Epidemiology of Bluetongue in Ethiopia: A review

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Abstract: Bluetongue is an infectious and non-contagious arthropod borne viral disease of domestic and wild ruminants, it is usually considered to be a disease of improved breeds of sheep, specially the fine-wool and mutton breeds. The disease derives its name from its mechanism of action to produce the disease that results in cyanotic or bluetongue. The disease was first described in the Cape Colony of southern Africa but now the virus has now been isolated on all continents except Antarctica. The distribution and intensity of BTV infection in regions of the continents is determined by climate, geography and altitude, presence *Culicoides* vectors and susceptible mammalian hosts. Recently, the global distribution and nature of BTV infection has changed significantly and climate change has been considered as a potential cause of this dramatic event observed globally. In line with global change in the distribution and infection of BTV, seo-prevalence studies made in different parts of Ethiopia showed the presence of circulating antibodies of BTV in each agro-ecological zone. Although there were no reported clinical case of BT in the country, results of a few studies made on the disease showed a trend of increasing sero-prevalence of circulating antibodies. The increase in seroprevalence of circulating antibodies may result in severe infection and high mortality if susceptible animals to the disease are introduced into or exposed to circulating antibodies. Sero-prevalence studies that were carried out regarding the disease in the country focused only on small ruminants and did not consider the situation in other host animals susceptible to the disease, the distribution and species of vectors responsible for the transmission of the disease and serotype (s) of the virus responsible for circulating antibodies were not determined. Moreover, studies made on the epidemiology of BT did not include all agro-ecological zones in all regions of the country. In general to fill the gaps of information in the disease epidemiology in Ethiopia, surveillance system and studies made on BTV infection should be extended so as to include other susceptible ruminant hosts and to study the distribution of insect vectors and should take in to account each agro-ecological zones of the country to better predict the situation of the disease in the future.
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1. Introduction

Bluetongue (BT) is an infectious and non-contagious arthropod borne viral disease of domestic and wild ruminants such as sheep, goat, cattle, camels, llamas, deer and antelopes. BT primarily affects sheep and deer, but subclinical diseases are present in cattle, goat and wild ruminants. Bluetongue is usually considered to be a disease of improved breeds of sheep, specially the fine-wool and mutton breeds (Merck, 2014).

Bluetongue derives its name from its mechanism of action to produce the disease that is mainly cell injury and necrosis that leads to vascular thrombosis, edema and hemorrhage which can result in cyanotic or bluetongue (Morphy *et al*., 2011).

The disease was first described in the Cape Colony of southern Africa after merino sheep breed were introduced into the region in the late 18th century, and was subsequently recognized in other parts of Africa, Europe, the Middle East, Indian subcontinent, America and Asia (Hofman *et al*., 2008) and the virus has now a day been isolated on all continents except Antarctica.

The distribution and intensity of BTV infection in regions of the continents is determined by climate, geography and altitude, as these affect the occurrence and activity of the *Culicoides* vectors, and by the presence of susceptible mammalian hosts. There is a gradation from con-tinuous BTV activity in tropical areas to absence of the viral transmission in colder areas of the world. In large countries that span different latitudes, such as the United States of America and Australia, there are areas that are free of infection (Radostits *et al*., 2006).

Recently, the global distribution and nature of BTV infection has been changing significantly. Climate change has been considered as a potential cause of this dramatic event observed globally.

Bluetongue infection is considered to be one of the major unsolved veterinary problems in certain breeds of sheep (Merck, 2014) as a result, a lot of research efforts have been made to facilitate rapid molecular detection and differentiation of Bluetongue Virus and BTV- related viruses in susceptible ruminants in many parts of the World, however, very little information is available about the epidemiology of Bluetongue Virus in East Africa including Ethiopia (Aradaib *et al*., 2005). In Ethiopia only a few studies have been made regarding BT and because of this all regions in the country have very little information about the disease and are not well aware of it. Therefore, the objectives of this review article are: to review the epidemiological status of Bluetongue in Ethiopia and to assess gaps on the studies made so far on the epidemiology of Bluetongue in the country.

2. Literature Review

2.1 History of Bluetongue

Bluetongue was first recorded at the end of the 18th century in South Africa after an import of fine wool sheep from Europe. It was first referred to as fever, malarial catarrhal fever of sheep or epizootic malignant catarrhal fever of sheep (Maclachlan *et al*., 2009).

The first well-documented epizootic of BT outside African countries occurred amongst sheep on Cyprus in 1943 (Worwa, 2009), although the disease had likely occurred there starting from at least 1924. BT was recognized thereafter in the United States of America, the Middle East, Asia and southern Europe. The increased recognition of BT in widely separated regions of the world in the middle of the 20th century was interpreted at the time to reflect the emergence of BT from its presumed ancestral origin in Africa particularly the southern Africa (Verwoerd and Erasmus, 2004).

The virus has currently been spread to North America and China, the disease has been detected up to 50°N. Since 1998 there has been a dramatic change in the distribution of BT, with the disease having spread into countries of north-western Europe and Scandinavia (Saegerman *et al*., 2011). It recently spread northward from the Caribbean Basin to invade the southeastern United States, in areas where it did not previously occur and to northern Australia (Johnson *et al*., 2012).

