The economic impact of Bluetongue and other orbiviruses in sub-Saharan Africa, with special reference to Southern Africa

John Duncan Grewar

Veterinary Services, Western Cape Department of Agriculture, Muldersvlei Road, Elsenburg, 7607, South Africa

Corresponding author at: Western Cape Department of Agriculture, Muldersvlei Road, Elsenburg, 7607, PO Box 84, South Africa.
Tel.: +27 83 642 0610, e-mail: johng@witshealth.co.za.

Veterinaria Italiana 2016, **52** (3-4), 375-381. doi: 10.12834/VetIt.503.2427.3
Accepted: 12.01.2016 | Available on line: 30.09.2016

IV International Conference on *Bluetongue and Related Orbiviruses*. November 5-7, 2014 - Rome, Italy - Selected papers

Keywords
African horse sickness,
Bluetongue,
Economic scale,
Orbivirus,
Preventive measures,
Southern Africa.

Summary

Bluetongue (BT) and African horse sickness (AHS) are considered the most important orbiviral diseases in Southern Africans countries. The general endemic status makes these diseases challenging to be quantified in terms of their economic impact. Using country reported data from BT and AHS outbreaks and cases, as well as international trade data, the economic impact of BT and AHS is evaluated on local, regional, and global scales. Local scale impact in the Southern African region is underestimated as shown by the underreporting of BT and AHS. Exceptions occur during epidemic cycles of the diseases and when the diseases impact regional animal movement and global trade, as in the case of AHS in South Africa. While BT is not directly implicated as a significant non-tariff barrier for regional movement, there are unspecified clauses in import permits which refer to the 'OIE listed diseases' and the freedom thereof includes endemic diseases like BT. African horse sickness has a much more tangible regional and global economic impact because of movement restrictions within AHS control zones in South Africa and through international movement of horses from this country.

L'impatto economico della Bluetongue e di altri Orbivirus *nell'Africa sud-sahariana e in particolare in Africa del Sud*

Parole chiave
Africa meridionale,
Bluetongue,
Economia di scala,
Misura preventiva,
Orbivirus,
Peste equina.

Riassunto

La Bluetongue (BT) e la Peste equina (AHS) sono considerate tra le più importanti patologie da *Orbivirus* nei paesi dell'Africa del Sud. Lo stato endemico generale in queste regioni crea difficoltà nel quantificare il loro impatto economico che comunque è stato valutato su scala locale, regionale e mondiale utilizzando le notifiche ufficiali dei focolai e dei casi di BT e AHS e i dati sul commercio internazionale. L'impatto locale nelle Nazioni dell'Africa del Sud risulta sottostimato per le segnalazioni incomplete dei casi di BT e AHS. Le omissioni si riducono nei periodi epidemici e in quelli in cui le malattie hanno un impatto determinante sulla movimentazione animale a livello regionale ed internazionale, ne è un esempio l'AHS in Sudafrica. Nonostante la BT non sia esplicitamente indicata tra patologie che limitano, specie a livello regionale, il movimento di animali, ci sono clausole non specifiche nei permessi di importazione che si riferiscono a "patologie della lista OIE" e che quindi includono patologie endemiche come la BT. La Peste equina ha invece un impatto economico più tangibile sia a livello locale sia a livello globale a causa delle limitazioni riguardanti la movimentazione degli equini nelle aree controllate in Sudafrica e soprattutto verso nazioni di altri continenti.

Introduction

The general status of endemic orbiviral diseases, including Bluetongue (BT) and African horse sickness (AHS), in Southern African countries, makes these diseases challenging to be quantified in terms of their economic impact. In a similar vein to landscape epidemiology, the economic impact of these 2 orbiviruses can be assessed spatially by evaluating their impact within local, regional, and global scales. For the purposes of this paper Southern Africa is defined as the region enclosed by the Southern African Development Community (SADC).

