Short Review:

Assessing the zoonotic potential of arboviruses of African origin

Marietjie Venter (PhD)*

*Corresponding author: Marietjie.venter@up.ac.za
Zoonotic Arbo- and Respiratory virus program, Department Medical Virology, Faculty of Health, University of Pretoria, South Africa.
+27832930884

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Abstract:

Several African arboviruses have emerged over the past decade in new regions where they caused major outbreaks in humans and/or animals including West Nile virus, Chikungunya virus and Zika virus. This raise questions regarding the importance of less known zoonotic arboviruses in local epidemics in Africa and their potential to emerge internationally. Syndromic surveillance in animals may serve as an early warning system to detect zoonotic arbovirus outbreaks. Rift Valley fever and Wesselsbronvirus are for example associated with abortion storms in livestock while West Nile-, Shuni- and Middelburg virus causes neurological disease outbreaks in horses and other animals. Death in birds may signal Bagaza- and Usutu virus outbreaks. This short review summarize data on less known arboviruses with zoonotic potential in Africa.

Introduction:

African arboviruses in the families *Flaviviridae* (West Nile Virus (WNV); Zika virus; Yellow Fever (YFV); Usutu virus); *Togaviridae* (Chikungunya virus) and *bunyaviridae* (Rift Valley fever (RVF) and Crimean Congo Haemorrhagic Fever (CCHF) were some of the major emerging and re-emerging zoonotic pathogens of the last decade [1,2].These viruses were largely unnoticed as diseases in Africa before they emerged internationally. Arboviruses often circulate between mosquito vectors and vertebrate hosts and spill over to sensitive species during climatic events where they may cause severe disease. One Health surveillance for syndromes associated with arboviruses in animals; screening of mosquito vectors and surveillance for human disease may help to identify less known zoonotic arboviruses and determine their potential to emerge internationally (Figure 1). This lead to identification of Shunivirus[3,4], Middelburgvirus[5], Usutu[6] and Bagazavirus[7] in Africa and Europe raising questions on the potential of further zoonotic pathogens to emerge internationally.

