Chapter

Emerging Vector-Borne Diseases in Central Africa: A Threat to Animal Production and Human Health

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Abstract

Although the potential for livestock production is high in Central Africa, it is not an important economic activity because of disease constraints, primarily trypanosomiasis transmitted by tsetse flies. Recently, a growing number of vector-borne diseases have also emerged in that region. Indeed, there is a progressive expansion of trypanosomiasis in known tsetse-free areas in the Far North of Cameroon, mechanically transmitted by Tabanidae. In the beginning of year 2019, there was an epidemic of African horse sickness (AHS) in Cameroon for the first time. In the meantime, AHS was also declared in Chad and reported in Nigeria. Besides, new cases of Rift Valley fever (RVF) are regularly detected in both Cameroon and Chad. The relative significance of most vector-borne diseases (VBDs) in livestock is difficult to quantify, because there is no study on their socioeconomic impact. But, certain VBDs have significant impact on food production, and others such as RVF can be transmitted to humans. Impact of VBDs on human health, animal health and trade, as well as the transboundary nature of these diseases means there is a need for regional coordination and cooperation to address challenges. This can be successfully achieved with One Health approach.

Keywords: trypanosomiasis, African horse sickness, Rift Valley fever, Cameroon, Chad

1. Introduction

sub-Saharan Africa has been classified into five agroecological zones (AEZs): arid, semiarid, subhumid, humid, and highlands [1]. AEZs are one of the most important determinants of the characteristics of livestock production systems, in terms of species, breed, stocking capacity, disease pressure, and individual productivity. In sub-Saharan Africa, the rural population lives mainly from agriculture and livestock. Ruminant livestock are found mainly in arid and semiarid zones in the following numerical order: goats, sheep, and cattle in arid zone and cattle, goats, and sheep in semiarid and subhumid zones [2]. Livestock production in this zone is usually a component of mixed smallholder crop-livestock systems. Pastoral system comprises 21 percent of total cattle numbers. About 30 percent are kept in the mixed semiarid system, 21.7 percent in the mixed subhumid, and only 3.6 percent in the mixed humid system [3].

Traditional ruminant production systems in sub-Saharan Africa are generally subdivided into two broad categories: grassland-based systems and mixed systems. In West and Central Africa, the main production system is mixed systems, which means the farming system is (i) based on livestock but practiced in proximity to, or perhaps in functional association with, other farming systems based on cropping such as pastoral systems in arable areas [4] and is (ii) characterized by a long tradition of seasonal penetration into the more humid areas, with southward movements during dry season and northward movements during rainy season [5]. Although the potential for livestock production is high in humid zone that occupies 112 million ha in Central Africa [6], it is not an important economic activity there because of disease constraints, primarily trypanosomiasis transmitted by tsetse flies [7]. Trypanosomiasis is not the only vector-borne disease that affects animal production in Africa. Indigenous African transboundary diseases such as African horse sickness (AHS), bluetongue, and Rift Valley fever (RVF) are diseases that can cause high mortality among animal population and decrease animal production.

A vector-borne disease can simply be defined as a disease transmitted by a living being, usually an arthropod vector, to a vertebrate host depending on a balance between the vector, the pathogen transmitted, and the host. Disease occurs in an area when all three components are in place, vector's density being determined by climatic conditions. As such, incidence of vector-borne disease is closely related to the presence of the vector. Climate change leads to changes in the geographical distribution of the vector which often has an influence on the epidemiology of the disease. In its extreme form favored by the introduction of a new pathogen, it can lead to the emergence or re-emergence of a disease.

This review is to highlight emerging vector-borne diseases in the Central Africa region and possible ways of control.

2. Vectors and transmission of infectious diseases

Vectors are living organisms, mainly arthropods that can transmit pathogens during their blood meal between vertebrate hosts including humans. Mouth parts of bloodsucking insects are adapted for piercing the skin of animal hosts and sucking their blood. Not all vectors are strictly hematophagous. For some species such as mosquitoes, blood feeding is needed for egg production. Thus, only females are bloodsuckers, while other species such as tsetse flies need blood meal for their survival, and both males and females are bloodsuckers. Arthropods can feed on various orders of mammals (although some have preferences) and contribute to spread pathogens between taxonomic groups.