Vector borne orbiviruses require adequate numbers of susceptible hosts, an environment conducive to survival, and vectors capable of transmission for successful disease to occur (MacLachlan 2011). The climatic classification of Southern Africa varies tremendously. The climate zones can be summarised as equatorial and tropical savannah in the Northern regions (Democratic Republic of Congo), humid subtropical in the Northern-Central region, warm semi-arid and desert in the Southern-Central region, and then a varied cold desert, mediterranean, and humid subtropical in the South region (South Africa) (Peel *et al.* 2007). With regards to BT, Southern Africa certainly contains domesticated ruminant amplifying hosts (Robinson *et al.* 2014, Verwoerd and Erasmus 2004) (see Figure 1) and *Culicoides* vectors (Baylis *et al.* 1999, Meiswinkel *et al.* 2004, Venter *et al.* 1996), allowing the disease to establish endemically (Verwoerd and Erasmus 2004). For AHS, the equine host occurs in comparatively lower densities compared to ruminants, although the Southern African region was already considered endemic for the disease when Theiler described its distribution in 1921 (Theiler 1921). Both BT and AHS also have competent wildlife hosts in the region, making the eradication of these diseases more difficult, if not impossible (Barnard 1997, Coetzer and Guthrie 2004, Verwoerd and Erasmus 2004).

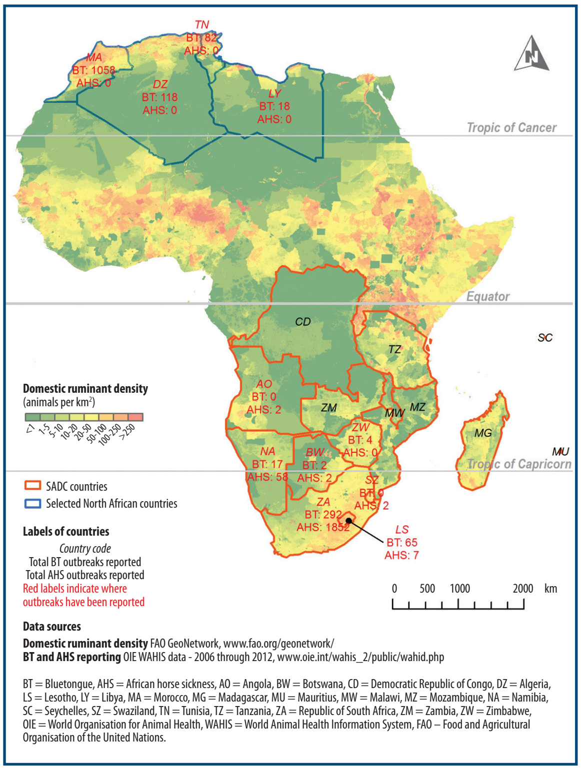

Figure 1. *The African continent indicating the Southern African Development Community (SADC) countries in the south with selected north African countries delineated in the north.* The domestic ruminant (bovine, ovine and caprine) density (animal per km^2) is shown on a green (low density) to red (high density) colour scale. Outbreaks of Bluetongue (BT) and African horse sickness (AHS) reported to the OIE between 2006 and 2012 are shown per depicted country. Labelled countries with no depicted AHS and BT values did not report the respective diseases for that time period.

Reporting of the disease

All SADC countries are members of the World Organisation for Animal Health (OIE), and this membership requires reporting of OIE listed diseases via the organisation to all the member countries[1]. The OIE terrestrial animal health code specifies criteria for the immediate notification of the listed diseases as well as the criteria for the 6-monthly reporting of listed diseases occuring in the country, which do not meet the criteria of immediate notifications. It is plausible that diseases and endemic diseases, with a low socio-economic impact, are underreported. A regional subset of data for the reporting of BT and AHS was obtained from the OIE's World Animal Health Information Database (WAHID)[2] for the 7 year period 2006-2012. Given that BT and AHS are endemic diseases in Southern Africa, it is clear that there is an underreporting for both of them (Figure 1) in parts of the region. One exception is represented by the reporting of AHS in South Africa, as in this country AHS is an important trade sensitive disease as will be discussed below.

Local scale impact

Bluetongue

The local scale impact of BT can be measured by the direct impact of the disease during both endemic and epidemic cycles. These measurements include

[1] World Organisation for Animal Health (OIE) 2014. Notification of diseases, infections and infestations, and provision of epidemiological information. OIE Terrestrial Animal Health Code. (www.oie.int, accessed on 15 October 2014).