One Health strategy for arbovirus surveillance in Africa

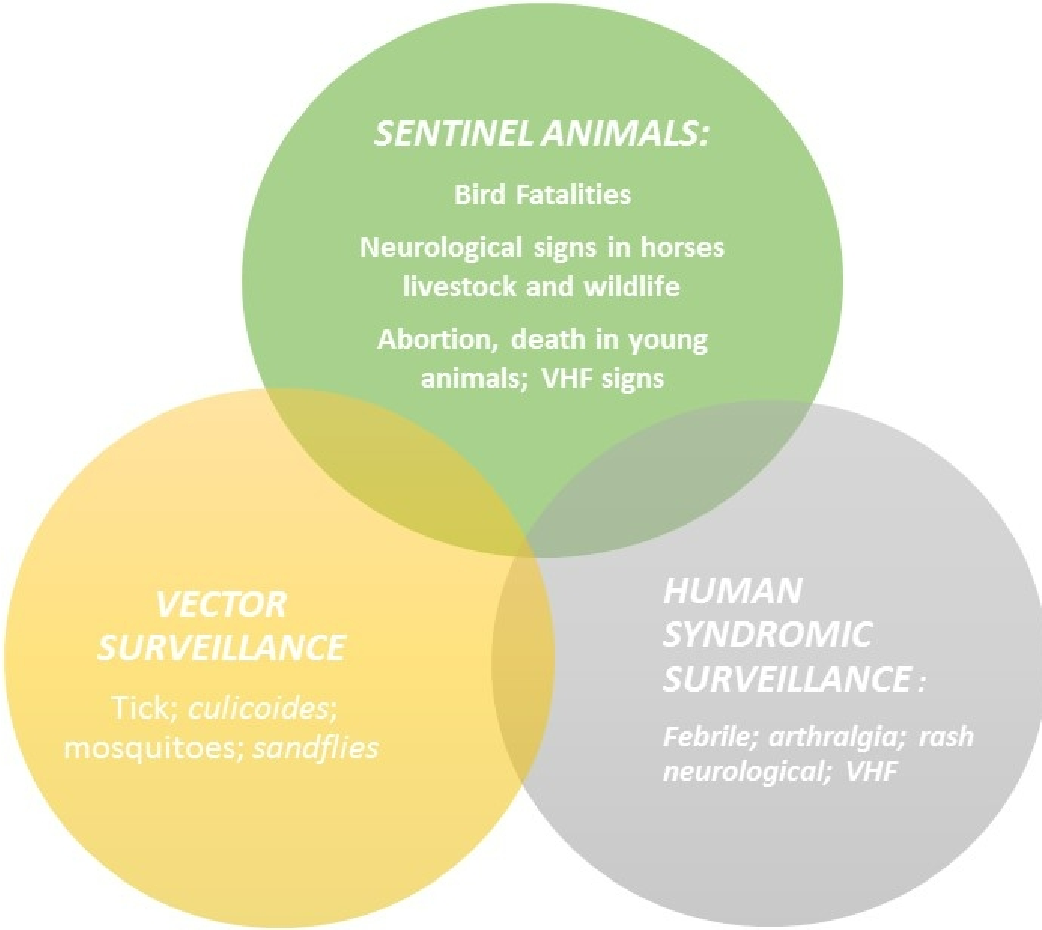

Figure 1. One Health Surveillance for arboviruses in Africa. Disease outbreaks in animals may act as an early warning system for arbovirus epidemics. RVF and WSLV are both associated with abortion and haemorrhagic manifestations in livestock [46•, 50], while neurological infections in horses and other species may signal WNV outbreaks [51, 52]. Bird die-offs may indicate WNV [53] or Usutu infections [54] however, endemic birds appear to have genetic resistance to WNV [55]. Passive surveillance for neurological disease in horses and other animals in South Africa over 8 years facilitated the description of the epidemiology of WNV lineage 2 [26•] and several other neurotropic arboviruses with zoonotic potential including Shuni virus (SHUV) [3•], Middelburgvirus, Sindbisvirus [5•], and Wesselsbronvirus (unpublished). These viruses were also detected in several wildlife species with neurological signs. Investigation of serological evidence in humans and syndromic surveillance for febrile disease, arthralgia and neurological signs identified arboviruses in unsolved meningo-encephalitis cases [27•]. Collection and screening of arthropod vectors in areas where clinical cases are detected may help to describe the epidemiology of these pathogens.

The purpose of this review is to summarise data on arboviruses with zoonotic potential detected in humans, animals and vectors in Africa.

Arboviruses and their ecology:

Zoonotic arboviruses mainly belong to the genera *Alphavirus*, family *Togaviridae*; *flavivirus* (*Flaviviridae*) and *Bunya*-; *Nairo*- and *Phlebovirus* genus (*Bunyaviridae).* A few zoonotic viruses belong to the *orbivirus genus* (family *Reoviridae*); the *Rhabdoviridae* and *thogotovirus* genus (family *Orthomyxoviridae*) however these are mainly animal pathogens[1]. Arboviruses mostly cause mild febrile disease but may progress to encephalitic, haemorrhagic fever signs, birth defects and death in humans and animals [2]. Arboviruses utilise animal hosts for amplification and arthropod vectors, including mosquitoes, *Culicoides* biting midges, sandflies and ticks for transmission and occasionally spill over into humans or domestic animals where they may cause disease. Their ecology is complex with several reservoir, amplification hosts and bridging vectors contributing to the amplification of virus and potential spill-over into humans and sensitive animals (Figure 2).

The vector epidemiology in combination with the availability of animal reservoirs and favourable environmental conditions determines the capacity to cause outbreaks, infect different species and emerge internationally [1,8].

Zoonotic Arboviruses in Africa

Many arboviruses were identified between 1930's-1970 by the Rockefeller foundation in Africa in arthropod vectors, animals and humans. Subsequent virus isolations from individual human and animal cases or larger outbreaks defined zoonotic associations [9-12] although burden of disease data is still lacking for many.

Table 1 summarises the African arboviruses with known zoonotic links from natural human infections in Africa, as collected in the International Catalog of Arboviruses [13] and reviews [14-17]. The most important zoonotic viruses are summarised below. Yellow Fever [18] and Dengue [19] are well described and mainly human pathogens so not covered in this short review.

FLAVIVIRUSES

The **Flaviviruses** are transmitted by mosquitoes and ticks. WNV and Wesselsbronvirus are the best described in Africa.

WNV, first isolated in 1937 in Uganda, spread across Africa the Western hemisphere, Europe and Asia to become one of the most important emerging vectorborne pathogens globally[20-22]. WNV circulates between ornithophilic mosquitoes, in particular *Culex univittatus* and *C. pipiens* and birds from where it may spill over into humans, horses and other sensitive animals[23](Figure 1). Two major lineages, 1 and 2 and several minor lineage are recognised with lineage 1 occurring mainly in Central to North Africa and the Western hemisphere, while lineage 2 is endemic in Southern Africa and Madagascar and now in Central Europe[24]. Surveillance for neurological

A.

