Egypt. J. Vet. Sci. **Vol. 54,** No. 3, pp. 395-402 (2023)

Egyptian Journal of Veterinary Sciences

https://ejvs.journals.ekb.eg/

Potential Influence of Climate Change on the Occurrence and Distribution of Vector-Borne Diseases among Animal Populations

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ONE OF the biggest risks to animal health is climate change. Their impact is increasingly being considered on a global scale, and their influence on animal production is particularly pertinent given rising demand and production constraints. Egypt's climate has distinctive considerations due to its geographic position. Extreme climatic conditions are a result of global warming, with summer temperatures routinely exceeding 40°C, especially in lower Egypt. Climate change has a direct impact on the growth of vector-borne illnesses that could be a serious health issues. Culicoides midges can spread vector-borne illnesses like bluetongue in tropical areas. As well, frequent flooding and large-scale population movements may aid in the spread of water-borne illnesses. Microclimatic parameters including temperature, relative humidity, air speed, rainfall, and sun radiation are influenced by the environment. As temperatures rise, the vector adapts to survive, and today's global warming causes more insects to survive each year, which results in more each year. Increased temperature and relative humidity cause stress in humans and animals, which lowers immunity and makes other viral infections more likely. This review focuses on determining the microclimatic factors associated with vector-borne diseases' occurrence and distribution through the climatic change impact on them, besides the occurrence of emerging and re-emerging diseases. Therefore, it is recommended in the article that an epidemiological monitoring and surveillance system be implemented in order to reduce and prevent climate-sensitive animal diseases.

Keywords: Climate change, Vector-borne disease, Emerging and Re-emerging diseases.

Introduction

The threat of severe social unrest, population dislocation, economic hardship, and environmental damage is posed by global climate change [1]. Furthermore, all ecosystems have been impacted by climate change and global warming, which are widely acknowledged realities [2]. While rural impoverished communities are particularly susceptible to the negative effects of climate change, agriculture and livestock are some of the most climate-sensitive economic sectors in developing countries [3]. The appearance and spread of disease hosts or vectors, as well as their development, reproduction, and disease transmission, are all impacted by climate change. As a result, it has an impact on assemblages, host-parasite relationships, and dispersion in new locations [1].

Animal health is predicted to be significantly impacted by climate change, particularly global warming, both directly and indirectly. The diseases that are vector-borne, soil-associated, water- or flood-associated, rodent-associated, or air temperature/humidity-associated and sensitive to climate are probable to be those where the direct climatic impacts on animal disease are most prominent [4]. Those resulting from animals' attempts to adapt to their thermal environments or from the impact of the climate on microbial populations, the spread of vector-borne diseases

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(Received 09/11/2022, accepted 15/02/2023)
DOI: 10.21608/EJVS.2023.173626.1409

and host resistance to infectious agents, feed and water shortages, or food-borne illnesses are just a few examples of indirect effects that follow more complicated pathways [2].

Climate change-related increases in temperature may speed up the development of some diseases and parasites that go through one or more life cycle stages [4,5]. The spatial distribution and intensity of current pests and diseases change as a result of rising temperatures, which has an impact on cattle productivity or, in some extreme cases, can result in livestock death [6]. Changes in the frequency of extreme events, as well as variations in the rainfall and temperature regimes, may have an impact on the distribution and quantity of disease vectors. At higher temperatures, arthropod vectors are more active and need to eat more frequently to maintain their increased metabolic activity, which increases the likelihood that diseases may spread from one host to another. Small changes in the properties of the vector can result in significant changes in the disease [4].

According to the OIE Scientific Commission, climate change is probably going to play a significant role in how some illnesses, particularly those that are vector-borne, spread. In a recent OIE survey, catarrhal fever (bluetongue) and rift valley fever were the two new and re-emerging cattle illnesses that were most frequently mentioned [7]. In recent years, there have been substantial variations in the distribution of bluetongue virus infection globally [8]. The effect of climatic variations on the transmission of vectors and VBDs in various types of systems will be demonstrated in this study. To better comprehend the climatic change impact, it is necessary to have a fundamental understanding of how the vectors are responding to microclimatic variables.