2.2 Etiology

BTV is the causative agent of BT, an insect transmitted disease of domestic and wild ruminants. BTV belongs to the family Reoviridae of the Genus *Orbivirus*. It has a double stranded RNA with 10 segments. The viral RNA codes for 3 non-structure proteins and 7 structure proteins (VP1–VP7). The virus has actually 26 serotypes that show no cross protectivity (Maan *et al*., 2012a). There is considerable genetic variability within the 26 serotypes. This arises mainly due to genetic drift of individual gene segment as well as by re-assortment of gene segment when host ruminants or the vectors are infected with more than one strain. There is also debate of the biological validity of the classification of BTV into strict types and all the 26 identified serotypes do not exist in any one infected area of the world (Radostits *et al*., 2006).

2.3 Epidemiology

2.3.1 Species Affected

All ruminants are susceptible to infection with bluetongue, but clinical disease is most often manifested in sheep; a serious disease also develops in white-tailed deer (*Odocoileus virginianus*) (Johnson *et al*., 2006). Cattle play an important role in the epidemiology of BTV mainly because of prolonged viraemia and subclinical course that they exhibit (Howerth *et al*., 2001). However, in the epidemics caused by BTV-8 serotype in Western and Central Europe, even cattle showed clinical disease (Elbers *et al*., 2008). It can also affect African antelopes, other wild ruminants, camelids and elephants (Elbers *et al*., 2008 and Henrich *et al*., 2007). The disease can also be transmitted to carnivores. For instance, Bluetongue has been reported in dogs following the use of BTV-contaminated vaccines (Evermann, 2008).

2.3.2 Geographic Distribution of Bluetongue Virus and Vectors

Bluetongue virus is found distributed worldwide within tropical and subtropical climates from approximately 35° S to 40° N and in some areas outside of this region (in parts of California). Endemic areas to the disease exist in Africa, Europe, the Middle East, North and South America and Asia, as well as on numerous islands such as Australia, the South Pacific and Caribbean. Outbreaks can occur outside endemic areas, but mostly the virus does not persist once cold weather kills the *Culicoides* vectors. However, in unusual circumstances, a serotype–8 virus overwintered for many years in both central and northern Europe (Howerth *et al*., 2001).

In the "Old World" the species *Culicoides imicola,* the most widely spread midge on the globe, is responsible for the transmission of the disease to susceptible ruminant hosts and regarded as the major BTV vector. The vector shows the highest activity at a temperature that ranges from 13°C to 35°C. It reproduces in damp or wet soils fertilized with manure and feeds on host animals such as cattle, sheep and horses (Mellor *et al*., 2002).

The C*ulicoides imicola* has been found in Africa, south of Asia, Portugal, Spain, Greece, Cyprus, Corsica, Italy, Israel, Turkey, Yemen, Oman and Jizan and Najran, district to horn Africa such as Ethiopia,

Eretria, Djibouti, Somalia and Sudan where the enzootic nature of BTV is larger in region of Africa, five serotypes namely serotypes 1, 2, 4, 5 and16) were identified in Sudan (Aradaib *et al*., 2005).

2.3.3 Epidemiology of Bluetongue in Ethiopia

The occurrence of precipitating antibodies to bluetongue virus in Ethiopia was first reported by (Woldemeskel *et al*., 2000) using c-ELISA in sheep sera collected from different agro-climatic areas and the study result revealed about 46.67% prevalence rate. The finding showed that there was significant variation among different agro-ecological zones, the infection rate being highest in sheep from low altitude areas and lowest among those sheep from the high altitude. The low prevalence in circulating antibodies in the highland areas might be due to the absence of *Culicoides* vector as the environment might not be suitable for its survival. Their finding also indicated that there was difference in prevalence of BT among the two breeds of sheep being higher in indigenous breed when compared to Awassi cross Menz. The finding of the study result is shown in the table 1 below.

Table 1: Prevalence of Bluetongue antibodies in Sheep from different altitudes in Ethiopia

Altitude	**Examined animals**	**Positive animals**	**Percentage**
Low altitude			
Male	5	5	100
Female	9	8	88.89
Total	**14**	**13**	**92.85**
Mid altitude			
Male	17	8	18
Female	28	18	64.28
Total	**45**	**26**	**57.78**
High altitude			
Male	0	0	0
Female	31	3	9.67
Total	**31**	**3**	**9.67**
Total	**90**	**42**	**46.67**

Source: (Woldemeskel *et al*., 2000)

The antibody of BVT was also confirmed in small ruminants from Wolaiyta Zone of southern Ethiopia and the result showed about 41.17% seroprevalece (Yilma and Mekonnen, 2015). Their finding revealed that age was one of the risk factors for the occurrence of the disease showing a prevalence rate of 26.1% and 73.9% in pre weaning age of less than three months and in weaning age of less than three months respectively as shown in the table 2 below. The logic behind this finding might be due to the fact that the later age group has high probability of being exposed to vectors of the disease when compared to the former age group. They also indicated in their study that agro-ecology was one of the risk factors for sero-positivity of small ruminants and to be infected by BTV and being higher (61.28%) in Humbo (lowland) than D/Sore (21.58%) in areas representing the highland in their study and their finding was in agreement with the finding of the previous researcher in the country (Woldemeskel *et al*., 2000) who reported higher prevalence of circulating antibodies of BTV in the lowland area when compared to the highland area. According to their study result, there was difference in sero-positivity between the two species of animals studied being higher in *Caprine* (54%) than in *Ovine* (30.9%) and they found the association to be significant.