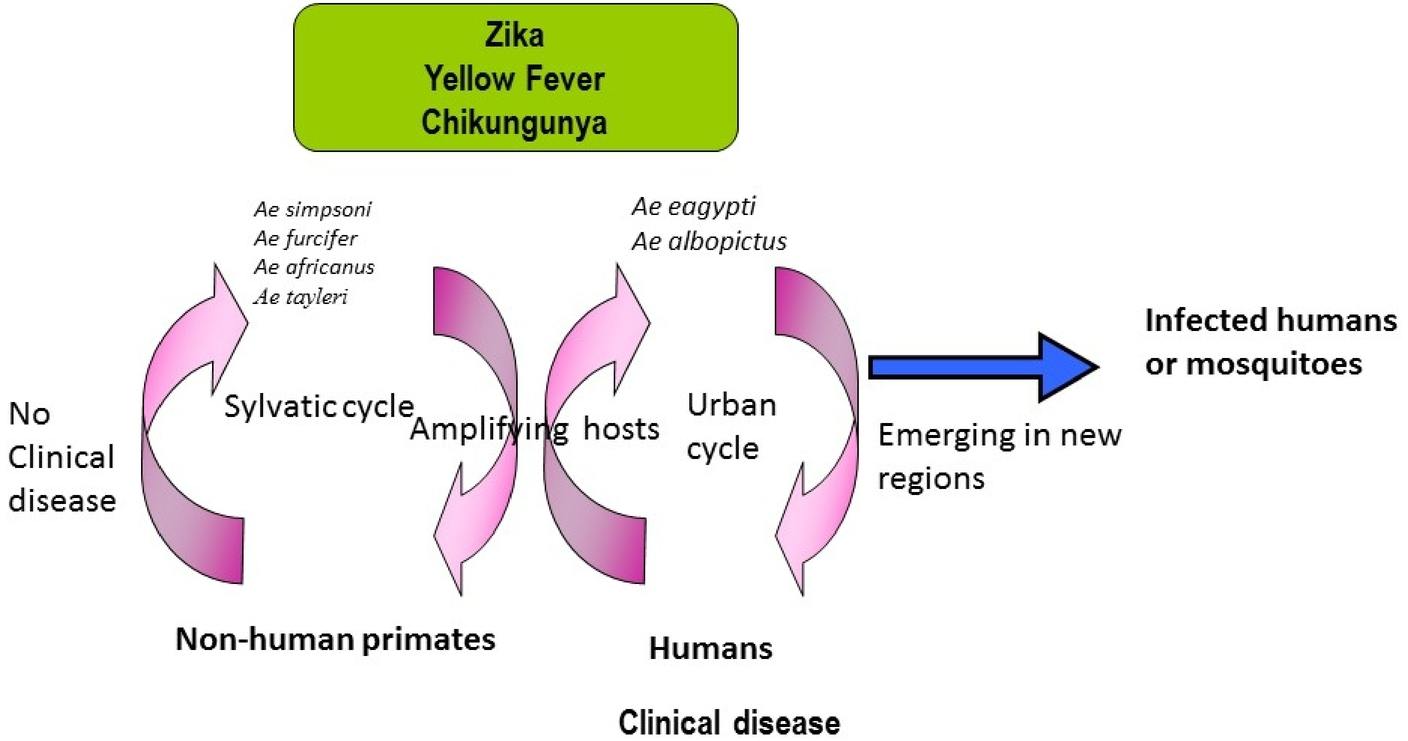

Figure 2. Ecology of arboviruses. (a) Yellow fever, chikungunya and Zikavirus utilise non-human primates as natural host in a sylvatic cycle with endemic Aedes mosquitoes but may use humans as only host in an urban cycle with competent vectors. Emergence of Aedes aegypti and A. albopictus as a highly effective vectors have been associated with international spread of these viruses and sustained urban outbreaks.

b.