Distribution of Vector-borne diseases (VBDS)

Although vector-borne diseases affect both humans and animals clinically, they were traditionally thought to originate in the tropics and impact cattle used in agriculture. This is no longer the case because they are now common in pets and may also be found in temperate regions like Europe. The improvement in diagnostic methods may have made it easier to identify vector-borne infections in both humans and animals [9]. Climate change makes us especially vulnerable to vector-borne diseases. The distribution and population of disease vectors could be impacted by variations in temperature and rainfall patterns, as well as the frequency of extreme climatic events. It is currently necessary to update the epidemiological data on vector-borne diseases in order to anticipate endemic, developing, or re-emerging diseases as well as the global effect of these diseases [10].

Microclimatic factors affecting the VBDS

VBDs' transmission is impacted by temperature fluctuations and precipitation, including their intensity, length, and variability, besides their minimum, and maximum values. These conditions could change to make disease transmission, as well as the vectors and/or animal reservoirs, more or less likely. Microclimatic factors include ambient temperature, drought, Humidity, and rainfall affect the occurrence and spread of VBDs and their transmission besides the changes will also have an influence on the human host [11,12].

Ambient temperature

The indirect impacts of temperature variations on the transmission of VBDs include the behaviour of the vectors in terms of biting, fertility, and survival [13], as well as insecticide resistance [14]. The frequency, duration, and abundance of rainfall as well as environmental humidity are other climatic factors that have a significant impact on the VBDs transmission [15]. Compared to temperate or cold regions, both tropical and/or subtropical areas have a higher prevalence of some infectious diseases. Therefore, global warming would have a tendency to widen their dominion area, heightening the severity of epidemics. Some of these illnesses are water- or food-borne pathogens that have the potential to spread throughout the entire region once they are introduced. During periods of rains, the potential of viral, bacterial, and protozoan agents that cause diarrhea to spread is increased because they can survive longer in warmer water [16].

Drought

The potential influence of drought on VBDS is dependent on climatic factors that affect the ecology of the arthropod vectors and the animals that serve as their hosts, as well as the pathogens' life cycles that cause the diseases they harbor. The life cycle of a vector can be affected by drought in a number of ways, including: survival, population size, behavior, distribution, and interactions between the vector, disease, and host. For instance, in times of drought, certain mosquito species may thrive because larger pools become shallower and rivers and canals move more slowly [17,18].

Humidity and rainfall

Humidity and rainfall play a vital role in the occurrence and spread of disease. Outbreaks of infectious diseases may be directly impacted by variations in rainfall. By increasing the area of the existing larval habitat and establishing new breeding grounds, increased precipitation may lead to arise in the presence of disease vectors. Additionally, a surge in plant growth and a concomitant increase in food resources for the vertebrate reservoirs would result from an increase in rainfall [19].

Climate change's indirect effects on the spread of Infectious diseases

Climate changes may have a significant impact on how the population's social and economic structures are organized. Therefore, shifting populations and overcrowding may promote human-to-human contact, human-to-animal contact, and human-to-polluted water contact, favouring infections from enteric or respiratory viruses [20, 21]. These pathogens could become large epidemics, possibly affecting the entire planet with diseases like the flu, if they are exposed to favourable conditions for spreading. Diseases spread by water during the climatic change event, and afterwards in the floods and other catastrophic climate events, water-borne illness (giardiasis, diarrhea, dysentery, typhoid fever, *E. Coli* infection, and salmonellosis) are significant dangers. In these circumstances, viral gastroenteritis (rotavirus, calicivirus, or norovirus) may manifest. More than 90% of gastroenteritis epidemics are caused by caliciviruses, which are easily spread throughout the world [22].

Climate change impact and disease Ecology

The survival of the pathogen, parasite, or intermediate vector may be influenced by climate, but other, indirect forces that are difficult to anticipate may also have an impact on the rate of transmission between different hosts. The likelihood of an infected animal comes into contact with a susceptible one may change as a result of changes in local animal transportation routes, farm size, and future patterns of international trade, all of which may be influenced by climate change. For instance, during a series of droughts in East Africa between 1993 and 1997, pastoral groups moved their livestock to graze in regions that were usually allocated for animals. Due to this, animals became infected with a mild strain of Rinderpest, which spread the disease to both vulnerable wildlife and other cattle [23].