[2] http://www.oie.int/wahis_2/public/wahid.php.

morbidity and mortality rates. In the majority of Southern Africa regions, endemic Bluetongue may not be considered clinically significant to farmers, because they are more familiar with the disease. This might lead to an underestimation of the costs of the disease, especially when considering that in dairy farming BT can significantly influence production (Barnard *et al.* 1998).

However, areas with seasonal epidemic desease, as in the more dry and temperate sub-tropical climates found in the Central to South-Western parts of southern Africa, can result in stock loss in the outbreak period, and mortality in susceptible sheep can range between 2-30% (Verwoerd and Erasmus 2004). The direct consequences of BT outbreaks, particularly in sheep, are wool quality loss and musculoskeletal changes after infection, which all play a role in the impact of the disease (Verwoerd and Erasmus 2004). Southern Africa also has larger populations of indigent owned small livestock and in these communities the low mortality rates have a significant social and economic impact. Nevertheless, indigenous livestock species are less likely to be affected by the disease (Verwoerd and Erasmus 2004).

An evaluation of BT outbreak reports to the OIE between 2006 and 2012 in the top 3 countries of the Southern African region (South Africa, Lesotho and Namibia) (Figure 1) showed that over 8,100 cases were reported with an associated death of approximately 1,900 animals (sheep, goats, and bovines). South Africa is listed as one of the most economically affected country by BT globally (measured by livestock units lost), based on the losses to the OIE between 2006 and 2009 (Sperling 2011).

One of the direct measurable economic impacts of BT on a local scale is the cost and the management of animal vaccination for control and prevention of the disease. The multivalent Onderstepoort Biological Products (OBP) vaccine is widely used in Southern Africa. This vaccine is given in 3 doses consisting of 15 serotypes of attenuated BT field strains. However, the use of this vaccine has some constraints: the correct managing and the administration of 3 doses with 3 weeks inter dose intervals coupled with ram and pregnant ewe considerations can make it an unattractive option (Erasmus 2013). There is also a risk of teratogenicity, viral reassortment, and vaccine strain reversion to virulence (Dungu *et al.* 2004). In 2004, it was reported that on average 9 million doses of the vaccine were sold per year in the decade prior to 2002. Eight million of these doses were sold per year in South Africa (Dungu *et al.* 2004). This sales trend has decreased slightly with an average of 6.6 million doses sold yearly in South Africa between 2005 and 2013 (J. Modumo, personal communication). The economic impact based on vaccine sales in South Africa amounts to approximately $2 million per year for farmers. Assuming a relatively stable sheep population in South Africa, this coverage amounts to approximately 25% of the population.

African horse sickness

Endemic and epidemic status of AHS, unlike BT, does not influence the local impact of the disease. Mortality is higher and the individual horse worth is significantly higher compared to small stock, meaning that even few deaths have an impact on both commercial and communal farmers.

Among the Southern African countries, South Africa reported the highest level of outbreaks for AHS to the OIE between 2005 and 2012 (Figure 1), with 1852 outbreaks reported. An evaluation of disease data submitted by South African provinces to the central competent veterinary authority has been assessed[3], and between 1993 and 2013 (21 years) a yearly average of 375 cases and 196 deaths associated with AHS was reported. While the average horse value is not known for each region, conservative estimates would probably value this loss at approximately $500,000 per annum. This is certainly conservative, since reporting of cases relies on passive surveillance, particularly in the AHS infected area of South Africa, which contains the majority of the equine population. Reporting of cases from the infected area in South Africa will generally only include the formal sector, where clients can afford veterinary care and definitive diagnosis. The impacts of AHS outbreaks are also dependent on where they occur. For example in South Africa, where specific AHS control zones are reported to be free of disease, the potential trade impact of these incursions is high. The control response and outbreak management effort in these cases is proportionally higher compared to control zones where outbreaks of disease occur regularly.

Unfortunately the economic impact of AHS, unlike BT, is sometimes difficult to quantify. Indigent communities experiencing AHS outbreaks in Southern Africa lose the animal when death occurs as well as the means for transport and the animal work ability (Grewar *et al.* 2013).