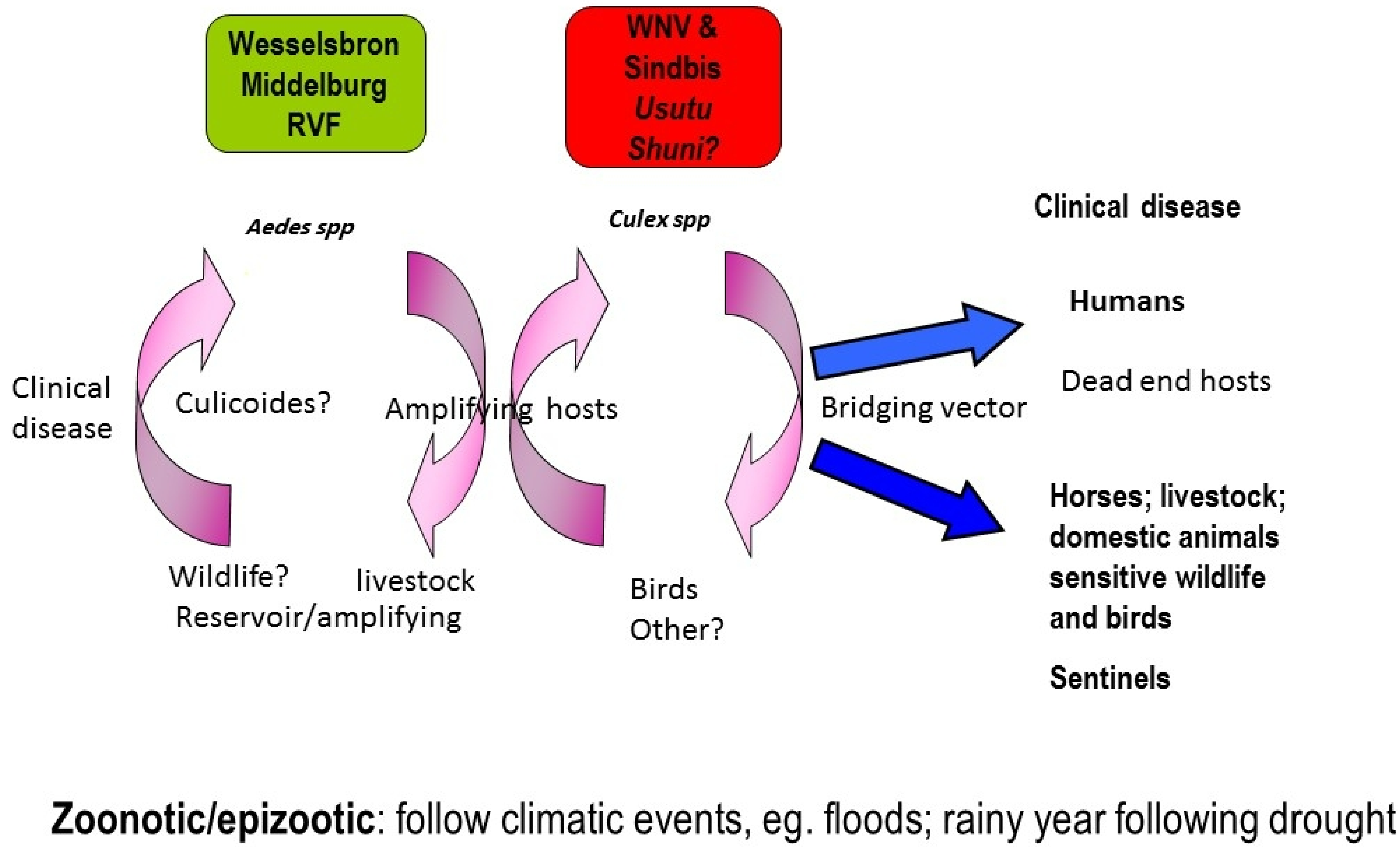

Figure 2. Ecology of arboviruses. (b) West Nile virus (WNV), Usutu and Sindbis on the other hand is dependent on amplification by birds and ornithophilic culex mosquitoes with humans and certain sensitive animals being dead-end hosts [1, 8]. Rift Valley fever and Wesselsbronvirus (WSLBV) may utilise wildlife as reservoirs in an inter-epidemic maintenance cycle with several species of Aedes mosquitoes but may be amplified following climatic events and hatching of vertically infected mosquito eggs following outbreaks involving ruminants. Humans may become infected through handling of infected animal tissue or sometimes mosquito bites [15]. Several less well known arbovirus may co-circulate such as Shuni virus and Middelburgvirus. Culicoides and additional mosquito vectors may contribute to the amplification cycle in animals or act as bridging vectors between species.

disease in horses and other animals in South Africa suggest horses are highly sensitive to WNV lineage 2. Neurological infections with fatality rates of 30% occur annually in late summer and autumn in horses[25,26].Human cases also occur every year with large epidemics reporting in 1974 and 1981. Severe disease may be missed with ~3% of unsolved meningoencephalitis cases in hospitals in Pretoria identified as WNV[27]. Detection of WNV lineage 1 in ticks collected from wildlife in Kenya suggest a potential mechanism for spread of the virus through attachment to migratory birds[28].The burden of disease due to WNV in humans and animals across Africa is likely underappreciated.

Wesselsbronvirus (WSLV) is associated with high mortalities in newborn lambs and kids, congenital malformation of the central nervous systems of the ovine foetus and *hydrops amnii* and abortion in ewes. Human cases are rare and mainly associated with non-fatal influenza-like illness[23]. A case of encephalitis was reported in an entomologist investigating an outbreak in South Africa[29]. The reservoir host is not known but recently isolations were made from black rats in Senegal[30]. The virus is thought to be transmitted by *Aedes caballus juppi* mosquitoes and is a differential diagnosis for Rift Valley fever[29]. WSLV antibodies has been detected throughout Africa although cases remain rare. Human cases of febrile disease were identified during a RVF outbreak in South Africa in 2011[31].

Other Flaviviruses:

Zikavirus has mainly been associated with mild infections in Africa since its discovery in Uganda in 1947. Primates are considered to be the natural host. The African lineage is postulated to cause less severe disease than the Asian strain that emerged in the Americas, since neurological infections and microcephaly have not been reported in Africa[32]. Recent serological and mosquito investigations demonstrated 6% seroprevalance in Senegal and Nigeria[33] and identified Zikavirus in 5/4313 febrile cases in Gabon as well as 2/137 *Aedes albopictus* pools[34]. The Asian strain has only been reported in travellers in a few countries following its international emergence but didn’t establish locally (http://www.healthmap.org/zika/#timeline).