Table 2: Risk factors associated with Bluetongue virus infection in Wolaiyta Zone

Risk factor	Num of tested animals	ELISA positive	Sero-prevalence	X^2
Sex				
Male	116	48	42.4	0.003NS
Female	360	148	41.1	
Age				
Pre weaning age of < 3 month	124	38	26.1	
Weaned age of > 3 month	352	158	73.9	7.7678**
BCS				
Emaciated	87	44	50.6	
Medium	298	100	33.6	19.893***
Good	91	52	57.1	
Location				
Humbo	235	144	61.2	59.001***
D/sore	241	52	21.58	
Species				
Goat	211	114	54	23.974***
Sheep	265	82	30.9	

***P, 0.001; **P, 0.01; NS-P >0.05

Source: (Yilma and Mekonnen, 2015)

Recently, antibodies of bluetongue virus were detected in different part of Ethiopia by (Daniel *et al*., 2016) and their finding indicated an overall seroprevalence of bluetongue to be 65.2% as shown in the table 3 below. They found higher seroprevalence in local breeds (72.13%) when compared to cross breed animals (59.32%) although the result signified that breed was not found to be risk factor for the circulating antibodies. However, they found that age, sex and species are among the risk factors for the seroprevalence of bluetongue in the study areas indicating higher seroprevalence (67.3%) in adult animals (> 1 year) than in young animals (< 1 year) that are with seroprevalence of 60.8%. Moreover, they found higher seroprevalence in sheep (69%) than in goats (60.53%) although this finding was not in line with the finding of (Yilma and Mekonnen, 2015) who reported higher prevalence in goats than in sheep during their study at Wolaiyta Zone of southern Ethiopia.

Table 3: Seroprevalence of Bluetonge in selected areas of Ethiopia

Centers or site	No. of tested	No. positive	Percentage
Adamitulu	241	57	23.65
Ambara	354	266	75.14
Areka	144	70	48.61
Arsi Negelle	50	34	68.00
Bene tsemay	70	64	91.43
Doyo Gena	76	52	68.42
G/Mekeda	30	24	80.00
Fafan	280	205	73.21
Jinka	175	154	88.00
Total	**1420**	**926**	**65.21**

Source: (Daniel *et al*., 2016)

Results of seroprevalence studies made in different parts of the country revealed the presence of circulating antibodies of BTV in each agro-ecological zone with varying percentage rate. The presence of antibodies in small ruminants in the studies made in the country indicated that the virus was found circulating in small ruminant population in the study areas. Study results showed that altitude, distribution of the *Culicoides* vector and age of study animals showed as a risk factor for the occurrence of circulating antibodies in the country. The finding also revealed that there is a trend of increasing

seroprevalence of circulating antibodies in the country. The increase in seroprevalence of circulating antibodies may result in severe infection and high mortality if exotic breeds and their crosses are introduced or exposed in to circulating antibodies. The three studies made and assessed in this article review indicated that studies carried out was only on small ruminants and did not incorporate the situation in cattle and other domestic animals and wildlife that could be susceptible to the disease. Moreover, the studies conducted in the country did not clearly indicate the distribution and density of the *Culicoides* vectors, the serotypes of the virus responsible for the presence of circulating antibodies and did not include all the agro-ecological zones in all regions of the country to know the real distribution and epidemiology of the disease.

2.3.4 Modes Transmission

Bluetongue is almost always transmitted by biting midges of the genus *Culicoides* and therefore outbreaks depend on the competent insect vectors, virus pathogen and susceptible ruminant hosts. The genus *Culicoides* recently includes 1300 to 1400 species, but out of this only about 30 of them act as vectors for BTV (Meiswinkel *et al*., 2004) and they are most frequently present in warm, damp and muddy areas that are rich in organic matter and plentiful in animal hosts on which they can feed on. They are most active during one hour before sunset until one hour after sunrise (Mellor *et al*., 2002).

The genus *Culicoides* consists of very small flies that 'bite midges' and haematophagous insects. They are infected with BTV after ingesting blood from infected animal hosts. Without the presence of the vector, the disease cannot spread from infected to susceptible host animals (Anonymous, 2013). Female *Culicoides* feeds on mammals (including humans) and birds. The insect vector ingests blood at intervals of three to four days, if available, as they need it for egg deposition. They have a painful bite and can cause irritation and annoyance to animals. The main parts of animals that are attacked by the vectors are the head and the neck. Their biting has been resulted in a hypersensitivity reaction (Koenraadt *et al*., 2014).

In addition to biting midges, BTV has been isolated from some arthropods such as sheep ked (*Melophagus ovinus*) or some species of ticks (Bouwknegt *et al*., 2010) and mosquitoes. However, these are mechanical vectors with only a negligible role in disease epidemiology. Bull semen can also transfer the virus, but it can be infected only when the bull is at the state of viraemia and when semen contains red or white blood cells with which the virus is associated (Bouwknegt *et al*., 2010). The passage of BTV across the placenta is another means of transmission. It has been recorded in cattle (Lewerin *et al*., 2010; Santman-Berends *et al*., 2010) sheep and in dogs (Saegerman *et al*., 2011).

Recently, unique route of transmission was described in ruminants. This involved ingestion of the placenta of a BTV-infected bovine fetus (Menzies *et al*., 2008). Transmission with colostrums has also been reported (Mayo *et al*., 2010). Bluetongue can also be spread by live attenuated vaccines against BTV, or even by vaccines against other antigens contaminated with BTV (Evermann, 2008).