Ticks (Ixodidae or "hard ticks") are main vectors of animal diseases found in countries with warm and humid climates [8, 9]. Their preferential habitats are forests, savannahs, grasslands, and scrublands, in which they find suitable environmental conditions for their survival [10]. However, the majority of arthropod vectors belong to four orders of hematophagous insects, namely, Phthiraptera (lice), Siphonaptera (fleas), Diptera (flies), and Hemiptera (true bugs). Fleas are vectors of various pathogens (protozoa, bacteria, viruses) in animals. The main group of insect vectors of both veterinary and human importance is Diptera including sand flies (*Phlebotomus* spp.), black flies (*Simulium* spp.), midges (*Culicoides* spp.), mosquitoes (belonging to several genera including *Aedes* spp., *Anopheles* spp., etc.), horseflies (*Tabanus* spp.), tsetse flies (*Glossina* spp.), and louse flies (*Hippobosca* spp.) [11].

Arthropod vectors are cold-blooded (ectothermic) and thus especially sensitive to climatic factors. Vectors require certain environmental characteristics that are unique for each type of organism. Mosquitoes, for instance, require humid conditions, whereas ticks can live in warm and dry climates [12].

Vector reproduction, survival, and distribution rely on environmental factors including temperature, humidity, and vegetation cover which are variable throughout the year and influence vector activity (biting rate). In the same country, a VBD prevalence in humans can vary from one season to another and from one area to another in the same period. In animals, VBD prevalence when transmitted by flies is linked to the intensity of animal-fly contact determined by the abundance and density of vectors, which is determined by climatic conditions. However, climate is only one of many factors influencing vector distribution and vector activity.

Several environmental components (vegetation, climate, geology) define the geographic area within which transmission takes place for a particular vector-host-pathogen system [13]. Impact of environmental factors on different pathogens and vectors is diverse and specific to individual vector-pathogen combinations.

Numerous viruses, bacteria, protozoa, and helminths have been found to require a hematophagous (bloodsucking) arthropod for transmission between vertebrate hosts. But, not all blood-sucking arthropods are vectors (transmitters) of disease agents [14]. Besides, vectors are not exclusive to any particular pathogen and can not only transmit more than one disease, but they can do so at the same time [11]. The ability and likelihood that a vector transmits a pathogen to a vertebrate host depends on a numerous of factors. These include the ability of an ingested pathogen to survive and multiply in the body of the vector and its ability to be transmitted during a subsequent blood meal to a vertebrate. Other determining factors are the number of pathogen ingested by the vector, the density of vectors in the environment, and its feeding preferences. The relationship between a specific vector and its preferred host is usually stable, but it can change, for various reasons including unavailability of the preferred host [15]. Another distinction that can be made is between primary and secondary vectors that is recognized for their importance in a disease transmission, keeping in mind that a known secondary vector on a global level can be seen as a primary vector on a local level.

An arthropod may transmit disease agents from one vertebrate host to another in two different ways, but the most important type of transmission is biological transmission. Biological transmission refers to morphological and physiological changes that a pathogen undergoes before its transmission from one host (vector) to another (vertebrate) belonging to different taxa. That modification enables pathogen's adaptation in the organism of its two hosts and occurs during a cycle called development cycle. The ability to transmit a pathogen biologically varies greatly among species of arthropods and even among geographical strains within a species [16]. Four types of biological transmission have been described according to the type of biological development the pathogen undergoes in the body of the arthropod vector:

i. Propagative transmission occurs when the organism ingested with the blood meal undergoes simple multiplication in the body of the arthropod.

ii. Cyclopropagative transmission in which the pathogen undergoes a developmental cycle (changes from one stage to another) as well as multiplication in the body of the arthropod.

iii. Cyclodevelopmental transmission: the pathogen undergoes developmental changes from one stage to another but does not multiply.

iv. Vertical and direct transmission occurs either via the transovarial route or by infection of eggs from female after oviposition, both leading to venereal transmission.