Impact on the pathogen

In general, greater temperatures and humidity speed up the rate at which some diseases' parasites, which have an independent life cycle, develop. Pathogen spread can be significantly impacted by changes in wind direction. Extreme climate events can result in flooding, which is ideal for many water-borne diseases. Most infections require dryness and desiccation to survive [24]. Shorter generation durations and an increase in the overall number of generations annually could result from this, which would raise the pathogen/parasite population ratios [25]. When uninfected hosts are introduced into new settings, pathogens may potentially spread through those hosts, allowing illness to arise. This is demonstrated by the global occurrence of varroasis, which followed the ongoing introduction of disease-free European honeybee stocks into enzootic areas of Asia, and the occurrence of bovine tuberculosis in New Zealand, which followed the introduction of brush-tail opossums from Australia, which served as a novel reservoir for the disease in that country [26].

Impact on the host

The spread of some viruses and their vectors could expose some animals to new pathogens, with potentially disastrous results. Low immunity may also be caused by environmental stressors such as heat distress and a lack of food and water [24]. The main host-related consequence is the genetic susceptibility to illness. Many animals have evolved some degree of genetic resistance to certain illnesses to which they are frequently exposed. The best example of this is provided by "wild mammals" in Africa that may harbor trypanosome infections but infrequently display symptoms of the illness due to "antigenic variation." In contrast to recently introduced European cow breeds, local Zebu cattle breeds have some trypano-tolerance or resistance to the disease. But since they had not been exposed to the infection before, African mammals were extremely vulnerable to the Rinderpest epidemic that ravaged the continent in the late 19th century.

Emerging and re-emerging diseases in animals

Since animals were domesticated, there has been frequent interaction between people and animals, which has contributed to the exchange of diseases and the spread of those diseases. The fact that an existing illness can be linked to an infectious cause may be the cause of its emergence. The term "emergence" can also refer to the return or restart of an infection that had been previously identified but had subsided in frequency, the dissemination of an agent, or the identification of an infection that had been prevalent in the population but had gone unnoticed [27].

MERS-CoV (Middle East Respiratory Syndrome—coronavirus)

It's a virus-related to respiratory illness brought on by a new coronavirus called MERS-CoV, which was initially discovered in "Saudi Arabia" in 2012. Since then, outbreaks of (MERS-CoV) have been documented in 26 nations, most recently in South Korea [28]. Animal MERS-CoV infections are currently being reported as an emergent illness [29]. Goats and camels, which are both widespread, have been identified as potential hosts, and recently, evidence of past dromedary camel infection has been revealed [30]. Due to their infrequent contact with humans and their potential role as reservoir hosts for MERS-CoV, bats are extremely unlikely to be the cause of the outbreak.

Bluetongue Disease

The spread of arthropod-borne "Blue Tongue Disease" will be aided by climate change, which will expand the range of tropical agents and other causal agents. The non-communicable disease known as "bluetongue" (BT) is spread by insects and affects ruminants, mainly sheep and some non-African wild ruminant species. The recent spread of BTV in Mediterranean islands, often covering lengths of up to several hundred kilometers, is likewise thought to have been caused by windborne insects [31]. The wind-borne transmission of virus-infected Culicoides midges has been attributed to severe climatic events such as storms, typhoons, and hurricanes, yet long-distance transmission of virus-infected insects probably can happen just on normal or regular winds. There is compelling evidence that in 2007, wind-borne insects transported BT virus serotype 8 from continental Europe to nearby areas of England [32].