2.3.5 Overwintering

The survival of the virus from one "vector season" to the next season is called "overwintering", but the mechanism involved in this situation is still poorly understood. However, BTV can survive in the absence of adult vectors for 9 to 12 months of cold weather in an infected host with no detectable viraemia, disease or sero-conversion (Takamatsu *et al*., 2003; Osmani *et al*., 2006; Wilson *et al*., 2007). One way by which overwintering may be achieved is by the infection of adult vectors (Wilson *et al*., 2008). Although the average life span of the virus is usually 10 to 20 days, they can occasionally live for up to 3 months (Lysyk and Danyk, 2007). This suggests that under favorable conditions some biting midges can live long enough to survive the period between two vector seasons (Wilson *et al*., 2008).

BTV survives at different stages of the *Culicoides* life cycle and overwinter in cattle owing to prolonged BTV viremia, that can occasionally last up to 100 days, another mechanism suggested for BTV overwintering is trans-placental infection (Lewerin *et al*., 2010; Santman-Berends., 2010; Backx *et al*., 2009). Pregnancy period in cattle is long enough for BTV to survive during a period free of competent insect vectors (Wilson *et al*., 2008).

Mechanical vectors may also be involved in virus overwintering; the virus has been isolated from sheep ked and some tick species, which are arthropod species living much longer than *Culicoides* midges. Mechanical vectors should therefore be considered as potential reservoirs for BTV and its transmission to susceptible host animals (Wilson *et al*., 2008; Bouwknegt *et al*., 2010).

2.3.6 Risk Factors

Pathogen and vectors: The geographical occurrence of bluetongue serotypes varies and is changing with time. There are differences in virulence between serotypes and between strains within serotypes and virulence is also related to virus dose and dependent on vector species, distribution and competence. Different *Culicoides* species vary in susceptibility to infection and some known vectors are resistant to infection with some serotypes, which in part explains regional differences in serotype occurrence. Different *Culicoides* species have

different host preferences and some have a distinct preference for cattle and little host preference for sheep (Radostits *et al*., 2006).

Climate: Climate is a major risk factor for the occurrence of the disease as *Culicoides* require warmth and moisture for breeding and calm, warm, humid weather for feeding. A cold winter or a dry summer can highly reduce vector numbers and risk for disease. Moisture may be in the form of rivers and streams or irrigation but rainfall is the predominant influence and rainfall in the preceding months is a major determinant of infection. Precipitation affects the size and persistence of breeding sites and the availability of humid microhabitats to allow shelter from desiccation during hot summer and autumn periods. Optimal temperature requirement for the survival of adults and larvae should be sustained above a mean of 12.5°C for the cooler months and in the range of 18 to 30°C in the summer and autumn for optimum recruitment to adults and for optimal adult activity. Temperature also affects the rate of virus production in *Culicoides*. The optimal temperature for virus replication in the insect is >25^{o} C. Beneath 10–12^{o}C there is no replication of the virus in the insects (Radostits *et al*., 2006; Maclachlan, 2011).

Serotype occurrence Genetic studies indicate that BTV tends to exist in discrete, stable ecosystems and that BTV serotypes that circulate in one region of the world are largely different from those in other regions. In Africa, serotypes 1, 16, 18, 19, and 24 are the major serotypes isolated. The BTVs are stable and resistant to decomposition and to some standard virucidal agents, including sodium carbonate. However, they are sensitive to acid, inactivated below pH 6 and susceptible to 3% sodium hydroxide solution, organic iodine complex, phenol and b-propiolactone (Radostits *et al*., 2006; Anonymous, 2009a).

Host risk factors: Cattle are the reservoir and amplifying host and have a high titer viremia. Cattle appear to be much more attractive to Culicoides spp, and this may enhance the importance of cattle as carriers. A critical density of cattle in a region may be required to sustain bluetongue in regions where the *Culicoides* vector is strongly cattle associated. Bos taurus breeds are more likely to be sero-positive than Bos indicus and bulls have a greater risk for infection than females or castrated males. Seroprevalence increases with age, probably a reflection of increased duration of exposure (Jauniaux *et al*., 2008; Radostits *et al*., 2006).

2.4 All breeds of sheep are susceptible but to varying degrees. Merinos and British breeds are more susceptible than native African sheep. There are also differences in age susceptibility to clinical disease which, inexplicably, vary with different outbreaks. Exposure to solar radiation can increase the severity of the disease, as can excessive docking, shearing, poor nutrition and other forms of stress (Radostits *et al*., 2006; Merck, 2014). **Pathogenesis**

Introduction of the virus is via the bite of an infected midge, then the virus is transported by the host dendritic cells from the skin to the local lymph nodes, the sites of initial virus replication, subsequently it spreads to the blood circulation inducing a primary viremia which seeds in secondary organs such as lymph nodes, spleen and lungs (Sánchez-Cordón *et al*., 2010). The virus replicates in vascular endothelial cells, macrophages and lymphocytes (Drew *et al*., 2010). In early viremia, the virus is found associated with all blood elements, while at later stages of viremia, it exclusively associates with erythrocytes/the red blood cells. Virus particles appear to be sequestered in invaginations of the erythrocyte membrane (Maclachlan *et al*., 2009). Infection with BTV results in cell necrosis and apoptosis. In addition, it induces the production of IL-1, IL-8, IL-6, IFN-I and cyclooxygenase-2 and enhances plasma concentration of prostacyclin and thromboxane, which frequently leads to an excessive inflammatory response and subsequent damage to the cells and tissues of infected animal (Sánchez-Cordón *et al*., 2010; Chiang *et al*., 2006).

