



Potential Impact of Climate and Environmental Changes on Occurrence and Transmission of Arboviral Diseases of Livestock in Nigeria

OLUWAYELU, D.O.

Department of Veterinary Microbiology and Parasitology, University of Ibadan, Ibadan, Nigeria
E-mail: ogloryus@yahoo.com, Telephone: +234-802-9442098

SUMMARY

There is strong evidence to suggest that climate and environmental changes especially affect the occurrence, distribution and prevalence of arboviral livestock diseases globally. The spread of infectious arboviral diseases involves at least 3 organisms: a parasite, a vector and a host. Climate change and alterations to the natural environment due to anthropogenic activities may change the milieu within which these entities interact, thus potentially affecting the epidemiology of these arboviral diseases and placing livestock populations at risk of avoidable outbreaks of vector-borne diseases. Such changes include increased ambient temperature, extreme weather events, changing wind patterns, deforestation, agricultural intensification, water projects, livestock trade and travel, and importation of used vehicle tyres. This paper reviews the potential impact of current climate and environmental changes on the transmission dynamics of arboviral diseases of livestock in Nigeria and recommends measures to mitigate their effects. Among others, strengthening of existing veterinary service structures for arboviral livestock diseases surveillance, establishment of a national animal arboviral diseases early warning system, capacity building for arboviral livestock

diseases research, reforestation and integrated vector management are identified as crucial factors in improving our ability to predict and prevent emergence and or re-emergence of vector-borne livestock diseases occasioned by climate and environmental changes in Nigeria.

KEY WORDS: Climate change, Environmental change, Transmission, Arboviral diseases, Livestock

INTRODUCTION

Livestock production occupies 70% of agricultural land and is responsible for 40% of global agricultural gross domestic product (Rowlinson et al., 2008). To meet projected growth in human population and per capita food demand, increases in livestock production will have to continue. However, several factors which result in low productivity and reduced profitability serve as limitations to the attainment of these production targets. Importantly, agriculture remains highly sensitive to climate variations which are the dominant

source of the overall interannual variability of production in many regions (Howden et al., 2007). As the effects of global change begin to alter climatic and ecological processes worldwide, the emergence of diseases and their vectors are certain to shift as well (El Vilaly et al., 2013). Indeed, Baylis and Githeko (2006) noted that the spatio-temporal distributions and incidences of many animal diseases are associated with climate and that the most responsive diseases will be those where the causative agent spends a period of time outside an animal host, exposed to environmental influence, the prime example being vector-borne diseases. Vector-borne viruses, also known as arboviruses, constitute the largest biologic group of vertebrate viruses and have been defined by the World Health Organization (WHO) as viruses that survive in nature by transmission from infected to susceptible hosts (vertebrates) by certain species of arthropods (mosquitoes, ticks, sandflies, midges, etc.). The viruses multiply within the tissues of the arthropod to produce high titres of virus in the salivary glands and are then passed on to vertebrates (humans and animals) by the bites of the arthropods (WHO, 1985). According to Lovejoy (2008), the etiology of diseases is rooted in the ecology of the disease agent. Consequently, a general understanding of the impact of climate and environmental changes on species and ecosystems is fundamental to understanding potential impacts on epidemiology. In Nigeria where the contribution of livestock to poverty alleviation cannot be overemphasized, there is no active national surveillance programme currently in place to monitor the occurrence and distribution of arboviral diseases of livestock, as well as the impact of these diseases on livestock production in the country. Crucial factors that could influence the effect of these arboviral diseases on the Nigerian livestock industry are climatic and environmental

variations. In this write-up, climate change will be used to describe a change of climate attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is, in addition to natural climate variability, observed over comparable periods while environmental change will refer to a change in major physical and biological systems, either caused naturally or influenced by human activity (Black and Nunn, 2009).



Figure 1: Ecological zones of Nigeria
Source: Aregheore (2009).