Bagaza virus was isolated in 1966 from mosquitoes in Bagaza, Central African Republic but also in domestic turkeys in South Africa in 1980[35]. Emergence in birds in Europe [7] and serological evidence in encephalitis patients in India [36] raise questions on its disease association in Africa. Recent isolation from exotic European pheasants with neurological signs in 2016 and 2017 in South Africa suggest local circulation and that Bagaza virus should be considered in febrile cases in humans (unpublished data, M. Venter).

Usutu virus was first isolated in South Africa in 1959 and has in recent years emerge in birds across Europe. Only 2 human cases are known in history in Africa although it’s been detected in mosquitoes across the continent[6].

Banzi and **Spondweni** viruses [37] are considered rare with only a few cases reported historically mostly in laboratory workers[38]. Spondwenivirus neurological infection in travellers to West Africa raised concern about its potential to emerge internationally [39]. Vector competence studies suggested low susceptibility to *Aedes eagypti, A. albopictus* and *Culex quinquefasciatus* [40].

ALPHAVIRUSES

A comprehensive review on **Chikungunya virus** in Africa describes the distribution throughout the continent and international emergence [41]. African green monkeys and baboons are thought to be the maintenance host in Africa however urban cycles may only involve humans and various *Aedes spp*. Expansion *of Aedes eagypti* and *A. albopictus* has been key in its international spread.

O'nyong-nyong is closely related to Chikungunya and has been associated with sporadic but large outbreaks in East Africa and Uganda involving 2 million people. An animal host has not yet been identified[42].

Sindbisvirus often co-circulates with WNV between wild birds and *Culex* mosquitoes in South Africa (Figure 2). Human infections are widespread in the Highveld of South Africa during late summer and mainly associated with rash, fever and arthralgia[43]. Recent investigation of febrile and neurological infections in horses in South Africa identified several Sindbis virus infections, in the brain of some horses including fatalities [5].

Middelburgvirus was isolated in Middelburg in the Karoo in South Africa in *Ae caballus* following a Wesselsbronvirus outbreak [29]. It has since been detected in neurological cases in various species including horses[5], cattle and several wildlife species as well as 2 human infections suggesting the virus has a wide host range (M Venter unpublished). Middelburg was also isolated from *Culicoides* which may amplify outbreaks in animals. **Old World alphaviruses** was previously thought to be mainly associated with fever, rash and arthralgia relative to the new-world alphaviruses [44] but Middelburgvirus appear to cause frequent neurological cases in horses in South Africa raising questions about its pathogenic potential in humans [5] although human cases appear to be rare.

BUNYAVIRIDAE:

The **bunyaviridae** family comprises >300 viruses that cluster into 4 genera: *Bunyavirus* genus (previously orthobunyavirus); *Hantavirus*- (not associated with arthropods); *Phlebo*- and *Nairovirus* genus as well as several unassigned viruses. The most common and important arboviruses present in Africa are listed in Table 1 and discussed.

Phlebovirus genus:

RVFV is associated with large outbreaks involving thousands of animal and human cases occurring at irregular intervals of 5-15 years or more[45]. RVF may cause necrotic hepatic and haemorrhagic signs in ruminants with abortions and heavy mortality in newborn lambs. It's thought to be maintained between epidemics in wildlife such as buffalo in endemic regions. Trans-ovarian transmission in maintenance vectors such as *Aedes mcintoshi* may re-establish epidemics following heavy rainfall and hatching of infected mosquito eggs while epidemic vectors such as *Culex theileri* may amplify the outbreak. Humans contract the virus through handling of infected animal tissue or abortions although infections through mosquito bites may occur. RVFV outbreaks periodically occur across Sub-Saharan Africa and emerged in 2001 in the Arabian Peninsula. RVFV has been reviewed extensively in the literature as it is of high concern for international emergence and may cause high fatality rates in animals and potentially severe infections in humans including haemorrhagic signs or encephalitis although most cases are mild[15,45-47].

***Nairovirus* genus:**

Crimean Congo Haemorrhagic Fever (CCHF) was first described in the Belgian Congo (now Democratic Republic of the Congo) in 1956 but the name later combined when recognised as the same agent as Crimean haemorrhagic fever. The virus is mainly transmitted by *Hyalomma* ticks with a geographic range resembling that of the vector across Africa, the Middle East, Eastern Europe and Asia. Various small mammals such as hares may act as reservoirs or amplifying hosts and facilitate viral transmission to feeding ticks. Antibodies have been identified in various wildlife and livestock species although they do not develop clinical signs. Apart from ostriches all other birds appear to be refractory. Slaughtering of cattle, wildlife, ostriches as well as nosocomial transmission has been associated with outbreaks in Africa but transmission is mainly through contact with fresh blood or tick bites. Natural increase in pH of meat following slaughtering inactivates the virus[15]. The fatality rate in humans in South Africa is approximately 25%. Cases are sporadic with only 154 cases described since its identification in 1981, relative to the high number of cases following the emergence of CCHF in Turkey and Greece[16].