The pathogenesis of bluetongue is characterized by injury of small blood vessels in target tissues, resulting in vascular occlusion and tissue infarction. Virus-induced vasoactive mediators produced by thrombocytes, dendritic cells, macrophages and BTV-infected endothelial cells increase damage to the endothelium, interfere with its function and increase vascular permeability; this leads to the development of edema and effusions (Maclachlan *et al*., 2009; Drew *et al*., 2010a).

2.5 Clinical Signs of Bluetongue

BTVs are found widely distributed in the tropics but mostly subclinical in the indigenous ruminant populations. Clinical disease is most prevalent in domestic sheep, especially those of the European ancestry, with high mortality rates, weight loss and disruption in wool growth. In highly susceptible sheep breed, morbidity can reach as high as 100%. Mortality rate averages from 2% to 30% but can be as high as 70% (Anonymous, 2013). Cattle often have a higher infection rate than sheep and demonstration as well as severity of clinical signs varies depending on the strain of virus involved in the infection. In countries where BT is endemic sheep are often naturally resistant to BT. Cattle are often considered asymptomatic reservoir host of the virus. The effect of the disease is that it leads to a huge loss of trade due to restrictions and the costs of surveillance, health testing and vaccination for the disease (Anonymous, 2013).

In sheep the clinical symptoms are more variable. After infection sheep showed fever up to 41 ^{O}C for 7–10 days, enlargement of the lymph nodes, and depression. Sheep that suffer from severe clinical symptoms showed salivation, severe dyspnoea, asphyxia, edema, and a blue swollen tongue partly hanging out of the mouth. These sheep showed also lameness up to recumbency due to swelling and inflammation at the coronary band (Darpel *et al*., 2007; Kirschvink *et al*., 2009). In rams inflammation and petechial bleedings of the scrotum, as well as inflammation of the epididymis and degeneration of the testis was seen. Infection of pregnant ewes and cows resulted in embryonic death, abortions, stillbirth, and congenital malformations in lambs and calves (Saegerman *et al*., 2011; Wouda *et al*., 2009).

2.6 Necropsy Findings

Necropsy findings in animals affected with BT revealed subcutaneous tissues infiltrated with gelatinous fluid in the head, hemorrhages in the tunica media of the pulmonary artery or even aorta, hyperemia, or occasionally cyanosis of the oral mucosa with petechiae and ecchymosis. Erosions with coats of necrotic tissue may be present in the lips, tongue and cheeks. There may be hyperemia of the ruminal pillars and reticular folds. The spleen, lymphatic nodes and tonsils are enlarged and hemorrhagic, occasionally with petechiae. The tongue root, pericardial sac, kidney, gut (particularly at the iliocaecal junction) and subcutaneous tissues may have petechiae. (Mauroy *et al*., 2008). Animals with damage to esophageal or pharyngeal musculature may have lung consolidation due to aspiration pneumonia. Microscopically there is thrombosis and widespread micro vascular damage leading to myodegeneration and necrosis (Radostits *et al.,* 2006).

2.7 Diagnosis

A preliminary diagnosis made based on clinical signs, post-mortem findings and epidemiological assessment should be confirmed by laboratory examination. Samples to be examined in the laboratory include non-coagulated blood (Use of EDTA or heparin is preferred), serum, post-mortem tissue samples such as spleen, lymph nodes, lungs. To be transported, the serum samples should be frozen at -20^{O}C (Maclachlan *et al*., 2009).

Specific diagnosis is either by isolation of the virus, detection of viral antigen or nucleic acid, or detection of specific antibodies in serum. Serological assays can detect prior exposure to BTV but cannot establish if the animal is viremic, which is currently still important for movement decisions concerning cattle (Radostits *et al*., 2006).

2.7.1 Bluetongue Virus Isolation

BTV can be isolated from blood, semen and various other tissue samples including liver, spleen, brain, lymph nodes and mucosal epithelium. The virus can be propagated in embryonated chicken eggs (ECE), cell cultures or in sheep. Embryonated eggs, 9 to 12 days old are inoculated with the materials by intravenous route for BTV isolation. This method is 100-1000 fold more sensitive than yolk sac inoculation. The material obtained from ECE can either be further propagated in cell culture or directly examined using molecular methods (Dadhich, 2004; Biswas *et al*., 2010).

2.7.2 Antigen Identification

Sandwich ELISAs have been described for the detection of BTV antigens in infected cell cultures or adult *Culicoides* midges. Although antigen ELISAs are specific, to give a positive result, molecular assay can be used in addition to ELISA to detect and identify the viral RNA of BTV or other related viruses (Batten *et al*., 2008). A direct identification of BTV in blood or tissue samples is possible with the use of the reverse transcription-polymerase chain reaction (RT-PCR) method that allows for sero-typing and can detect BTV RNA in samples as late as 6 months after infection (Vanbinst *et al*., 2010; De Leeuw *et al*., 2015).

2.7.3 Antibody Identification

Serogroup-specific antibodies against BTV can be detected by competitive ELISAs test targeted to the VP-7 protein. This is a rapid method permitting determination of serum or plasma antibody as early as the 6th day of post-infection (Mars *et al*., 2010; Kramps *et al*., 2008).

