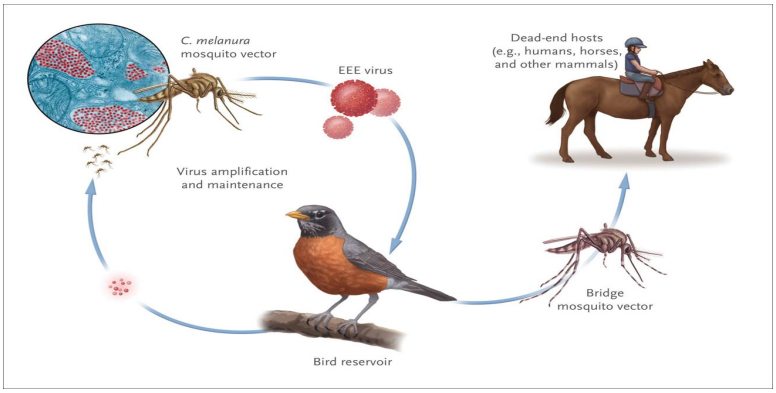

Figure 16: Transmission Cycle of Eastern Equine Encephalitis Virus (EEEV) [61]

3. Materials and Methods

3.1. Search Methods

This review was written to demonstrate the importance and impact of mosquitoes in transmitting various diseases. It also aims to understand the types of insects that play an influential role in medicine and diseases. Therefore, some theoretical studies of previous research in this field were used, including some sources and references mentioned at the end of the review, for the purpose of description, study and analysis. To achieve the main important research objectives, this review used both quantitative and qualitative methods and a combination of different sources. The search was conducted in the literature belonging to researchers and scientists using online databases. Searches were also conducted using the World Health Organization website.

3.2. Data Screening

All information and facts were screened for the purpose of assessing their suitability for review based on the information in the title and abstract. All relevant information was selected, sorted by section, reviewed and verified for reliability and source and then compiled into the manuscript.

3.3. Data Sources

A review was conducted to collect data from its various sources, including communication through reading and focusing on some previous studies to understand the effect of mosquitoes in causing diseases and determining the method of disease transmission. The main sources of data were books and magazines obtained from the library of Al-Muthanna University as well as those downloaded from the Internet.

4. Results

Mosquitoes secrete chemicals in their saliva that prevent blood clotting and numb the area of the bite. The secreted chemicals trigger a response that causes local redness, swelling, and itching. A mosquito bite must last at least six seconds for a reaction to occur. Because mosquitoes feed on blood, they inject their saliva into the pores of the skin. This saliva has an anesthetic property, so you don't feel the bite until the mosquito has flown away. According to researchers, mosquito saliva contains various proteins that are foreign to the human body and cause allergies in the body, which recognizes the mosquito protein as something foreign. Consequently, immune cells begin to attack it, causing itching, allergies, and discomfort.

When reviewing the history of dengue, yellow fever, Zika, and chikungunya viruses, we note that these four viruses exhibit different epidemiological patterns as well as similar ecological and evolutionary patterns in their distribution and transmission around the world. They all originate in African forests, where the basic life cycles involve Aedes aegypti and other Aedes species, with some key hosts. The viruses, like Aedes aegypti, have been transmitted by chance across the Atlantic and Pacific Oceans to all countries of the world. All viruses have exploited the local form of Aedes aegypti, which at some point in its development and feeding has adapted to urban environments. Mosquito populations prefer to enter homes and feed on humans. Thus, all of these dangerous viruses can remain transmissible between humans without relying on the animal and forest cycles from which they originated.

It has very advanced sensors and is superior to all medical sensors in locating blood vessels. The male mosquito feeds on flower nectar and is a peaceful creature, unlike females who feed on blood. The female mosquito has a very precise sense that enables it to locate the victim, as it senses the concentration of carbon dioxide emitted by the breathing of animals and humans, and the mosquito has a very strong sense of smell. Mosquitoes are attracted to pregnant women about twice as much as they are to others, due to the high temperature of the pregnant woman's body compared to others and the increased amount of carbon dioxide emitted from it. The mosquito's suction tube has a high ability to move and twist, and can fold 90 degrees. The mosquito eats blood and does not suck it, as it filters the water in the blood and expels it in the form of drops from the back of its body, and it consumes the proteins in the blood to produce eggs and reproduce.

5. Conclusion

The use of all preventive measures to protect healthy individuals from mosquito infection and its impact can have a significant impact on the social and economic health of people living especially in some poor and developing countries. Reducing sources and eliminating habitats is the best option and the right strategy to slow down mosquitoes as the only possible way for mosquitoes to breed and spread is the presence of stagnant water. Removing water, whether fresh or sewage, and disposing of it is a guarantee of the absence of mosquitoes in these places.