Regional scale impact

Regional scale economic impact in Southern Africa of orbiviruses is linked directly to the movement (and constraint thereof) of animals. A review of a sample of Southern African inter-country movement permits of both livestock and livestock products in

[3] www.daff.gov.za.

relation to BT did not reveal examples of BT specific constraints to trade. In comparison, foot and mouth disease prompts much higher constraints to trade and it is named specifically in import permits. However, general clauses, often requiring freedom from all OIE listed diseases, remain in many import permits in the Southern African region. While it is not often possible to be prescriptive over every disease of interest, countries must be clear in what they expect from an exporting country. To the best of our knowledge, currently there are no BT free zones within the Southern African region.

The regional economic impact of orbiviruses in the Southern African region was found to be most evident with AHS control in South Africa. In this country, AHS control zones with varying AHS infection status and vaccination requirements are defined by the central veterinary authority[4] and pre-movement authorisation is required when horses are moved to a zone with a higher level of control. This was primarily initiated to facilitate the direct export of horses from this country to the European Union (EU) from a defined free zone (Bosman *et al.* 1995). While it is difficult to estimate the actual economic impact of this regional movement control, the general impact is on the private equine sector (through vaccination, testing, and registration as movement requirements) and the government sector (through staff utilisation and the logistics involved in maintaining control of movements).

Between 2010 and 2013 an average of 3000 horses per annum has been moved between AHS control zones in South Africa, where pre-notification of movement was required with the relevant veterinary checks and vaccination requirements. For these movements, a conservative estimate of $200 000 per annum can be attributed to the cost of zoning. This impact is offset by the positive flow of income into the country through the export of horses.

Global scale impact

The global scale impact of BT and AHS is intimately linked to the movement of animals and animal products. In the section below, unless otherwise specified, all references to trade market value, quantities, and proportions have been made using data sourced from Trade Map, International Trade Centre[5] and the United Nations Commodity Trade Statistics Database (UNCOMTRADE)[6].

Bluetongue

Some authors have generally stated that BT-free countries use BT to constrain small stock trade (Mogajane 2004, Tabachnick 2010). While this may be true for exporting Southern African countries, there are many other more important internal factors within African industry and government structures which negatively influence trade. Examples of these include non-sanitary factors, such as customs tariffs, inappropriate trade legislation, inadequate holding, and transport infrastructure. There is also a lack of organisation of stakeholders in various animal production systems (Mankor 2013).

To establish the impact of BT on Southern African countries, it is important to evaluate what role this region has in the African and global trade market. Africa's export of live small ruminants is dominated in the North East by countries in the horn of Africa (Ethiopia and Somalia) as well as Sudan, with robust markets within the region and also access to Gulf state markets (Aklilu and Catley 2010). East African countries account for approximately 85% of Africa's small stock live export value, while Southern African countries only contribute 5%. Given that Africa only accounts for approximately 28% of the live small stock export value globally (global average of approximately $1.5 billion per year between 2009 and 2013), the market in Southern Africa which could theoretically be impacted by BT is currently relatively small. The value of live bovine exports from the African region is even smaller on a global scale (compared to the one of live small stock), with African countries contributing only 4% of the global trade market, which has had a global average of almost $8 billion per year between 2009 and 2013. This includes African intra-continental trade, which forms a large part of the African contribution. Southern African countries for instance contribute a third of the African live bovine trade. However, during this period only Namibia (which is the largest contributor, with 87% of southern Africa trade value and 28% of Africa's trade value) exported 96% of its value across its border to South Africa.

Ruminant semen is another product on which BT can have an impact in a global trade sense. The OIE Terrestrial Animal Health Code has recommendations for the ruminants semen importation[7] from BT infected areas. These import recommendations could only have a real impact on South Africa and Tanzania, where between 2009 and 2013, these countries contributed 77% and 22%, respectively

[4] South African Government 1984. Animal Diseases Act: Act No. 35 of 1984, Pretoria.

[5] ITC www.intracen.org/marketanalysis.

[6] http://comtrade.un.org/.