A complement fixation test (CFT) has been used to identify BTV or to detect a rise in BTV-specific antibody titre following infection. These assays that primarily detect early antibodies, IgM, depend on inhibition of the complement-mediated lysis of activated erythrocytes by BTV antigen/antibody complexes that can also fix the available complement. However, they may only be effective for a relatively short period of time following infection and have largely been superseded by the use of the ELISA (OIE, 2014).

2.8 Differential Diagnosis

The clinical signs of bluetongue can easily be mistaken for those of other ruminant diseases such as Orf (Contagious pustular dermatitis), foot and mouth disease, acute photosensitization, acute haemonchosis (With depression and submandibular edema), *Oestrus ovis* infestation, pneumonia, plant poisoning, salmonellosis, sheep pox, Peste des Petits Ruminants (Wilson and Mellor, 2009), malignant catarrhal fever, pododermatitis and epizootic hemorrhagic disease of deer (Savini *et al*., 2005; Wilson and Mellor, 2009; Radostits *et al*., 2006).

2.9 Economic Importance

The economic losses due to bluetongue is around 3 billion US$ per year in the world. The direct losses caused by the disease include death, abortions, weight loss and reduced milk and meat productions and indirect losses are export restrictions of live animals, semen and fetal calf serum (Bitew *et al*., 2013). Major production losses in clinical young lambs are more apparent and mortality can reach up 30-70% and these include death, unthrifteness during prolonged covalence, wool break and reproductive losses. Indirect losses are associated with decrease in body weight and condition, drop in milk production and yield and poor subsequent reproduction performance were thought to have greater economic effect than occasional overt disease (Ducheyne *et al*., 2007), in addition to this there is restriction of international trade of livestock and associated gram plasm from BTV endemic countries unless the animals are certified as free of infection by convectional virus isolation or serology and such restriction could lead to economic loss for BTV endemic countries (Santman-Berends *et al*., 2013).

2.10 Prevention and Control

Symptomatic therapy includes gentle handling of affected animals, their stabling and, if indicated, administration of non-steroidal antiphlogistic drugs (Radostits *et al*., 2006; Tweedle and Mellor, 2002). An immediate ban on animal import from countries with bluetongue is the priority measure, followed by the monitoring of farms raising domestic ruminants which include clinical examination and serological and virological testing, and a monitoring of insect vectors. Prophylactic immunization and the removal of vectors or prevention of vector attacks can also be used (Tweedle and Mellor, 2002).

2.10.1 Prophylactic Immunization

Vaccination can prevent clinical bluetongue or at least mitigate its course by interrupting the BTV cycle in the environment; it thus reduces the economic losses due to animal infection and makes transfer and trading of animals from BTV enzootic regions possible (Caporale and Giovannini, 2010). Bluetongue vaccines are serotype- specific (Bhanuprakash *et al*., 2009) and therefore, before use in a given geographic area, the serotypes present in that environment should be taken into consideration. The vaccines in use for BT are of two types namely live attenuated and inactivated.

Live Attenuated Vaccines: Live attenuated vaccines were until recently the only bluetongue vaccines commercially available and were originally used in endemic situations where multiple serotypes of the virus are common (South Africa). In these regions multivalent live attenuated vaccines against the serotypes present there are still used (Giovannini *et al*., 2004). One dose of live attenuated vaccine of BT is enough to provide good protection for at least one year. Their production is inexpensive (Bhanuprakash *et al*., 2009) but they may lose efficiency at a temperature over 35°C and may provide poor protection against infection with a heterologous BTV serotype. However, there are growing concerns about the use of BTV live attenuated commercial vaccines (Veronesi *et al*., 2009) which can result in clinical signs of bluetongue, abortion, reduced milk production, temporary poor semen quality in rams and fetal malformation in pregnant ewes (Breard *et al*., 2007). Because of this, it is recommended to vaccinate ewes 9 to 15 weeks before mating and rams after the mating period, but at least 6 weeks before the beginning of the following period (Savini *et al*., 2005; Bhanuprakash *et al*., 2009).

Inactivated Vaccines: If properly produced, inactivated vaccines can induce reliable and protective immunity but, for a good and lasting effect, they require re-vaccination. Although their production is expensive, currently they are the best compromise in terms of safety and efficiency (Singh *et al*., 2004; Bhanuprakash *et al*., 2009). Well inactivated vaccines can prevent the development of clinical disease in susceptible hosts, reduce direct economic losses due to infection, facilitate safe trading in animals and prevent the development of viremia, or make it less severe, monovalent inactivated vaccines were first prepared against BTV-2, then against BTV-4; bivalent vaccines were made against BTV-2 and BTV-4 (Savini *et al*., 2005). Now a day monovalent vaccines against BTV-1, BTV-8 and BTV-9 are available in the market (Zientara and Schwartz, 2011).

New-generation Vaccines: Recently new types of vaccines are being developed and include vaccines such as recombinant vector vaccine, sub-unit vaccine and other vaccines that would offer advantages such as no risk of virus transmission, rapid onset of immune response or options to make them polyvalent. However, they are expected to have a higher production cost, that is the disadvantage of these vaccines (Roy *et al*., 2009).