Nairobi Sheep Disease is associated with fever, haemorrhagic manifestations and abortion in pregnant animals and high mortality in sheep and goats. It's transmitted by *Amblyomma variegatum* and *Rhipicephalus appendicilatis* ticks. Cases has been identified from Kenya to the Congo around the equator. Antibodies have been detected in several countries in East Africa to Botswana. Human infections were associated with febrile disease with arthralgia and malaise. Sero-prevalence is 20% in humans in endemic areas [15].

Dugbe virus was isolated from ixodid ticks in Nigeria, the Central African Republic, Kenya and Ethiopia and from cattle blood in surveys as well as *Aedine* mosquitoes and *Culicoides* midges. A few febrile human infections and a case of mild meningitis was identified in Nigeria and the Central African republic where the virus was isolated from CSF[15,16].

***Bunyavirus* genus**:

Most **Bunyaviruses** are transmitted by mosquitoes. **Bunyamwera**, the prototype strain is widespread across Africa based on mosquito isolations and serological surveys but few human cases have been reported and were mostly mild. It has been isolated from rodents but it's not clear if it affects other animals. **Ngarivirus** was isolated during a RFV outbreak in Kenya and appear to be a recombination between Bunyamwera- and Batai virus. An animal reservoir has not been identified but transmission through various human feeding *Aedes* and *Anopheles* mosquitoes raised concerns that it may become an important human pathogen[15]. **Shunivirus** was first identified in a cow and febrile child during a survey in Nigeria in the 1960's but has recently been isolated from several severe neurological cases in horses across South Africa [48] as well as several other species. Antibodies were detected in 5/123 (3.9%) of large animal veterinarians across South Africa suggesting human exposure occur [49]. It recently emergence in Israel where it was associated with birth defects in cattle and sheep [4]. *Culex theileri* has been implicated as the vector (Table 1).

Conclusion:

Several African arboviruses are considered important emerging zoonoses internationally but remain neglected in Africa with little epidemiological data available to determine their importance in humans. Syndromic surveillance in humans and animals in Africa as well as vector studies may elucidate the importance and risk of the less well known viruses to emerge internationally and identify control options to prevent widespread epidemics.

Table 1:A non-exhaustive list of African arboviruses thought to be zoonotic (Compiled from [13-17]).

.Family Genus	Antigenic complex	virus	Vertebrate host	vector	Syndrome in humans	region
Togaviridae *alphavirus*	Semliki Forest	Semliki-Forest virus(SFV)	primates Humans rodents	*Ae abnormalis* *Ae africanus* *Culex pipiens*	Febrile encephalitis	Africa: Uganda, Mozambique, Cameroun, Central African Republic, Kenya, Nigeria, Senegal. Asia
		Chikungunya	Humans primates	*Ae tayleri/Ae. Furcifer; Ae aegypti; Cx tritaeniorhynchus*	Fever; rash Myalgia; arthralgia Neurological Febrile	Africa; Tanzania Uganda;Mozambique; S. Africa ; Congo; Zimbabwe; Nigeria; Senegal; Indian ocean islands Americas Asia Europe
		O'nyong-nyong	Humans	*An funestis* *An gambiae*	Febrile; rash; arthralgia	Africa Uganda, Kenya, Tanzania, Malawi, Senegal
	Middelburg	Middelburg-virus (MIDV)	Birds Horses Wildlife Cattle Sheep goat Human	*Ae caballus; Ae Banksinella* *Aedes caballus Aedes circumluteolus;AedesAedimorphus* *Aedes lineatopennis;Aedes dalzieli Senegal;Aedes palpalis* *Culicoides*	?; febrile and neurological	Africa: South Africa, Zimbabwe, Senegal, Kenya, Cameroun, Congo, Ivory Coast
	Western Equine encephalitis	Sindbisvirus	Birds Horses Humans	*Culex univentatus?*	Fever; rash Myalgia; arthralgia Febrile	Africa: Egypt, Uganda, South Africa, Cameroun, Central African Republic, Mozambique, Zimbabwe, Nigeria, Asia; Europe Middle East; Australia
	Ndumu complex	Ndumu virus	Cattle Human	*Mansonia uniformis* *Aedes circumluteolus* *Aedes abnormalis group* *Aedes dalzieli* *Aedes minutus*		Zimbabwe Natal, South Africa Central African Republic Senegal
Flaviviridae *Flavivirus*						
	Unassigned	Yellow Fever	Humans primates	*Ae aegypti* *Ae simpsoni*	Febrile Hemorrhagic Fever-	Tropical Africa South America