The second way of transmission called mechanical transmission consists of a simple transfer of the organism on contaminated mouthparts or other body parts. No multiplication or developmental change of the pathogen on or in the arthropod takes place during this type of transmission. The relative infection of the vector is usually of short duration in such cases because the vector is mere a pathogen carrier. Successful mechanical transmission depends on the degree of contact insects have with the vertebrate hosts and on feeding behavior [16].

The vector and pathogen interactions greatly affect the dynamics of VBDs and explain many of the particular characteristics of each infection and its epidemics. Vector-borne pathogen transmission occurs when host, vector, and pathogen interact in space and time within a permissive environment. The ability of arthropods to transmit a disease agent depends on many complex factors including ecological changes, either natural or human-induced, climate change, habitat destruction, and changes in population density/distribution. It has been assumed that observed changes in temperature, rainfall, and humidity that are occurring under different climate change scenarios affect the biology and ecology of vectors and intermediate hosts and consequently the risk of disease transmission [17].

Temperature can affect both distribution of vectors and effectiveness of pathogen transmission through vectors. Ticks exhibit strong seasonal dependence of mortality and disease transmission, which can be related to temperature and vegetation conditions [18]. Not all changes in climate favor vectors. Extreme temperatures can act positively or negatively on their development cycle. Many vectors need water for their maturation. Some species lay eggs directly onto the water surface, and others need moist substrates near water. For the first group, heavy rains and floods are directly related to high vector density, while for insects needing microenvironment next to backwater and ponds, floods are inadequate for their development. Such a negative effect is also observed in temperate zones during colder and longer winters [19, 20]. When temperature increases, larvae reach maturity within a very short time, and that enhances its capacity to produce more offspring. The vector biting rate increases and, consequently, intensity of disease transmission because the blood ingested by the hematophagous insect is rapidly digested [21].

In tropical areas, although climate patterns, particularly temperature and rainfall trends, have direct effects on VBD transmission [22], the actual magnitude and spatial extent of VBDs within regions are also governed by several non-climatic factors including epidemiological, environmental, social, economic and demographic factors [19, 23, 24]. Human interventions on the environment through urbanization, deforestation, domestic and industrial use of chemical products, migration, modern agricultural systems, and increase in the emissions of greenhouse gases are known to also influence dynamics of VBDs [11]. Global warming offers better conditions for the development of some vectors by decreasing temperatures and reducing diurnal and nocturnal ranges [19]. There are countries where environmental conditions are not so favorable for certain vector populations, but immigration allows them to persist [25].

3. Emerging vector-borne diseases and epidemics

Several infectious diseases have emerged during the last four decades in both animal and human health sectors. Other diseases considered to have been under control or quiescent have resurged, often spreading to geographical areas in which they had not been previously found, due to various reasons including movement of vertebrate host, human, or animal. Pathogens of some of them further need a "carrier" to switch from an infected host to another and are vector-borne.

Emerging diseases is usually defined as infections that have newly appeared in the population or have existed but are rapidly increasing in incidence or geographic range [26]. An author [27] defines the word "emerging diseases" as all entities comprising resurgent or recurrent known diseases (usually caused by "new" or mutated previously known agents), truly new diseases to man, but caused by animal pathogens, and syndromes caused by new agents easily detected through advances in research and development. More simply, a disease is recognized as "new" when its clinical signs are distinct from other known diseases [28].

Diseases transmitted by ticks and insects called vector-borne diseases (VBDs) are a growing threat all over the world. In Central Africa, VBDs have been playing a particularly important role because many of them are endemic and the burden of VBDs continues to be very heavy both in animal and human health sectors.