[7] World Organisation for Animal Health (OIE) 2014. Bluetongue. OIE Terrestrial Animal Health Code (www.oie.int, accessed on 15 October 2014).

to the Southern African region's total export trade value for bovine semen, which has averaged just over $630,000 per annum. Southern Africa, in a similar trend to its contribution to the global ruminant livestock export market, plays a small role in the global bovine semen export market, which is mainly dominated by the United States and Canada. Southern Africa has contributed less than 0.5% to the global trade in bovine semen, but in contrast to the small stock export trade from Africa, Southern Africa plays a much bigger role on a continental scale. In fact, 94% of bovine semen exports from Africa between 2009 and 2013 originated from Southern Africa.

African horse sickness

The impact of AHS from a global trade perspective with regards to the Southern African region is most important for the South African export of live horses to Europe. Trade data for live horses, asses, mules, and hinnies [Harmonised System code (HS) 0101] was evaluated and an assumption is made that this trade primarily involved horses. The formalisation of equine EU import requirements occurred in January 1997, with the publication of the European Commission Decision 97/10/EC, which laid out the details regarding temporary admission and imports of registered horses from South Africa into the Community. It was in this decision where reference was made to specific zones of the Western Cape of South Africa, including the AHS surveillance zone and the AHS free zone as discussed by Bosman and colleagues (Bosman *et al.* 1995). While changes have been made over time to the requirements (97/10/EC was codified and repealed by the European

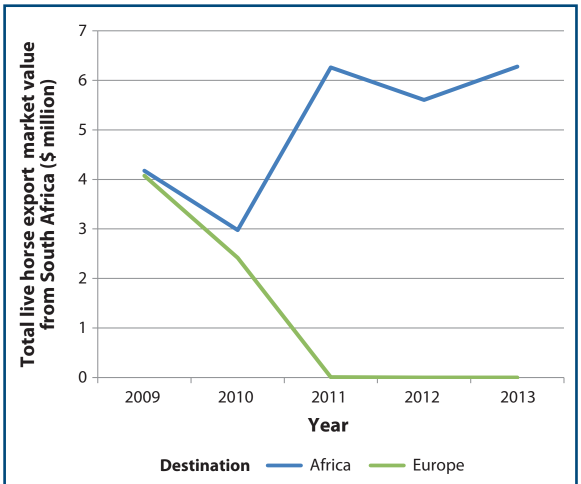

Figure 2. *Total value (in $ millions) of exported horses from South Africa per annum to African (blue line) and European (green line) destinations.* Data source: Trade Map, International Trade Centre, www.intracen.org/marketanalysis and United Nations Commodity Trade Statistics Database, http://comtrade.un.org/.

Commission Decision 2008/698/EC), the impact of African horse sickness on live horses export has been extensive. Between January 1997 and October 2014, direct exports have only been viable from South Africa to Europe for 54% of the time period. The periods of inactivity were a direct consequence of AHS outbreaks in the AHS control zones of South Africa in 1999, 2004, 2006, and 2011. These zones were set up for the primary purpose of export (Bosman *et al.* 1995) and long periods of export suspension lead to a loss of institutional memory (both in government and industry) with regards to requirements pertaining to the zones. The suspension of export activities also undermines the reason and motivation to maintain monitoring and control systems. This is partly evidenced through conclusions made during European Commission evaluations of animal health controls to export equidae from South Africa to the EU[8,9].

Between 2011 and 2013, the average exported value of live horses from Southern Africa amounted to $6.7 million per annum, with South Africa being the major component of exports with an average of 92% of the export share over that time period. While direct exports were still open from South Africa's AHS free zone before 2011, the export value from South Africa to other African countries was equivalent to that from South Africa to European destinations. Between 2009 and 2010 approximately half of the live equine export value from South Africa had African destinations and half European destinations. The 2011 AHS outbreak in the Western Cape Province near the AHS free zone had a distinct impact for export market distribution. From 2011 onwards, the direct export to European markets came to a standstill. However, the export value from South Africa to African destinations increased to an average of 98% of the export market value between 2011 and 2013 (Figure 2).

Following the 2011 AHS outbreak, there has been a significant increase in the number of live horses exported from South Africa (the surveillance zone) to Mauritius, which increased significantly by 65% between the 2009 and 2010, compared to the 2011 and 2013 period. The Mauritius statistics show that this country is being used as a stepping stone to other markets outside of Africa, in particular

[8] European Commission: Health and Consumers Directorate-General 2005. Final report of a mission carried out in the Republic of South Africa from 28 February to 7 March 2005 in order to evaluate animal health controls, in particular over Foot and Mouth disease and African horse sickness, public health control systems for fresh meat and wild game meat and certification procedures. [DG(SANCO)/7605/2005].