According to the Federal Office of Statistics, Nigeria is located in the tropics between latitudes 4° to 14° N and longitudes $2^{\circ} 2'$ and $14^{\circ} 30'E$ (FOS, 1989). Thus, the Nigerian climate varies more than any other country in West Africa due to its great length from the south to the north (1100 km), and there are three climatic zones which cover the north, middle and southern areas of the country (Ojo, 1977). Additionally, Nigeria has seven ecological zones which, from south to north, are the Mangrove, Freshwater Swamp, Rainforest, Woodland (and Tall Grass Savannah), Montane, Short Grass Savannah and Marginal Savannah zones (Abiodun et al., 2011). These ecological zones (Figure 1) influence the occurrence of

climatic and environmental changes of which some, such as high ambient temperatures, floods, droughts, deforestation, agricultural and animal husbandry practices, urbanization and importation of used vehicle tyres, have been identified in Nigeria. A combination of any of these climatic and environmental factors could lead to the introduction of vectors which were hitherto exotic to Nigeria, resulting in the establishment of the viral diseases they transmit in the local livestock population. For example, recent floods across the country due to climatic influences could alter breeding patterns of disease vectors thereby increasing vector populations nationwide with resultant outbreaks of arboviral livestock diseases. However, there is presently a paucity of information on the effects of climate and environmental variations on animal health and production in Nigeria. This paper therefore highlights the potential impacts of climatic and environmental variables on the occurrence and transmission of arboviral diseases of livestock in Nigeria, and prescribes measures that could serve as immediate and long-term solutions to these challenges.

POTENTIAL IMPACT OF CLIMATE CHANGE ON ARBOVIRAL LIVESTOCK DISEASES IN NIGERIA

“Whoever would study medicine aright must learn of the following subjects. First, he must consider the effect of each of the seasons of the year, and the differences between them. Secondly, he must study the warm and cold winds, both those which are common to every country, and those peculiar to a particular locality” - Hippocrates, 430 BC.

From the above quotation, it is obvious that the influence of climate on occurrence of infectious diseases is an age-long topic of interest. The mechanisms involved in the

climate-related emergence or resurgence of arthropod-borne diseases are complex, with the prevalence of infection depending on the inter-relationship between hosts, pathogens and vectors. Any climate-related factor that affects this triangular relationship will affect the epidemiology of the arthropod-borne disease (Van den Bossche & Coetzer, 2008). Indeed, climate has been identified as a major factor in determining the geographic and temporal distribution of arthropods, characteristics of arthropod life cycles, dispersal patterns of associated arboviruses, the evolution of arboviruses and the efficiency with which they are transmitted from arthropods to vertebrate hosts (Gould & Higgs, 2009). Recent global climate change is thus expected to have direct and indirect impacts on arboviral diseases of livestock in Nigeria. Direct impacts include increased ambient temperature, extreme weather events such as floods and droughts, and changing wind patterns while indirect impacts are the result of reduced availability of water and forage, and changes in the environment that promote the spread of arboviral diseases.

A) Direct impacts

i. Increased ambient temperature

The recent phenomenon of global warming is having significant effect on the incidence and distribution of infectious diseases of humans and animals. Specifically, Mellor (2004) noted that global climate warming is likely to increase the importance of the insect vectors of arboviral livestock diseases by increasing their population sizes (as insects are poikilothermic, warmer weather leads to more frequent blood feeding, thereby increasing the number of eggs produced) and by increasing their levels of oral susceptibility. For many arboviruses, the extrinsic incubation period (EIP), which is the time between when an uninfected vector feeds on a viremic host and is able to infect a susceptible host, is shortened at higher

temperatures. Moreover, the feeding rate of many arthropod vectors increases at higher temperatures, thus increasing exposure of livestock to pathogens, and hence the spread of disease (Gale et al., 2009).