The participation of predator species is an important stage to eliminate and decrease the number of mosquitoes. Although the compatibility and relationships between predator and prey are a complex and very important element, the number of mosquitoes can be reduced to a certain extent by following this method.

The use of plant extracts to repel mosquitoes is an old and very cheap method since long time and is still used in African countries and the Old World. Different types of chemicals present in plants show a special response to repel mosquitoes from the surface on which they are applied.

The approach of integration between all these management tactics would elicit a great response in the context of a viable solution to mosquito infection. In addition, some modern technologies such as the invention of ultraviolet traps are a great result of science. In the future, there is great potential to explore simpler and safer ways to escape the threat of mosquito-borne diseases.

Article Information

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Author's Contributions: Ali designed the study, analyzed the data, and drafted the manuscript, and Areej participated in data collection and also contributed to the preparation of the manuscript.

Conflict of Interest Disclosure: The authors declare that there is no conflict of interest.

References

[1] A. Sarkar, P. Banerjee, and "Mosquito-Borne A. Mazumdar. Veterinary diseases, "in mosquitoes: Biology, pathogenicity and management, omkar, ed. *ed Singapore: SpringerNature Singapore*, pages 287–302, 2024.

[2] N. Becker, D. Petric, M. Zgomba, C. Boase, M. Madon, C. Dahl, et al. *Mosquitoes and their control*. Springer Science Business Media, 2010.

[3] L. Al-Eitan, M. Alnemri, H. Ali, M. Alkhawaldeh, and A. Mihyar. Mosquito-borne diseases: Assessing risk and strategies to control their spread in the middle east. *Journal of Biosafety and Biosecurity*, 6:1–12, 2024.

[4] H. H. Al Saffar and R. S. Augul. Checklist of insects-borne diseases in iraq. *GSC Biological and Pharmaceutical Sciences*, 25:068–106, 2023.

[5] R. C. Wilkerson, Y.-M. Linton, and D. Strickman. *Mosquitoes of the World*, volume 1. Johns Hopkins University Press, 2021.

[6] K. Gardikas. *Landscapes of Diseas*. Central European University Press, Malaria in Modern Greece, 2018.

[7] J. Mitchell. Anopheles mosquito. *Health and Difference: Rendering Human Variation in Colonial Engagements*, 8:68, 2016.

[8] T. T. Macan. The anopheline mosquitoes of iraq and north persia. 1950.

[9] A. M. Hadi. The role of mosquito in the transfer of blood protozoa in baghdad, iraq. 2019.

[10] N. Becker, D. Petrić, M. Zgomba, C. Boase, M. B. Madon, C. Dahl, et al. Morphology of mosquitoes. *Mosquitoes: Identification, Ecology and Control*, pages 77–99, 2020.

[11] R. Adesola and I. Idris. Arboviruses, an emerging threat to public health: Focus on nigeria, west africa. *Infection Epidemiology and Microbiology*, 8:379–385, 2022.

[12] L. M. Rueda. Global diversity of mosquitoes (insecta: Diptera: Culicidae) in freshwater. *Freshwater animal diversity assessment*, pages 477–487, 2008.

[13] R. E. Harbach. The culicidae (diptera): a review of taxonomy, classification and phylogeny. *Zootaxa*, 1668:591–638, 2007. -591–638.

[14] S. Khan. *Mosquito (Diptera: Culicidae) Ecology in Monroe County, Indiana: Diversity and Abundance Patterns Across Environmental Gradients*. Indiana University, 2024.

[15] A. N. Clements. *The biology of mosquitoes*, volume 2. sensory reception and behaviour, 1999.

[16] T.-Y. Zhao and R.-D. Xue. Integrated mosquito management in rice field in China. *Wetlands Ecology and Management*, 30:963–973, 2022.

[17] A. Nebbak, L. Almeras, P. Parola, and I. Bitam. *Mosquito Vectors (Diptera: Culicidae) and Mosquito-Borne Diseases in North Africa. Insects 13 (10): 962*. ed, 2022.

[18] Deadly B. Breedlove. Dangerous, and decorative creatures. *London School of Hygiene Tropical Medicine, London, United Kingdom.: Emerg Infect Dis*, 28(2):495–6, 2 2022. doi: 10.3201/eid2802.AC2802.

[19] W. A. Foster and E. D. Walker. Chapter 15 - mosquitoes (culicidae). In G. R. Mullen and L. A. Durden, editors, *Medical and Veterinary Entomology (Third Edition)*, pages 261–325. Academic Press, 2019.

[20] S. L. Blanken, W. Prudhomme O'Meara, F. J. H. Hol, T. Bousema, and C. F. Markwalter. xc0; la carte: how mosquitoes choose their blood meals. *Trends in Parasitology*, 40:591–603, 2024.