Over decades, trypanosomiasis has been described as a major animal disease constraint to livestock production in sub-Saharan Africa. It is estimated that animal trypanosomoses significantly reduce the number of cattle: 37% in subhumid zone to 70% in humid zone. The meat production is reduced by 5–30%, milk production from 10 to 40%. The cost of these losses is estimated at 1338 millions of US dollars. Production work for draft oxen is reduced by 33%. Although losses due to morbidity (loss of weight, decrease in reproductive performance, increase in interrelated diseases, etc.) are more difficult to evaluate, the total agricultural production would be reduced by 2–10% in the risk zone [29]. The disease is cyclically transmitted by tsetse flies, and its occurrence normally overlaps tsetse fly distribution across Africa: approximately 11 million km^2 between 15°N and 29°S. The incidence and severity of trypanosomiasis in livestock are closely related to the species of *Glossina* present in the area. Although species of the subgenus *Austenina* (fusca group) are mainly incriminated in the transmission of animal trypanosomiasis and in a lesser extent species of the subgenus *Glossina* (morsitans group), all 31 species of tsetse flies can transmit animal trypanosomiasis, depending to their individual vector competence and capacity. But species of animal trypanosomes and even trypanosome infectious rate is different from one locality to another.

Ecology of tsetse flies is highly correlated to environmental factors, including temperature (20–30°C) and humidity. In general, higher temperatures (>38°C) are not suitable for the survival of adults, and lower temperatures (>17°C) do not allow immature stages to complete their development cycle. Therefore, tsetse flies are absent in hot and dry areas. But tsetse flies are not the only vectors of animal trypanosomiasis. Tabanids and stomoxes can also transmit that disease, though mechanically [30], and contribute to its spread even in tsetse-free areas.

In Central Africa countries, mainly in Cameroon and Chad, African animal trypanosomiasis (AAT), also called Nagana, has been so far found in savannah areas, and 70 percent of drug farmers' expenses are for trypanocides. There are important seasonal variations in the degree of risk to which livestock are exposed in areas that have pronounced variation between wet and dry seasons. During pronounced dry seasons, there is a general regression in the distribution of tsetse particularly if the dry season is also hot. The burning, usual in the savannah lands, accelerates the diminution in the extent of suitable tsetse habitats, and these have been seen as natural tsetse control measures. Farmers with trypanosomiasis-sensitive cattle take advantage of these and implement a rotational breeding system based on seasonal variations.

Recently, there has been a gradual expansion of AAT in known tsetse-free areas in Cameroon and Chad. Indeed, the Ministry in charge of livestock of Cameroon, through it national office against Glossina (MSEG) has noticed an increase incidence of AAT due to *T. brucei* and *T. vivax* in a tsetse-free area: the locality of Pette (10.97 N, 14.50S), Diamare Division, Far North region. Disease is mechanically transmitted and maintained by tabanids, present in the area (MSEG activity report, unpublished). The emergence of AAT in Pette (Cameroon) and in some areas beyond the tsetse belt of South-East of Chad is not the only emerging VBD that face countries of Central Africa.

In April 2019, Cameroon veterinarian services notified sudden morbidity of donkeys and mortalities of horses in two divisions of the Far North region detected by the national network surveillance of animal diseases (RESCAM report, unpublished). After laboratory investigation, African horse sickness (AHS) was confirmed. It is the first time that disease is notified in that country. In the meantime, AHS was also officially declared in Chad, while it was 3 months ago reported by veterinarian services of Nigeria. AHS is a vector-borne viral disease transmitted by *Culicoides* spp. Following the first notification of that disease in Cameroon, three divisions of the same region and two of the adjacent North region were also affected. It was an epidemic.

AHS occurs across a wide range of biotic and abiotic parameters that relate to interactions among host, pathogen, vector, and environment. *Culicoides* spp. remains the least studied of the major dipteran vector groups despite their veterinary and economic importance. The small size and fragility of *Culicoides* spp. and their limited direct impact on public health occurring through nuisance biting inflicted by female adults [31] could explain that lack of attention. Nevertheless, more than 1400 species have been described worldwide (except Antarctica and New Zealand) in the genus *Culicoides*. Geographical distribution and ecology of these holometabolous flies rely on the existence of moisture-rich habitats that are necessary for their development cycle [32]. Thus, the occurrence of AHS is preceded by seasons of heavy rain that alternate with hot and dry climatic conditions, which favor transmission by the insect vector [33].