Vector competence, which is the susceptibility of the vector to infection with the pathogen and the ability of the infected vector to transmit the pathogen to a host during blood feeding (Tabachnick, 2010), may also be affected by temperature. For example, Bluetongue virus (BTV) is transmitted most efficiently by *Culicoides imicola* at temperatures of 28-30°C, much less efficiently at lower temperatures, and not at all below 10°C (Gloster et al., 2007). In Nigeria where a sharp rise in air temperature was reported between 1971 and 2005 (Odjugo, 2010), an increase in prevalence of some insect-borne livestock diseases is thus likely as elevations in ambient temperature might lead to increased incidence of diseases such as Bluetongue (BT) and African horse sickness (AHS).

Apart from insects, ticks spend a large part of their life living off their hosts and are thus subject to ambient temperature and humidity. As with other vectors, increasing temperature accelerates the ticks' developmental cycle, egg production, population density and distribution (Gray, 2008). Climatic influences will therefore potentially affect the population and distribution of ticks in Nigeria with a corresponding change in the occurrence of the diseases they transmit such as Crimean-Congo hemorrhagic fever (CCHF), a zoonosis transmitted by *Hyalomma* ticks from domestic and wild animals (Zavitsanou et al., 2009). Antibodies to this virus have previously been reported in humans and cattle in Nigeria (Umoh et al., 1983; Tomori et al., 1988) (Table I).

ii. Extreme weather events (EWEs)

Warming of the global climate system accelerates the hydrological cycle, producing more droughts, floods and other extreme weather events (EWEs) (Karl and Trenberth, 2003). An important arboviral disease already associated with climate change is Rift Valley fever (RVF). Epizootics of this zoonosis linked with periods of heavy rainfall and flooding or with the combination of heavy rainfall following drought associated with the El Niño Southern Oscillation (ENSO) (Linthicum et al., 1999) have occurred. In Nigeria, RVF virus (RVFV) was isolated from sheep (Ferguson, 1959) while RVFV antibodies were detected in sheep and other animals (Ezeifeke et al., 1985; Olaleye et al., 1996) (Table I). Considering the heavy rains and flooding experienced in Nigeria recently (Atdhor et al., 2011; Aderogba, 2012), the risk of full-blown outbreaks of RVF in the Nigerian livestock population becomes heightened. In addition, the annual peak in *Culicoides* abundance in Nigeria is reported to occur shortly after the rainy season and during the coldest part of the year while the insect is rare or absent during the hot, dry season (Mellor et al., 2000). Therefore, a disruption in the onset of the rainy season or undue prolongation of the rains due to climate change can potentially increase the incidence of midge-borne diseases such as BT and AHS in Nigeria.

African swine fever (ASF), another arboviral disease of livestock, is maintained and transmitted in a sylvatic cycle involving the natural hosts (warthogs) and argasid (soft) ticks of the *Ornithodoros moubata* complex (Penrith et al., 2004). Although *O. moubata* has not been reported in the West African sub-region (Penrith, 1998), *O. sonrai* has been identified as the primary vector for ASF virus (ASFV) in Senegal (Vial et al., 2007). Argasid ticks have a great ability to resist desiccation. Thus, they survive well in very dry, desert conditions and, because of

drought in many areas of sub-Saharan Africa, *O. sonrai* has expanded its range (Trape et al., 1996), with the likelihood of persistence of ASF. This may facilitate their expansion in range with climate change. With drought and desertification becoming increasingly problematic in Nigeria (Odjugo and Ikhuoria, 2003), it is possible that *O. sonrai* could have expanded its range into Nigeria, contributing to the persistence and recent repeated episodes of ASF outbreaks in the Nigerian pig population.

iii. Changing wind patterns

There may be important effects of climate change on vector dispersal, particularly if there is a change in wind patterns. According to Mellor et al. (2000), apart from temperature and moisture, vector distributions are also largely dependent on variables such as wind. Wind movements have been associated with the spread of epidemics of many Culicoides- and mosquito-borne diseases (Sellers et al., 1982; Sellers & Maarouf, 1991). More recently, Alba et al. (2004) noted that infected Culicoides may be transported on the wind over distances of about 100 km. With changing wind patterns, it is therefore likely that non-native Culicoides species may be carried on the wind and expand their range into Nigeria bringing with them strains of BTV, AHSV, and other arboviruses that are alien to the country. This can alter the arbovirus biodiversity in Nigeria and possibly lead to the generation of variant virus strains due to genetic reassortment.