2.10.2 Vector Control

It seems impossible to completely eliminate *Culicoides* midges in the natural environment. It is, however, possible to reduce the populations of midge to acceptable levels, or to prevent vector attacks by stabling susceptible animals overnight since midges have nocturnal feeding habits. In addition, the protection of animals in stables can be improved by door and window screens made of a fine mesh or a coarse fabric impregnated with insecticide (Calvete *et al*., 2010). Another alternative approach involves moving the animas away from insect resting area and breeding sites or complete elimination of such sites. The species *C. imicola*, *C.obsoletus* and *C. pulicaris*

breed in wet soils rich inorganic matter and such grounds should be drained and dried. The control of adult midges can be carried out by use of approved insecticides applied outside or inside (In areas with *C. dewulfi* occurrence) the stable or directly to the boy of susceptible host animals (Schmahl *et al*., 2009).

3. Conclusion and Recommendations

Results of seoprevalence studies made in different parts of Ethiopia revealed the presence of circulating antibodies of BTV in each agro-ecological zone. Although there were no reported clinical case of BT in the country, results of a few studies made on the disease showed a trend of increasing seroprevalence of circulating antibodies. The increase in seroprevalence of circulating antibodies might result in severe infection and high mortality if exotic breeds and their crosses are introduced in to in the country. Studies that were carried out regarding the disease in the country focused only on small ruminants and did not consider the situation in other host animals susceptible to the disease; the distribution and species of vectors responsible for the transmission of the disease from infected to susceptible hosts; the exact serotype (s) of the virus responsible for circulating antibodies in the country were not determined. Moreover, studies made on the epidemiology of BT did not include all agro-ecological zones of all regions in the country. Therefore, based on the above conclusion the following recommendations will be forwarded:

- Surveillance system for BTV infection should be extended so as to include other susceptible ruminant hosts and to study the distribution of the insect vector to better predict the situation of the disease in the future;
- Strict care should be taken while importing improved breeds of animals from endemic countries so as to prevent the introduction of more virulent serotypes of the virus in to the country;
- Situation will be changed in the virulence of serotypes responsible for circulating antibodies in the country, so government should consider for emergency preparedness plan;
- Farmers and livestock keepers all over the country should be educated about the impact of the disease on the health and productivity of animals so as to implement participatory approach in the prevention and control of the disease and the vectors;

Further epidemiological research should be conducted to know the status of the disease taking in to account the specific situation of each agro-ecological zone in the country.

References

1. Anonymous, 2009a. Bluetongue. Animal disease data. Office International des Epizooties, Paris. http://www.oie.int/fileadmin/Home/eng/Animal Health in the World/docs/pdf/BLUETONGUE FINAL.pdf (ac- cessed July 29, 2010).
2. Anonymous, 2013. What is Bluetongue (BT)? OIE Disease Information. http://www.oie.int/fileadmin/Home/Media center/docs/pdf/Diseasecards/BLUET EN.pdf. Accessed 30.03.2013.
3. Aradaib, I.E., M.E. Mohamed, T.M. Abdalla, J. Sarr, M.A. Abdalla, M.A. Yousof and A.R.E. Karrar, 2005.Serogrouping of United States and some African serotypes of bluetongue virus using RT-PCR. Veterinary microbiology, 111(3): 145-150.
4. Backx, A., R. Heutink, E. Van Rooij and P. Van Rijn, 2009. Transplacental and oral transmission of wild-type bluetongue virus serotype 8 in cattle after experimental infection Vet. Microbial, 138: 235-243.
5. Batten, C.A., S. Maan, A.E. Shaw, N.S. Maan and P.P.C. Mertens, 2008. A European field strain of bluetongue virus derived from two parenteral vaccine strains by genome segment reasortement. Virus Research, 137: 56-63.
6. Bhanuprakash, V., B.K. Indrani, M. Hosamani, V. Balamurugan and R.K. Singh, 2009. Bluetongue vaccines: the past, present and future. Expert review of vaccines, 8(2): 191-204.
7. Biswas, S.K., K. Chand, A. De, L.K. Pandey, J.K. Mohapatra, G. Prasad and B. Mondal, 2010. Isolation of bluetongue virus serotype 1 (BTV-1) from goats and its phylogenetic relationship to other BTV-1 isolates worldwide based on full-length sequence of genome segment-2. Arch. Virol., 155(12): 2041-2046.
8. Bitew, M., S. Nandi, C. Ravishankar and R. Somvanshi, 2013. Serological and molecular evidence of bluetongue in sheep and goats in Uttar Pradesh, India. Afr. J. Biotechnology, 12(19): 2699-2705.
9. Bouwknegt, C., P.A. Van Rijn, J.M. Schipper, D. Holzel, J. Boonstra, A.M. Nijhof, M.A. Van Rooij and F. Jongejan, 2010. Potential role of ticks as vectors of bluetongue virus. Experimental and Applied Acarology, 52:183-92.
10. Breard, E., N. Pozzi, C. Sailleau, B. Durand, V. Catinot, E. Sellem, P. Dumont, B. Guerin and S. Zientara, 2007. Transient adverse effects of an attenuated bluetongue virus vaccine on the quality of ram semen. Veterinary Record, 160: 431-435.
11. Calvete, C., R. Estrada, M.A. Miranda, R. Del Rio, D. Borras, F.J. Beldron and J. Lucientes, 2010. Protection of livestock against bluetongue virus vector Culicoides imicola using insecticide-treated netting in open areas. Medical and veterinary entomology, 24(2): 169-175.