Arboviruses circulate among wild animals, and many can be transmitted to humans and agriculturally important domestic animals through a process known as spillover [34]. The emergence of African horse sickness in Central Africa could be due the movement of reservoir animals from one area to another or the importation of vectors which can bring with it new diseases with great adaptability in the part of the pathogen and the vector.

Epidemics of vector-borne disease have arisen from specific conditions occurring within the context of the large-scale drivers of infectious disease emergence. Global climate change has been assumed to lead to an increase of vector-borne infectious diseases and disease outbreaks. It could affect the range and population of pathogens, host, and vectors and transmission season [21]. Changes in ecosystem lead to the increase of population in natural hosts or vectors for certain emerging infectious disease. These factors are becoming increasingly prevalent [35], suggesting that infections will continue to emerge and probably increase. In fact, although not endemic, cases of Rift Valley fever (RVF) are increasingly detected by the national veterinary laboratory of Cameroon in ruminants mainly in the North region. Evidence of the circulation of RVF virus in Cameroon was demonstrated in 2017 on samples collected in years 2013 and 2014 on small ruminants and cattle [36]. Few years ago, some authors had shown the presence of RVF virus in goats in forests of South region Cameroon [37] and others in domestic ruminants in Chad [38]. According to them, the presence of RVF virus antibodies in domestic animals suggests that this virus may also be circulating in human populations, despite the absence of reports.

In addition to being a vector-borne disease, RVF can be transmitted to humans (by nonvector means) and causes hemorrhagic fever, encephalitis, and mortalities. Mosquitoes are main "transmitters" between animals, while humans can contract disease after a direct contact with infected bodily fluids or tissues of infected animals. Human infection after mosquito bites is mild or asymptomatic [39, 40]. Epidemiological patterns of that disease differ from one area to another. In East Africa, several RVF outbreaks have been linked to prolonged heavy rainfall [41], whereas in West Africa, outbreaks usually occur during years of normal or poor rainfall [42, 43]. Such studies have not yet been conducted in Cameroon.

A change in the geographical distribution of a vector-borne disease is related to a change in the distribution of its vector and/or the pathogen through human or animal movement. Due to climate change leading to unsuitable environmental conditions for its survival, vector moves and thus shifts its geographical range of distribution. But the mere presence of a vector does not necessarily mean presence of a disease. Human African trypanosomiasis due to *Trypanosoma brucei gambiense* has been described to not exist in some areas where the main vector *Glossina palpalis* prevails. Whatever it is, factors contributing to emerging and re-emerging zoonoses can be divided into two groups: intrinsic factors and extrinsic factors. Intrinsic factors are factors that lead to the emergence of new pathogens; and extrinsic factors are those related to environmental changes or human behavior including deforestation, urbanization, and agropastoral activities.

Deforestation provides new ecological niches and conditions for proliferation of newly arriving and/or adaptive vectors and their pathogens. Agriculture and livestock production create a favorable habitat for pathogens and their respective host vectors. Humans are exposed to new pathogens during their daily activities and animals, mainly in pastures. Because of the scarcity of their preferential vertebrate host, some vectors display a conversion from a primarily zoophilic (bites to animal) to primarily anthropophilic (bites to human) orientation [44]. That hypothesis has been argued to explain prevalence of human African trypanosomiasis due to *Trypanosoma brucei rhodesiense* and transmitted by *Glossina morsitans,* assumed to be linked to the disappearance of wild mammals. In the same way, water control projects create new breeding habitats for insects, their larvae, and their pathogens. The construction of new roads provides access for new human, livestock, vector, and pathogen populations [45].

In addition to increased public health response, a better understanding of the epidemiology of VBDs is needed to identify the drivers of these epidemics and inform the public health response.

4. Impact of emerging vector-borne diseases in Central Africa

The relative significance of most VBDs in livestock is extremely difficult to quantify, because there is no study about their socioeconomic impact. However, it is known certain VBDs do have a particularly significant impact on food production.