B) Indirect impacts

The indirect impacts of climate change on arboviral diseases of livestock are the result of reduced availability of water and forage, and changes in the environment that promote the spread of arboviral diseases through increased contact between animals and disease vectors, or increased

survival or availability of the virus or its host. According to Githeko et al. (2000), climate change may exert effects on animal health indirectly by altering local ecosystems and animal behaviour in ways that affect the geographic distribution or transmission dynamics of infectious diseases. For instance, droughts and floods decrease food supplies and force changes in grazing behavior that bring populations of susceptible animals into contact with each other and with infectious agents that they may otherwise have avoided, especially when they congregate at watering points. This pattern, which is existent in Nigeria as evidenced by the seasonal migration of nomadic Fulani herdsmen and their animals across the country in search of pasture, may be aggravated in future due to the possibility of increased occurrence of these weather events.

POTENTIAL IMPACT OF ENVIRONMENTAL CHANGES ON ARBOVIRAL LIVESTOCK DISEASES IN NIGERIA

The distribution, prevalence and impact of arboviral diseases are often affected by environmental changes engendered by anthropogenic activities. According to Eisenberg et al. (2007), these environmental changes can affect population levels of the host, vector, or environmental stage of the pathogen as well as the transmission rate at which pathogens move between hosts, vectors, and environment. In Nigeria, environmental changes with the potential to impact the occurrence of arboviral diseases of livestock include deforestation, agriculture and animal husbandry practices, water projects, transportation of animals and abandonment of used car tyres. These factors may disrupt the natural ecosystem of the vectors of these diseases and cause their introduction into new territories or a change in their feeding habits.

I) Deforestation

Deforestation causes extensive ecosystem reconstitution which in turn influences vector-borne disease transmission, and has contributed to the exposure of livestock and their owners to new arthropods and the viruses they transmit. It is driven by a wide variety of human activities including agricultural development/intensification, logging, transmigration programs, road construction, mining and hydropower development (Walsh et al., 1993). These anthropogenic activities are part of ongoing agricultural, industrial and human habitat development initiatives in Nigeria. Moreover, land degradation as a result of deforestation and overgrazing is already severe in many parts of the country (Abiodun et al., 2011). Deforestation could therefore have considerable impact on mosquito vectors of arboviral livestock diseases in the country. The most significant effects would be altered breeding grounds and shelter for mosquitoes which would change the intensity of contact with livestock, thereby affecting the occurrence and distribution of these arboviral diseases.

ii) Agriculture and animal husbandry practices

The growing worldwide demand for food has increased the conversion of natural ecosystems into agrarian ones that suit the raising of both plants and animals (Tilman et al., 2001). Agricultural practices are important determinants of vector-borne disease transmission. Indeed, agriculture has pervasive local effects on vector-borne diseases by affecting the availability of breeding sites for different species of vectors (Mouchet & Brengues, 1990). With the increasing rainfall and rising temperatures reported in Nigeria in the past three decades (Abiodun et al., 2011), it is certain that agricultural practices will change especially as regards irrigation and cropping patterns. Also, animal husbandry

may increase the occurrence and transmission of some vector-borne livestock diseases as vector populations grow with the additional feeding options livestock offer.