			Ae furcifer *Ae africanus*	jaundice-	
	Spondweni	Humans ?	*Mansonia uniformis;* *Aedes circumluteolus; Mansonia Africana;* *Aedes cumminsii* *Culex neavei*	Fever, headache, body pains, weakness, nausea, epistaxis	Africa: South Africa, Nigeria; Cameroun, Mozambique
	Wesselsbron	Sheep Humans	*Aedes fryeri/fowleri* *Ae (neo) lineatopennis* *Ae caballus juppi*	Fever Headache Retroorbital pain Encephalitis Sheep: Abortions, hemorrhage, hepatitis in newborn lambs	Africa: South Africa, Zimbabwe, Senegal, Nigeria, Kenya, Cameroon, Central African Republic Asia
	Zikavirus	Primates humans	*Ae aegypti* *Aedes africanus* *Ae luteocephalus*	Fever Guillian Barre Microcephaly	Africa: Uganda; Central Africa; Tanzania; Senegal; Egypt; Mozambique; Kenya South America Asia
Ntaya serogroup	Bagazavirus (Israel Turkey meningoencephalitis virus)	Birds Human	*Culex perfuscus* *Culex guiarti Centr.African* *Culex guiartiingrami* *Culex thalassius*		Africa: Central African Republic Cameroun South Africa Europe (Spain)
Dengue	Dengue 1-4	Humans primates	*A eagypti*	Fever; rash; myalgia; HF	Africa; Pacific America; Asia
Japanese Encephalitis serogroup	West Nile	Birds Humans Horses Several other	*Culex univetatus* *C. Pipiens*	Fever; rash; encephalitis	Africa (Wide spread) Asia Americas Australia Europe
	Usutu	Birds Humans Cattle and sheep	*Culex neavei*	Fever Rash Encephalitis*	Africa: South Africa; Central African Republic; Senegal; Uganda; Nigeria; Camaroon; Mozambique Europe
Uganda S	Uganda S	Birds primates	*Aedes (Fin) longipalpis* *Aedes (Fin) ingrami*	?	Africa: Uganda, Nigeria, Central African Republic

			Aedes (Adm) natronius		
	Banzi	Human Cattle *Mastomys natalensis*	*Culex rubinotus* *Culex nakuruensis* *Mansonia africana*	Fever	Africa: South Africa; Tanzania; Kenya; Zimbabwe, Mozambique
Bunyaviridae *Bunyavirus* *(Orthobunya-virus)*	Bunyamwera	Human Primates Rodents Domestic animals	*Aedes spp., Ae circumluteolus, Ae pembaensis, Mansonia africana,*	Fever; Stiff neck, arthralgia, CNS signs (encephalitis) (pleocytosis	Africa: South Africa, Uganda, Nigeria, Cameroun, Central African Republic, Kenya, Senegal
	Ngari	Humans	*Aedes simpsoni (males)* *Aedes vittatus* *Aedes neoafricanus* *Aedes Argenteopunctatus* *Anopheles gambiae* *Anopheles gamibiae* *Anopheles mascarensis*	Possible VHF	Senegal Burkino Faso, Central African Republic, Madagascar
	Ilesha	Human	*Anopheles gambiae*	Febrile illness; with rash	Africa: Nigeria, Uganda, Cameroun, Central African Republic, Senegal Africa:
	Shokwe	Human	*Aedes circumluteolus* *Aedes cumminsii* *Mansonia africana* *Aedes argenteopunctatus* *Aedes dalzieli* *Anopheles brohieri* *Aedes tarsalis group* *Aedes dentatus*	?	South Africa; Senegal;Ivory Coast
	Germiston	Human Cattle rodents	*Culex rubinotus; Culex theileri*	Hyperthermia, headache, lumbo-sacral pain, weakness, mental confusion, rash	South Africa; Zimbabwe, Uganda, Mozambique, Kenya
	Bwamba	Human Donkeys (antibody) Birds (antibody)	*Anopheles funestus* *An funestus;* *An gambiae*	Fever, headache, conjunctival inflammation, myalgia, pulse slow (avg. 84)	Africa: Uganda, Nigeria, Central African Republic, Kenya, Kenya

		Pongola	humans	*Aedes circumluteolus* *Mansonia uniformis* *Ma africana* *Aedes dalzieli* *Aedes vittatus* *Anopheles coustani* *Mansonia africana* *Ma africana, Aedes fowleri, Ae tarsalis* *Ma africana* *Ma uniformis* *Aedes tarsalis* *Anopheles coustani* *An funestus*	Febrile disease	South Africa, Mozambique, Senegal, Kenya, Uganda, Central African Republic, Ethiopia, Ivory Coast
Bunyavirus	Nyando antigenic group	Nyando	human	*Anopheles funestus* *An funestus* *Aedes dalzieli*	Febrile	Kenya, Central African Republic, Senegal
Bunyavirus	Simbu antigenic group	Shuni	human cattle, sheep horses wildlife	*Culicoides* *Culex theileri*	Febrile	South Africa Nigeria Zimbabwe Israel
Phlebovirus genus	Phleboto-mus Fever Antigenic Group	Rift Valley Fever	Humans Sheep Cattle Buffalo certain antelopes and rodents	*Eretmapodites chrysogaster group* *Aedes (Ochlerotatus) caballus* *Aedes (Neomelaniconion) circumluteolus* *Culex theileri* *Culicoides.* *Micropteropus pusillus* *Hipposideros abae (bat)*	Fever, headache, prostration, conjunctival inflammation, stiff neck, myalgia, arthralgia, CNS signs (encephalitis, hemorrhagic signs, lymphadenopathy, vomiting, central scotoma- detached retina	Africa: Kenya, Uganda, South Africa; Egypt Sudan Nigeria
Nairovirus genus		Pretoria virus		*Argas (A.) africolumbae*	Unknown	South Africa