Dengue fever (DF)

Mosquitoes transmit this tropical and subtropical virus. Incidence has increased 30 times in 50 years' later, whereas transmission has significantly increased [33]. As a result of the ongoing climate change impact, which include arise in the earth's surface temperature and changes in rainfall patterns, the burden of dengue may shift on a global, national, and local level [34]. The habitat that mosquitoes and dengue viruses require to develop and thrive will alter as a consequence of these changes. DEN virus is mostly carried by mosquitoes of the Aedes genus, especially *Aedes aegypti* and *Aedes albopictus*. New literature suggests that there may be 400 million cases of DF annually [35]. Climate has an impact on vector populations and DENV directly. Climate has an impact on vector populations and DENV both directly and indirectly [36]. Temperature controls viral replication in the mosquito and has an impact on the development, death, and behaviour of the vector [37]. Numerous studies [38-40] have predicted future dengue sickness load, epidemic potential and, regional dispersal of cases, or population exposure to dengue-prone climates. Furthermore, predicting the upcoming of dengue under scenarios of climatic change requires not only a thorough understanding of how climate and dengue are related, but also a thorough understanding of how the climate and other factors (like demographics) will alter in the future, as revealed in Table (1) and Fig. 1 [41, 42].

TABLE 1. Vector-borne diseases spread by vectors [41]

Vector		Disease caused	Type of pathogen
Mosquito	*Aedes*	Dengue fever	Virus
		Lymphatic filariasis	Parasite
		Rift Valley fever	Virus
		Yellow Fever	Virus
		Zika	Virus
	Anopheles	Lymphatic filariasis	Parasite
		Malaria	Parasite
	Culex	Japanese encephalitis	Virus
		Lymphatic filariasis	Parasite
		West Nile fever	Virus

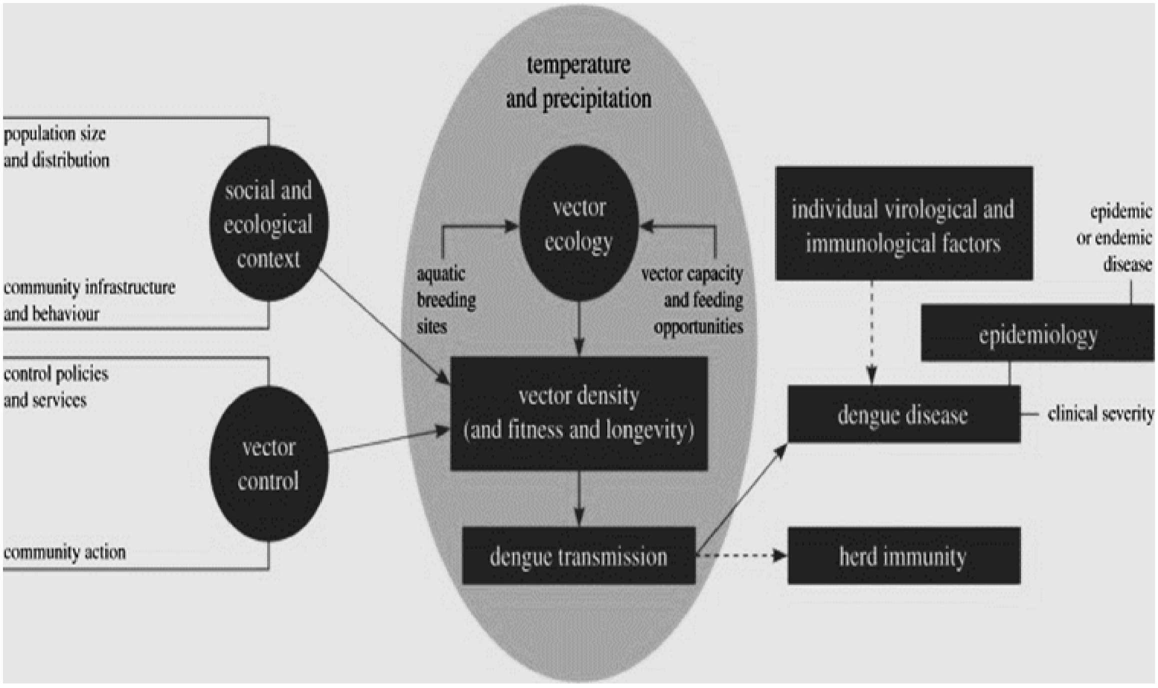

Fig. 1. Relations between meteorological data and other determinants of dengue transmission cycle [42].