iii) Water projects

One of the basic infrastructural needs in any growing human population is the establishment of water projects such as irrigation networks and dam construction. However, these projects also cause changes in water flow pattern which may affect mosquito habitats and provide breeding sites for mosquito vectors of arboviral livestock diseases to proliferate. For example, it is known that outbreaks of RVF in North and West Africa are not associated with excessive rainfall but with the presence of large rivers and dams that provide new suitable breeding sites for the mosquito vectors and make such areas more prone to RVF epidemics (Van den Bossche & Coetzer, 2008). In addition, irrigation schemes may significantly increase relative humidity thus favouring vector longevity i.e. the life span of the adult insect. According to the WHO (1996), the longer a mosquito lives, the more blood meals it will take and the greater the chances of transmitting pathogens. Thus, the various irrigation projects (e.g. the FADAMA projects of the Federal Government) and dams across Nigeria may provide excellent breeding grounds for mosquito vectors of arboviral livestock diseases in the beneficiary communities.

iv) Livestock transportation and trade

Increased long-distance livestock transportation facilitates the movement of viruses and arthropods (especially ticks) around the world (MacLachlan & Dubovi, 2011). In developing countries, movement of livestock is common in order to find grazing and water, move away from drought or follow natural seasonal migrations, or because of migrations

precipitated by social tensions or local trade. Such movements inevitably bring livestock from different groups into contact (FAO, 2002). This scenario, which is common in Nigeria, may lead to increased livestock contacts and exposure of susceptible animals and herds to infection and vector infestation. Additionally, livestock marketing practices permit movement of animals across borders which allow ticks and tick-borne viruses to move between countries. These commercial activities are fodder for potential emergence of arboviral livestock diseases. For instance, trade in livestock was implicated as the source of the RVF epizootic that occurred in Egypt in 1997 (El-Rahim et al., 1999). Thus, the continuous transborder trade in cattle, sheep, goats and camels from neighboring West African countries, due largely to non-existent or ineffective animal control posts, makes it possible for the influx of arboviruses from these countries into Nigeria through illegal animal movement or smuggling.

Another anthropogenic factor that can potentially contribute to increased incidence of vector-borne viral diseases of livestock in Nigeria is the importation of improved livestock species into the country. This could be a means of introducing the tick vectors of diseases such as CCHF into the Nigerian livestock population. Gould et al. (2006) reported that emergence of CCHF virus (CCHFV) largely depends on the transportation of livestock such as cattle and goats on which infected ticks feed. Since this virus can infect a wide variety of ticks, its introduction into Nigeria through animal importation is not inconceivable. Moreover, importation of semen and embryos for artificial insemination may also be a source of introduction of arboviral diseases of livestock into Nigeria. For example, BTV can be introduced through the importation of infected livestock and

livestock germplasm such as semen as it is known to occur in the semen of rams and bulls at the time of peak viraemia and can be transferred to a developing foetus (Venter et al., 2011).

v) Abandonment of used vehicle tyres

Aedes albopictus mosquitoes are known to have adapted well to human activities such as the transportation, abandonment and storage of used car tyres, which provide small pools of water in which they lay their eggs (Gould & Higgs, 2009). According to Pfeiffer and Dobler (2010), *Aedes* spp. mosquitoes are associated with the transmission of arbovirus diseases of animals such as RVF, Eastern equine encephalitis and West Nile fever. Thus, the practice of abandoning used vehicle tyres, which is widespread in Nigeria, is a potential means of introducing mosquito-borne arboviruses to the Nigerian livestock population.