It has been assumed that animal trypanosomiasis that prevents the use of draft animals has serious impact on land use. Cattle farming is practiced mainly in dry areas where tsetse flies cannot survive and also where there are not large areas of pasture. The consequence of that is overstocking and land degradation [46]. Emerging of trypanosomiasis in dry area maintained by mechanical transmission further impoverishes local populations. In the locality of Pette (Cameroon) where such a situation has occurred, farmers have adopted a night pasture system. That means animals are kept from tabanids bites in day time inside cowsheds and brought to grazing areas overnight when tabanids are inactive. The consequence is that not only cattle are undernourished but also local populations who live from their farm production. With the non-governmental organizations' (NGO) support aiming at increasing their productivity and income, farmers have implemented sustainable agricultural methods to preserve natural resources. These methods involved water management in irrigation scheme. Irrigation is needed not only to grow food for human consumption but also for livestock feed and provides suitable environment conditions for mosquitoes and midges. So there was no surprise about the occurrence of others VBD even among populations. For example, storage dams built in irrigation schemes to improve food security in the

Far North region of Cameroon have been shown to provide suitable habitats for the aquatic snails, the intermediate hosts of schistosome parasites. As these areas are also used by local populations for other domestic purposes including laundry and swimming by children, they are exposed to the emerging schistosomiasis which becomes endemic. Vector-borne diseases are a threat to animal and human health, animal welfare, and trade. Impact of RVF on domestic markets and international trade is probably greater than the direct mortality and production impacts of the disease. Trade restriction still remains one of RVF's major economic effects that prevent farmers to declare to veterinary services first cases of RVF or report an outbreak when occurring. This can delay implementation of control measures until the disease spreads to neighboring areas, sometimes across borders, and creates an international epidemic [47].

Morbidity and mortality from AHS in the Far North and North regions of Cameroon have constrained the draft power of working equine, mainly donkeys, thereby affecting food security, poverty alleviation, and gender equality. AHS virus is also a major threat to equine sport. Several races took place across Nigeria, Cameroon, and Chad and within countries, across regions. Economic value of horse racing, though not evaluated, is considerable. The value of horses as companion animals is less well defined but can provide physical and psychological benefits to owners and riders. Epidemics of AHS were controlled by quarantine of equines moving from endemic and epidemic AHS regions or country to virus-free areas, vaccination, and stabling. Because of that equine movement restriction, local farmers underwent serious losses in their income.

In Senegal, a study conducted on the economic impact of AHS after the outbreak of 2007 revealed a loss of US$ 1,793,581.596 following a morbidity rate of 0.26% and a mortality rate of 0.23% of equine [48]. Following the 2006–2007 RVF outbreaks in Kenya, a socioeconomic study has shown significant financial losses along the livestock value chain. The value of these losses ranged from US$ 1500–8900 by actors, depending on the nature of product lost. For livestock producers, that loss of milk production was caused by abortion. Livestock traders lost sales because of animal deaths, while slaughterhouses closed, and butchers stopped their activities because of fewer animals being killed and marketed [49].

The public health impact of VBDs is induced by pathogens that can be transmitted to humans. Although major livestock outbreaks precede human epidemics, most of the pronounced RVF events in history were first diagnosed in humans. The amplifying livestock epizootics were recognized only after the disease was noticed in the human population [47]. Such a situation is not yet documented in Central Africa. Nevertheless, inter-epidemic serological evidence in human was demonstrated in Gabon [50] which shared with Cameroon the second large forest of the world: the Congo Basin. That forest harbors more than 10 species of forest ungulates, and RVF virus has been detected from a number of wild African ungulates [51]. The potentiality of RVF virus and other pathogens to migrate between ungulates, domestic animals, and humans could have considerable effects not only on animal production but also on human health.

The impact of vector-borne diseases on human health, animal health, and trade as well as the transboundary nature of these diseases means there is a need for regional coordination and cooperation to address challenges.

5. Suggesting approach to control emerging vector-borne diseases

The complex epidemiology of vector-borne diseases creates significant challenges in the design and delivery of prevention and control strategies, especially in sight of rapid social and environmental changes.