[21] S. Thomas, S. Ravishankaran, N. Justin, A. Asokan, M. T. Mathai, N. Valecha, et al. Resting and feeding preferences of anopheles stephensi in an urban setting, perennial for malaria. *Malaria journal*, 16:1–7, 2017.

[22] G. Galhena, G. Ganehiarachchi, R. Gunathilaka, and D. Jayatunga. Effect of abo and rh blood groups on host preference, oviposition success, and development of laboratory-reared aedes aegypti. *International Journal of Tropical Insect Science*, pages 1–10, 2022.

[23] W. H. Organization. Vector-borne diseases. *WHO Regional Office for South-East*, Asia2014.

[24] N. Becker, D. Petrić, M. Zgomba, C. Boase, M. B. Madon, C. Dahl, et al. *Mosquitoes*. Springer Nature, ecology and control, 2020.

[25] H. A. Hantosh, H. M. Hassan, B. Ahma, and A. Al-fatlawy. Mosquito species geographical distribution in iraq 2009. *Journal of vector borne diseases*, 49:33–35, 2012.

[26] S. Cebrián-Camisón, J. Martínez de la Puente, and J. Figuerola. A literature review of host feeding patterns of invasive aedes mosquitoes in europe. *Insects*, 11:848, 2020.

[27] S. J. Gan, Y. Q. Leong, M. F. H. bin Barhanuddin, S. T. Wong, S. F. Wong, J. W. Mak, et al. Dengue fever and insecticide resistance in aedes mosquitoes in southeast asia: a review. *Parasites vectors*, 14:315, 2021.

[28] H. A. Hantosh, H. M. Hassan, B. Ahma, and A. Al-fatlawy. Mosquito species geographical distribution in iraq 2009. *Journal of Vector Borne Diseases*, 49, 2012.

[29] S. K. Moser, M. Barnard, R. M. Frantz, J. A. Spencer, K. A. Rodarte, I. K. Crooker, et al. Scoping review of culex mosquito life history trait heterogeneity in response to temperature. *Parasites Vectors*, 16:200, 2023.

[30] M. Nicoletti. *Insect-borne Diseases in the 21st Century*. Academic Press, 2020.

[31] M. E. Sinka. Global distribution of the dominant vector species of malaria. In *Anopheles mosquitoes-New insights into malaria vectors*. IntechOpen, ed, 2013.

[32] M. A. Saleem and I. Lobanova. Chapter 5 - mosquito-borne diseases. In A. I. Qureshi and O. Saeed, editors, *Dengue Virus Disease*, pages 57–83. Academic Press, 2020.

[33] P. Thongsripong, J. M. Hyman, D. D. Kapan, and S. N. Bennett. Human–mosquito contact: a missing link in our understanding of mosquito-borne disease transmission dynamics. *Annals of the Entomological Society of America*, 114:397–414, 2021.

[34] S. Singh and B. K. Mann. Insect bite reactions. *Indian journal of dermatology, venereology and leprology*, 79:151, 2013.

[35] S. J. Abdullah, D. S. Abdulateef, H. S. Rahman, S. O. Mahmood, V. N. Mustafa, R. O. Ahmed, et al. A severe case of falciparum malaria, 10 years after malaria eradication: A case report. *Yale J Biol Med*, 94:277–284, 6 2021.

[36] Z. Shahid, N. Karim, F. Shahid, and Z. Yousaf. Covid-19 associated imported plasmodium vivax malaria relapse: first reported case and literature review. *Research and reports in tropical medicine*, pages 77–80, 2021.

[37] M. Semakula, F. Niragire, and C. Faes. Spatio-temporal Bayesian models for malaria risk using survey and health facility routine data in rwanda. *International Journal of Environmental Research and Public Health*, 20:4283, 2023.

[38] E. Y. Klein. Antimalarial drug resistance: a review of the biology and strategies to delay emergence and spread. *International Journal of Antimicrobial Agents*, 41:311–317, 2013.

[39] H. Bakhshi, A. M. Jafari-Nozad, K. Arzamani, H. Ghasemzadeh-Moghaddam, M. Fani, M. Shoushtari, et al. Emergence of mosquito-borne viruses in iran and adjacent countries: The case of chikungunya. *Journal of Health Sciences Surveillance System*, 11:397–407, 2023.

[40] T. Y. V. de Lima Cavalcanti, M. R. Pereira, and S. O. de Paula andR. F. *d. O. Franca, "A review on chikungunya virus epidemiology, pathogenesis and current vaccine development, " Viruses*, 14:969, 2022.

[41] M. Madariaga, E. Ticona, and C. Resurrecion. Chikungunya: bending over the americas and the rest of the world. *Brazilian Journal of Infectious Diseases*, 20:91–98, 2016.