RECOMMENDATIONS

a) Strengthening of Veterinary Services for Arboviral Livestock Diseases Surveillance According to Van den Bossche and Coetzer (2008), the development of an effective and sustainable animal health service, associated surveillance and emergency preparedness systems, as well as sustainable disease control and prevention programmes is perhaps the most important strategy for dealing with the challenge of climate change in many African countries. Surveillance programmes for early detection of virus activity or increased virus activity in vector populations provide an early warning system of increased risk of transmission and disease outbreak. Therefore, in order to effectively manage the potential threat of endemic and/or emerging arboviral livestock diseases in Nigeria, there is a urgent need to strengthen existing veterinary service structures so that they can effectively undertake regular arbovirus

surveillance activities in the Nigerian livestock population. This will not only facilitate the gathering of baseline data for the evaluation of time trends or outbreaks, it will also help to define priority areas for intervention or research, and evaluate actions taken.

b) Establishment of National Animal Arboviral Diseases Early Warning System (NAADEWS)

Efficient early warning and forecasting of animal arboviral disease trends is crucial to effective containment and control of these diseases. Therefore, in mitigating the impact of climate and environmental changes on arboviral diseases of livestock in Nigeria, there is need for veterinary authorities in the country such as the National Animal Diseases Information Systems (NADIS) to develop a National Animal Arboviral Diseases Early Warning System (NAADEWS). This will help reduce the burden of arboviral livestock diseases in Nigeria by gathering and disseminating information about arboviral disease emergencies, thus provoking appropriate responses from relevant stakeholders. Additionally, increased surveillance coupled with disease modeling and use of geographically-based data systems will afford more anticipatory measures against these diseases. The modern techniques of Geographic Information Systems and remote sensing can be applied by NADIS to develop temporally- and spatially-explicit models capable of predicting both when and where disease outbreaks are likely to occur in Nigeria, and determine how disease patterns might alter with climate change. For example, predictive models that could identify the occurrence of a specific arboviral disease outbreak were used to accurately predict the 2006-2008 RVF outbreak in humans and livestock in countries in the Horn of Africa two to six weeks prior to its onset (Anyamba et al., 2009).

c) Funding and Capacity Building for Arboviral Livestock Diseases Research

There is a need for sustainable investment in arboviral livestock diseases research in Nigerian universities and research institutes through increased government funding as well as support from multinational corporations and other private organizations. Such funds can be used to conduct studies aimed at determining the prevalence of these diseases, isolating and characterizing the currently circulating causative viruses, identifying the mosquito, midge or tick species transmitting them in Nigeria and developing possible candidate vaccines. The outcome of such research efforts will guide the design and implementation of relevant vector control measures. Additionally, funding of research aimed at understanding the relative role of biotic and environmental processes in the ecology of these vector-borne diseases is essential for developing early warning systems for them. Since there is presently a dearth of personnel with requisite training in the diagnosis, prevention and control of arboviral livestock diseases in Nigeria, relevant authorities should fund training workshops for capacity building, thus preparing a critical mass of professionals who can be deployed in cases of disease emergencies.

TABLE I: Arboviral diseases of livestock identified in Nigeria

Vector	Disease(s)	Animal species	Method(s) of detection	Reference(s)
Mosquitoes	Rift Valley fever	Sheep	Virus isolation	Ferguson, 1959
	West Nile fever	Sheep, goats, cattle, horses, camels	Serology	Ezeifeke <i>et al.</i> , 1985; Olaleye <i>et al.</i> , 1996
		Sheep, goats, cattle, camels	Serology	Olaleye <i>et al.</i> , 1990
	Wesselsbron disease	Sheep, cattle,	Serology	Baba <i>et al.</i> , 1995
Biting midges (<i>Culicoides</i>)	African horse sickness	Horses	Virus isolation	Best <i>et al.</i> , 1975; Oladosu <i>et al.</i> , 1993
		Horses, donkeys, camels, dogs	Serology	Baba <i>et al.</i> , 1992
	Bluetongue	Cattle	Virus isolation	Lee <i>et al.</i> , 1974
		Sheep, goats, cattle	Serology	Moore & Kemp, 1974; Herniman <i>et al.</i> , 1983
Ticks	Crimean-Congo haemorrhagic fever	Cattle, goat	Virus isolation	Causey <i>et al.</i> , 1970
		Cattle	Serology	Umoh <i>et al.</i> , 1983, Tomori <i>et al.</i> , 1988
	African swine fever	Pigs	Virus isolation	Odemuyiwa <i>et al.</i> , 2001; Fasina <i>et al.</i> , 2010
			Serology	Olugasa <i>et al.</i> , 2005; Fasina <i>et al.</i> , 2010
Louse (<i>Haematopinus suis</i>)	Swine pox	Pigs	Clinical & pathological signs, electron microscopy	Olufemi <i>et al.</i> , 1981