VBD management must be based on realistic and achievable objectives such as reducing the burden or interrupting transmission cycle of the disease. The most successful approaches to the management of VBDs of importance to livestock and humans are often multifaceted and include awareness creation, treatment, or vaccines as well as efforts to reduce the population of the vector. But for a number of livestock vector-borne pathogens, no vaccines are available.

It has been suggested to use vaccination as a control strategy to limit the circulation of RFV virus in enzootic areas and to prevent epidemics in free areas. Vaccination is most effective when used in conjunction with other control strategies like movement restriction and sanitary slaughter [52]. In contrary, immunological control of African trypanosomiasis is not possible yet because of the antigenic variation of trypanosomiasis agents. Therefore, trypanocides are widely used to control AAT in cattle. However, no new veterinary drugs for the treatment of AAT have been released since 1985 [53], and there is increasing resistance to the existing trypanocides. Mitigation risk of exposure goes through avoiding grazing in infested areas and use of prophylactic trypanocides. Trypanotolerant breeds and crossbreds are also recommended [54] but not appreciated by farmers because of their low production rate.

Vector control can also be part of an overall strategy for reducing host-pathogen contact through the vector. This strategy has provided great success in Burkina Faso [55, 56] and Cameroon [57, 58] against AAT. Larviciding measures at mosquito breeding sites are the most effective form of vector control against RVF if breeding sites can be clearly identified and are limited in size and extent. Keep in mind that during periods of flooding, the number and extent of breeding sites is usually too high for larviciding measures to be feasible [59].

Training and education is paramount. Communities need to be educated both on the impact of zoonotic diseases and control methods of VBDs. It has been assumed that education of inhabitants on the pathological impacts of AAT on animal health and peasant economy will ease their cooperation for control activities that will guarantee and ensure sustainability and success of control measures [60].

Veterinarian capacities should be built on one health approach that helps to address the complexities of VBDs and its associated impacts. The One Health concept signifies a collaborative, multidisciplinary, and holistic approach, looking at optimizing animal, environmental, and human health, which are interdependent on each other [61]. Bringing animal health, human health, and environmental actors and partners together within the type of One Health program optimizes the use of scarce resources and could achieve cost-effective benefits for all components targeting conservation and human well-being. Epidemics control and more effective mitigation of impacts can be achieved by coordinated actions involving human, animal, and environmental health to prevent, detect, and respond to animal and human diseases as well as infected vector populations. Environmental risk assessment and early detection of pathogen in livestock is the best approach to protect human health.

But this cannot be successful without an effective surveillance system. Risks related to the transmission of disease need to be determined including evaluation of the potential spread to new areas or the introduction of exotic species or diseases. Predicting outbreaks and early detection are useful tools to mitigate animal health and economic impacts. Surveillance and preparedness should be implemented in a multi-sectoral approach that fully integrates animal and human health sectors, epidemiology, wildlife, and environment. A holistic approach that transcends disciplines such as joint-risk assessment, joint investigation, and response is essential to implement risk-based surveillance and build overall response capacity.

Countries should put in place-specific measures when dealing with transboundary animal diseases and targeting cross-border ecosystems. Emerging vector-borne disease means that the lack of zoo sanitary precautions at national borders including sustainable vector control has contributed to its spread from a neighbor country, especially in light of predominant climate change scenarios.

6. Conclusions

There is a regional emergence or re-emergence and expanding geographical distribution of vector-borne diseases in Central Africa, with an increased frequency of epidemic transmission. Central Africa is a hotspot of emergence or re-emergence disease. Impact of these diseases goes beyond animal mortality and mortality that seriously affects animal production and prevents poverty reduction to reach and threat human health. Reversing the trend of emergent/resurgent vector-borne diseases is very challenging. One Health-oriented collaborations among professionals working in diverse sectors such as animal health, human health, public health, entomology, and animal production will contribute to overcome the challenges faced by the sustainability of control of VBDs.

Conflict of interest

The authors declare no conflict of interest.

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