Conclusions

It has been concluded that, Variability in the climate has a direct impact on the spread of vector-borne diseases, and there is ample evidence to support the link between climate change and these diseases. This evidence demonstrates contradictory outcomes, with disease incidence rising in some circumstances but falling in others. General predictions are nearly difficult due to the complexity of climatic changes impact on VBDs and the existence of opposing effects. Investigating the climatic change impact at a very detailed and local scale is necessary in order to make suggestions based on data that can be used to develop policy. The introduction and reappearance of abundant vector-borne diseases in various parts of the world strongly suggest a connection between climatic change and disease occurrence.

Recommendations

The epidemiological surveillance system should be able to differentiate between transient and seasonal increases in VBDs incidence and increases observed at the beginning of a dengue outbreak. Environmental management seeks to change the environment in order to prevent or minimize vector propagation. Besides improving water supplies is a fundamental method of controlling *Aedes* vectors. Appropriate livestock husbandry and management techniques, adequate disease outbreak response plans, improved disease surveillance and monitoring systems, and the development of effectively coordinated, locally appropriate strategies should all be implemented in order to reduce and prevent climate-sensitive animal diseases.

Conflict of interest

The authors do not have any competing interests.

Funding statement

This review Article is a self-funding.

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التأثير المحتمل لتغير المناخ على حدوث وانتشار الأمراض المنقولة بالنواقل بين مجموعات الحيوانات

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قسم الصحة والأمراض المشتركة والوبائيات - كلية الطب البيطري - جامعة بني سويف - بني سويف ٦٢٥١١ - مصر .

يعد تغير المناخ أحد أكبر الأخطار التي تهدد صحة الحيوان في القرن الحادي والعشرين.لذا يتم دراسة تأثيرات تغير المناخ بشكل متزايد على نطاق عالمي ، والتأثير على الإنتاج الحيواني وثيق الصلة بشكل خاص بالنظر إلى زيادة الطلب وقيود الإنتاج. إن مصر لديها اعتبارات مناخية فريدة بسبب موقعها الجغرافي. الظروف المناخية المتطرفة هي نتيجة للاحتباس الحراري ، حيث تتجاوز درجات الحرارة في الصيف بشكل روتيني ٤٠ درجة مئوية ، خاصة في الوج القبلى لمصر. المناخ له تأثير مباشر على الأمراض المنقولة بالنواقل والتي يمكن أن تكون مشكلة صحية خطيرة. إن فيروس حمى الضنك ينتقل في الغالب عن طريق البعوض. ويمكن أن ينشر الهاموش بعض الأمراض مثل اللسان الأزرق في المناطق الاستوائية الحارة. بالإضافة إلى ذلك هناك أمراض مستجدة مثل عدوى فيروس كورونا المسبب لمتلازمة الشرق الأوسط التنفسية (فيروس كورونا الجديد) والتى ممكن أن تنقلها الخفافيش. كما أن الفيضانات المتكررة والتحركات السكانية على نطاق واسع قد تساعد في انتشار الأمراض المنقولة عن طريق المياه. على وجه التحديد ، تؤثر العوامل المناخية بما في ذلك درجة الحرارة والرطوبة النسبية وسرعة الهواء وهطول الأمطار وإشعاع الشمس على البيئة. مع ارتفاع درجات الحرارة ، يتكيف الناقل للبقاء على قيد الحياة ، ويسبب الاحترار العالمي اليوم المزيد من الحشرات على قيد الحياة كل عام ، مما يؤدي كل عام إلى المزيد من الأمراض الفيروسية. كما أن زيادة كلا من درجة الحرارة والرطوبة النسبية تؤدي إلى الإجهاد الحرارى لدى الإنسان والحيوان ، مما يقلل من المناعة ويزيد من احتمالية الإصابة بالعدوى الفيروسية الأخرى. ترتكز هذه المقالة على تحديد تأثيرالعوامل المناخية على حدوث الأمراض المنقولة بالنواقل إلى جانب حدوث الأمراض الناشئة والمستجدة. لذ يوصى بتنفيذ نظام للرصد والمراقبة الوبائية من أجل الحد من الأمراض الحيوانية الحساسة للمناخ والوقاية منها.

الكلمات المفتاحية: تغير المناخ ، الأمراض المنقولة بالنواقل ، الأمراض الطارئه والمستجدة .