d) Reforestation

According to Abiodun et al. (2011), since the major challenge of climate change in Nigeria is increased air temperature which leads to flooding around the coastal areas and drought in the Short Grass Savannah zone, the key adaptation strategy against this impact is reforestation. This would lower the rate of warming, reduce runoff (i.e. flooding) over coastal regions, preserve soil moisture and enhance rainfall over the Savannah zones. Thus, it is recommended that the Nigerian government embark on extensive reforestation programme across the country

e) Screening of imported livestock and livestock germplasm for arboviruses

Since importation of infected livestock and livestock germplasm (e.g. semen) has been shown to be a source of introduction of arbovirus diseases, relevant veterinary authorities in Nigeria should establish properly equipped centers at the nation's entry ports to perform screening of imported livestock and livestock germplasm for arboviruses such as BTV, CCHFV and AHSV before they are allowed into the country.

f) Vector control

Since there are no vaccines against majority of these diseases, the cornerstone of prevention is to reduce vector populations by vector control strategies and environmental manipulation. This can be achieved by adopting an Integrated Vector Management (IVM) strategy that encourages a multi-disease control approach, integration with other disease control measures, and the systematic application of a range of interventions, often in combination and synergistically (Campbell-Lendrum & Molyneux, 2005). Therefore, for mosquito-borne livestock diseases, vector control activities that could be undertaken include spraying with

insecticides, use of predatory fish in water ponds and larviciding. Okogun et al. (2005) recommended larviciding of mosquito breeding sites a month before onset of rainfall as a strategy for vector control in Nigeria. Key environmental interventions include covering all water storage containers, draining stagnant water, and proper waste disposal such as eliminating used vehicle tyres and other containers that can collect water. For the control of tick-borne livestock diseases in Nigeria, an integrated tick control programme involving vaccinations, use of resistant breeds of livestock, manipulation of tick populations to allow the establishment or maintenance of conditions of endemic stability, and strategic use of acaricides (Pegram et al., 1993) can be adopted. Moreover, regulation of livestock movement and grazing patterns through appropriate legislation is recommended.

CONCLUSION

From the foregoing, climate and environmental changes have the propensity to alter the dynamics of occurrence and transmission of several arboviral diseases of livestock in Nigeria and this may lead to the emergence/re-emergence of diseases such as BT, RVF, AHS, ASF, WNF, CCHF, Eastern equine encephalitis and lumpy skin disease that were hitherto absent or not currently reported in epidemic proportions in Nigerian livestock. Ultimately, this will cause severe economic losses due to increased morbidity and mortality with attendant reduction in the contribution of the livestock sector to the country's annual GDP. Moreover, since some of these diseases are zoonotic in nature, a corresponding increase in their occurrence among the human population is likely. For example, the emergence of CCHF in humans in West Africa was attributed to movement of livestock nearer to cities to

obtain animal feed during drought (Nabeth et al., 2004). In order to avoid such economic and public health calamity, there is a need to institute measures to mitigate these outlined effects of climate and environmental changes on the livestock resources of the country. Since a programme for the effective control of arboviral livestock diseases is presently non-existent in Nigeria, strengthening of existing veterinary services structures, appropriate legislation on deforestation, water management strategies (to reduce mosquito habitats), livestock transportation/trade and importation of used vehicle tyres, as well as adoption of integrated vector management strategies, among others, should be major policy thrusts of both Federal and State governments when dealing with problems of climate and environmental change and their dual impact on arboviral diseases of animals.

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