		Crimean Congo Hemorrhagic fevers (CCHF)	Humans Hares Wildlife Cattle Ostriches wildlife	*Hyaloma ticks*	Fever, headache, vomiting, hemorrhagic syndrome	Russia, Central Europe, Greece, Africa: Uganda, Senegal, Zaire, Nigeria, Pakistan, Kenya, Iraq, S. Africa, Iran, Mauritania
	Nairobi sheep disease antigenic group.	Dugbe	Human Cattle	*Colicoides* *Ixodidae* *Aedes aegypti Amblyomma variegatum;* *Boophilus decoloratus* *Hyalomma truncatum* *H. rufipes*	Febrile	Nigeria, Central African Republic. Uganda, Senegal, Ethiopia
	Nairobi sheep Disease antigenic group	Nairobe sheep Disease	Humans cattle	*Culicoides,* *Ixodidae* *Aedes aegypti Amblyomma variegatum Ambloyomma variegatum* *Boophilus decoloratus* *Hyalomma truncatum H. rufipes*	Febrile	Africa: Nigeria, Central African Republic. Uganda, Senegal, Ethiopia
Other: Orthomyxoviridae	Thogoto antigenic group	Thogoto	Humans Cattle Camels	*Boophilus decoloratus, Rhipicephalus simus, Rh appendiculatus, Rh evertsi; Amblyomma variegatum, Bo annulatus; Hyalomma truncatum* *Hy anatolicum* *Rh sanguineus*	CNS signs (including encephalitis). Other significant symptoms: optic neuritis, meningoencephalitis	Egypt, Kenya, Nigeria, Central African Republic , Ethiopia, Cameroun, Uganda Europe: Portugal, Cicely, Middle East: Iran

Figure 1: One Health Surveillance for arboviruses in Africa

Disease outbreaks in animals may act as an early warning system for arbovirus epidemics. RVF and WSLV are both associated with abortion and haemorrhagic manifestations in livestock [46,50], while neurological infections in horses and other species may signal WNV outbreaks [51,52]. Bird die-offs may indicate WNV[53] or Usutu infections[54] however, endemic birds appear to have genetic resistance to WNV[55]. Passive surveillance for neurological disease in horses and other animals in South Africa over 8 years facilitated the description of the epidemiology of WNV lineage 2 [26] and several other neurotropic arboviruses with zoonotic potential including Shunivirus (SHUV)[3], Middelburgvirus, Sindbisvirus [5], and Wesselsbronvirus (unpublished). These viruses were also detected in several wildlife species with neurological signs. Investigation of serological evidence in humans and syndromic surveillance for febrile disease, arthralgia and neurological signs identified arboviruses in unsolved meningo-encephalitis cases [27]. Collection and screening of arthropod vectors in areas where clinical cases are detected may help to describe the epidemiology of these pathogens.

Figure 2: Ecology of arboviruses

a.) Yellow fever, chikungunya and Zikavirus utilise non-human primates as natural host in a sylvatic cycle with endemic *Aedes* mosquitoes but may use humans as only host in an urban cycle with competent vectors. Emergence of *Aedes aegypti and A. albopictus* as a highly effective vectors have been associated with international spread of these viruses and sustained urban outbreaks.

b.) West Nile virus (WNV), Usutu and Sindbis on the other hand is dependent on amplification by birds and ornithophilic *culex* mosquitoes with humans and certain sensitive animals being dead-end hosts [1,8]. Rift Valley fever and Wesselsbronvirus (WSLBV) may utilise wildlife as reservoirs in an inter-epidemic maintenance cycle with several species of *Aedes* mosquitoes but may be amplified following climatic events and hatching of vertically infected mosquito eggs following outbreaks involving ruminants. Humans may become infected through handling of infected animal tissue or sometimes mosquito bites [15]. Several less well known arbovirus may co-circulate such as Shunivirus and Middelburgvirus. *Culicoides* and additional mosquito vectors may contribute to the amplification cycle in animals or act as bridging vectors between species.

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Highlights:

- African arboviruses have emerged as major public health problems in new regions in recent years.
- Several less known arboviruses circulate in Africa in vectors, animals and humans that should be investigated for zoonotic potential.
- The epidemiology of zoonotic arboviruses may be described by using a One Health approach of syndromic surveillance in humans and animals.