[9] European Commission: Health and Consumers Directorate-General 2013. Final report of an audit carried out in South Africa from 20 to 29 May 2013 in order to evaluate the animal health controls in place in relation to export of equidae to the EU, with particular reference to African horse sickness. [DG(SANCO) 2013-6936].

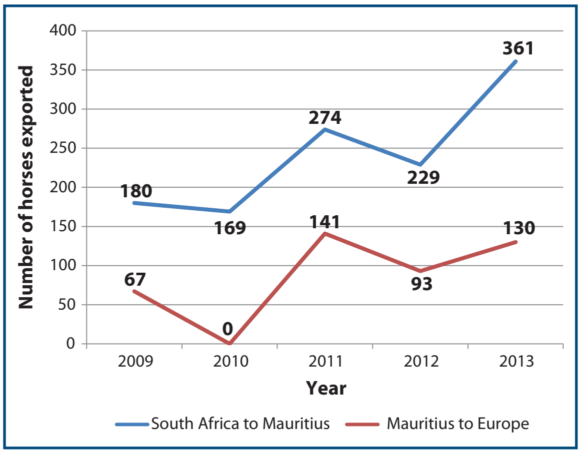

Figure 3. *Number of live horses exported between 2009 and 2013 from South Africa to Mauritius (blue line) and exported from Mauritius to countries in Europe (red line).* Data source: Trade Map, International Trade Centre, www.intracen.org/marketanalysis and United Nations Commodity Trade Statistics Database, http://comtrade.un.org/.

in European countries. The raise in exports of live horses from South Africa is mirrored by the increase from Mauritius to Europe (Figure 3).

Conclusion

Southern Africa is generally endemic for BT and AHS and these two diseases have enough socio-economic impact on the local and regional economy to stimulate much research into understanding their epidemiology and ways of controlling and preventing their occurrence. The local impact of BT is influenced by the fact that this is an endemic disease in much of Southern Africa. It is clinically difficult, particularly in cattle, to detect and report new cases in passive surveillance systems, because the occurrence of BT may not be considered clinically significant to farmers. Vaccination measures associated with preventive local economic factors of AHS and BT generally have a high economic impact and are complicated by the multiple serotypes associated with these diseases. In both cases, multiple inoculations per season are required. This creates challenges in maintaining vaccine coverage and compliance, where applicable. Where this lack of coverage spans multiple seasons, the disease resilience of the domestic ruminant and equine populations decreases, making the local impact of the invariable outbreaks more significant than they would otherwise be.

The regional and global economic impact of AHS and BT in Southern Africa is linked to the movement of animals, either within country (as in the case of AHS control zones in South Africa) or globally. Bluetongue's economic impact regionally and globally is diminished in Southern Africa due to the small contribution that this region makes to ruminant trade. Wildlife trade has not been assessed in this paper and there are certainly pre-export BT control and testing requirements for ruminant wildlife. However, given the greater value in individual wildlife compared to domestic livestock, the requirements for wildlife pre-export with regards to BT are not going to influence significantly this trade. This paper has briefly evaluated the past impact of AHS in the Southern African region, but unless constant and concerted efforts are made to ensure the maintenance of viable and sustainable import and export routes within the region for horses, the occurrence of this disease will continue to put future equine events in Southern Africa on hold and prevent the growth of this industry in the region.

With BT and AHS being present in Southern Africa for many decades, the research focus of academic institutions in this region have included various aspects of these diseases. Globally this research has given AHS and BT free regions and countries the opportunity to make scientifically orientated decisions regarding orbiviral diseases and their control. This has led to an improved economic situation for these countries, given that risk based trade can occur and be improved with our expanding knowledge of orbiviruses.

Acknowledgements

Thanks to Dr. Lesley van Helden and Dr. Marna Sinclair (Western Cape Department of Agriculture, Veterinary Services) for their kind suggestions and comments on this manuscript.