[42] M. B. Hahn, R. J. Eisen, L. Eisen, K. A. Boegler, C. G. Moore, J. McAllister, et al. Reported distribution of aedes (stegomyia) aegypti and aedes (stegomyia) albopictus in the united states, 1995-2016 (diptera: Culicidae). *Journal of medical entomology*, 53:1169–1175, 2016.

[43] G. H. Leung, R. W. Baird, J. Druce, and N. M. Anstey. Zika virus infection in australia following a monkey bite in indonesia. *Southeast Asian Journal of Tropical Medicine and Public Health*, 46:460, 2015.

[44] S. R. Favoretto, D. B. Araujo, N. F. Duarte, D. B. Oliveira, N. G. da Crus, F. Mesquita, et al. Zika virus in peridomestic neotropical primates, northeast brazil. *Ecohealth*, 16:61–69, 2019.

[45] L. Barzon, M. Trevisan, A. Sinigaglia, E. Lavezzo, and G. Palu. Zika virus: from pathogenesis to disease control. *FEMS microbiology letters*, 363, 2016.

[46] Y. Acosta-Ampudia, D. M. Monsalve, L. F. Castillo-Medina, Y. Rodríguez, Y. Pacheco, S. Halstead, et al. Autoimmune neurological conditions associated with zika virus infection. *Frontiers in molecular neuroscience*, 11:116, 2018.

[47] T. P. Monath. Yellow fever: an update. *The Lancet Infectious Diseases*, 1:11–20, 2001.

[48] L. V. Simon, M. F. Hashmi, and K. D. Torp. Yellow fever: Statpearls publishing, treasure island (fl). 2023.

[49] P. Swapnil, M. Meena, V. Kumar, and J. Goutam. The yellow fever outbreak in global perspective is serious and of great concern. *Epidemiology (Sunnyvale)*, 7:331, 2017.

[50] R. F. Fleming and J. M. French. Dengue in iraq. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 40:851–860, 1947.

[51] S. Sinbat, A. K. Mousa, and H. J. Hasony. Seroepidemiology of dengue viruses in basrah, southern iraq. *Annals of the Romanian Society for Cell Biology*, 25:12588–12597, 2021.

[52] V. Duong, L. Lambrechts, R. E. Paul, S. Ly, R. S. Lay, K. C. Long, et al. Asymptomatic humans transmit dengue virus to mosquitoes. *Proceedings of the National Academy of Sciences*, 112:14688–14693, 2015.

[53] K. M. Martinez. *Understanding the spatiotemporal spread of infectious diseases using mathematical and statistical models and methods of data analytics*. Colorado School of Mines, 2020.

[54] J. Khan, A. Ghaffar, and S. A. Khan. The changing epidemiological pattern of dengue in swat, khyber pakhtunkhwa. *PloS one*, 13: e0195706, 2018.

[55] A. H. Abd AL-shabbani. In iraq, the first application of serological snap elisa technique in detection of canine heartworms (dirofilaria immitis) in herder dogs of al-qadisiyah and dhi-qar provinces. *Kufa Journal For Veterinary Medical Sciences*, 7:192–198, 2016.

[56] G. Capelli, C. Genchi, G. Baneth, P. Bourdeau, E. Brianti, L. Cardoso, et al. Recent advances on dirofilaria repens in dogs and humans in europe. *Parasites vectors*, 11:1–21, 2018.

[57] R. K. Prichard. Macrocyclic lactone resistance in dirofilaria immitis: risks for prevention of heartworm disease. *International Journal for Parasitology*, 51:1121–1132, 2021.

[58] A. M. Barakat, T. Smura, S. Kuivanen, E. Huhtamo, S. Kurkela, N. Putkuri, et al. The presence and seroprevalence of arthropod-borne viruses in nasiriyah governorate, southern iraq: A cross-sectional study. *Am J Trop Med Hyg*, 94:794–9, 4 2016.

[59] L. A. *d. Castro-Jorge, M. J. L. Siconelli, B. d. S. Ribeiro, F. M. d. Moraes, J. B. d. Moraes, M. R. Agostinho, et al., "West Nile virus infections are here! Are we prepared to face another flavivirus epidemic?, " Revista da Sociedade Brasileira de Medicina Tropical*, 52: e20190089, 2019.

[60] A. Naveed, L. G. Eertink, D. Wang, and F. Li. Lessons learned from west nile virus infection: Vaccinations in equines and their implications for one health approaches. *Viruses*, 16:781, 2024.

[61] D. M. Morens, G. K. Folkers, and A. S. Fauci. Eastern equine encephalitis virus—another emergent arbovirus in the united states. *New England Journal of Medicine*, 381:1989–1992, 2019.