References

Aklilu Y. & Catley A. 2010. Livestock exports from the Horn of Africa: an analysis of benefits by Pastoralist Wealth Group and policy implications. Feinstein International Center, Tufts University, Medford, USA.

Barnard B.J.H. 1997. Antibodies against some viruses of domestic animals in southern African wild animals. *Onderstepoort J Vet*, **64**, 95-110.

Barnard B.J.H., Gerdes G.H. & Meiswinkel R. 1998. Some epidemiological and economic aspects of a bluetongue-like disease in cattle in South Africa - 1995/96 and 1997. *Onderstepoort J Vet*, **65**, 145-151.

Baylis M., Meiswinkel R. & Venter G.J. 1999. A preliminary attempt to use climate data and satellite imagery to model the abundance and distribution of *Culicoides imicola* (Diptera: Ceratopogonidae) in southern Africa. *J S Afr Vet Assoc*, **70**, 80-89.

Bosman P., Bruckner G.K. & Faul A. 1995. African horse sickness surveillance systems and regionalisation/zoning: the case of South Africa. *Rev Sci Tech OIE*, **14**, 645-653.

Coetzer J.A.W. & Guthrie A.J. 2004. African horse sickness. *In* Infectious diseases of livestock, 2nd Ed. (J.A.W. Coetzer & R.C. Tustin, eds), Oxford University Press, Cape Town, 1231-1246.

Dungu B., Gerdes T. & Smit T. 2004. The use of vaccination in the control of bluetongue in southern Africa. *Vet Ital*, **40**, 616-622.

Erasmus B.J. 2013. Beheer bloutong in skape. *Veeplaas*, **4**, 86-89.

Grewar J.D., Weyer C.T., Guthrie A.J., Koen P., Davey S., Quan M., Visser D., Russouw E. & Bührmann G. 2013. The 2011 outbreak of African horse sickness in the African horse sickness controlled area in South Africa. *J S Afr Vet Assoc*, **84**, 1-7.

MacLachlan N.J. 2011. Bluetongue: history, global epidemiology, and pathogenesis. *Prev Vet Med*, **102**, 107-111.

Mankor A. 2013. Promoting intra-Africa trade in animals and animal products. *In* Proc. 20th Conference of the OIE Regional Commission for Africa, Lomé, Togo, 18-22 February 2013. OIE, 1-6.

Meiswinkel R., Venter G.J. & Nevill E.M. 2004. Vectors: *Culicoides* spp. *In* Infectious diseases of livestock, 2nd Ed. (J.A.W. Coetzer & R.C. Tustin, eds), Oxford University Press, Cape Town, 93-136.

Mogajane M.E. 2004. Trade implications of bluetongue in Africa. *Vet Ital*, **40**, 691-692.

Peel M.C., Finlayson B.L. & McMahon T.A. 2007. Updated world map of the Köppen-Geiger climate classification. *Hydrol Earth Syst Sc*, **4**, 439-473.

Robinson T.P., Wint G.R.W., Conchedda G., Van Boeckel T.P., Ercoli V., Palamara E., Cinardi G., D'Aietti L., Hay S.I. & Gilbert M. 2014. Mapping the global distribution of livestock. *PLoS ONE*, **9**, e96084.

Sperling U. 2011. World livestock disease atlas. A quantitative analysis of global animal health data (2006-2009). Agriculture and Rural Development (ARD), Washington, D.C., USA.

Tabachnick W.J. 2010. Challenges in predicting climate and environmental effects on vector-borne disease episystems in a changing world. *J Exp Biol*, **213**, 946-954.

Theiler A. 1921. African horsesickness (Pestis Equorum). *Union of South Africa, Department of Agriculture Science Bulletin*, **19**, 1-29.

Venter G.J., Nevill E.M. & Van der Linde T.C. 1996. Geographical distribution and relative abundance of stock-associated *Culicoides* species (Diptera: Ceratopogonidae) in southern Africa in relation to their potential as viral vectors. *Onderstepoort J Vet*, **63**, 25-38.

Verwoerd D.W. & Erasmus B.J. 2004. Bluetongue. *In* Infectious diseases of livestock, 2nd Ed. (J.A.W. Coetzer & R.C. Tustin, eds), Oxford University Press, Cape Town, 1201-1220.