12. Caporale, V. and A. Giovannini, 2010. Bluetongue control strategy, including recourse to vaccine: a critical review, Scientifiquet Technique Office International des Epizooties, 29: 573-591.
13. Chiang, E.T., D.A. Persaud-Sawin, S. Kulkarni, J.G. Garcia and F. Imani, 2006. Bluetongue virus and double-stranded RNA increase human vascular permeability: role of p38 MAPK. Journal of Clinical, Immunology, 26: 406-416.
14. Dadhich, H., 2004. Bluetongue: An overview of recent trends in diagnostics. Vet. Ital., 40: 564-566.
15. Daniel G., Demeke S., Brehan A. and Mesfin S. (2016): Sero- prevalence study of bluetongue infection in sheep and goats in selected areas of Ethiopia, *Ethiopian Veterinary Journal 2016, 20 (1):105-114.*
16. Darpel, K.E., Batten, C.A., Veronesi, E., Shaw, A.E., Anthony, S., Bachanek-Bankowska, K., Kgosana, L., Bin-Tarif, A., Carpenter, S., Müller-Doblies, U.U., Takamatsu, H.-H., Mellor, P.S., Mertens, P.P.C., Oura, C.A.L., 2007. Clinical signs and pathology shown by British sheep and cattle infected with bluetongue virus serotype 8 derived from the 2006 outbreak in Northern Europe. Vet. Rec. 161: 253–261.
17. De Leeuw, I., M. Garigliany, G. Bertels, T. Willems, D. Desmecht and K. De Clercq, 2015. Bluetongue Virus RNA Detection by Real-Time RT-PCR in Post-Vaccination Samples from Cattle. Transboundary and emerging diseases, 62(2): 157-162.
18. Drew CP, Heller MC, Mayo C, Watson JL, MacLachlan NJ (2010a). Bluetongue virus infection activates bovine monocyte-derived macrophages and pulmonary artery endothelial cells. Vet. Immunol. Immunopathol. 136:292–296.
19. Ducheyne, E., R. De Denken, S. Becu, B. Codina, K. Nomikou, O. Mangana, G. Georgiev, B.V. Purse and G. Hendrickx, 2007. Quantifying the wind dispersal of Culicoides species in Greeceand Bulgari Geospatial Health, 2: 177-189.
20. Elbers, A.R.W., E. Backx, G. Gerbier, C. Staubach, G. Hendricks, A. Vander and K. Mintiens, 2008. Field Observation During Bluetongue Serotype 8 Epidemic In 2006 Detection Of First Outbreak And Clinical Sign In Sheep And Cattle In Belgium France And The Netherland. Preventive Veterinary Medicine, 87: 2130.
21. Evermann, J.F., 2008. Accidental introduction of viruses into companion animals by commercial vaccines. Veterinary Clinics of North America-Small Animal Practice, 38: 919-929.
22. Giovannini, A., P. Calistri, D. Nannini, C. Paladini, U. Santucci, C. Patta and V. Caporale, 2004. Bluetongue in Italy-Part II. Vet Italy, 40(3): 252-259.
23. Henrich, M., M. Reinacher and H.P. Hamann, 2007. Lethal bluetongue virus infection in an alpaca. Veterinary Record, 161(22): 764-764.
24. Hofmann, M.A., Renzullo, S., Mader, M., Chaignat, V., Worwa, G. and Thuer, B., 2008. Genetic characterization of Toggenburg Orbivirus, a new bluetongue virus from goats, Switzerland. *Emerg. Infect. Dis*., 14: 1855–1861.
25. Howerth, E.W., D.E. Stallknecht E.W., D.E Stallknecht P.D. Krikland, 2001. Bluetongue, epizootic Hemorrhagic disease and other Orbivirus related diseases. Infectous Disease of Wild Mammals. 3:77-79.
26. Jauniaux, T.P., K.E. DeClerq, D.E. Cassart S. Kennedy, F.E. Vandenbussche, E.L Vandemeulebroucke, T.M. Vanbinst B.I. Verheyden, N.E. Goris and F.L. Coignoul, 2008. Bluetongue in Eurasian Lynx. Emerging Infectious Diseases, 14: 1496-1498.
27. Johnson, D.J., E.N. Ostlund, D.E. Stallknecht, V.H. Goekjian, M. Jenkins-Moore and S.C. Harris, 2006. First report of bluetongue virus serotype 1 isolated from a white-tailed deer in the United States. Journal of veterinary diagnostic investigation, 18(4): 398-401.
28. Johnson, D.J., K. Nomikou and P.C. Mertens, 2012. Identification and differentiation of the twenty six bluetongue virus serotypes by RT-PCR amplification of the serotype-specific genome segment 2. PLoS ONE 7(2): e32601. doi:10.1371/ journal.pone.0032601.
29. Kirschvink, N., Raes, M., Saegerman, C., 2009. Impact of a natural blue-tongue serotype 8 infection on semen quality of Belgian rams in 2007.Vet. J. 182: 244–251.
30. Koenraadt, C.J., T. Balenghien, S. Carpenter, E. Ducheyne, A.R. Elbers, M. Fife and B. Losson, 2014. Bluetongue, Schmallenberg-what is next? Culicoides-borne viral diseases in the 21st Century. BMC veterinary research, 10(1): 77.
31. Kramps, J.A., K. Van Maanen, M.H. Mars, J.K. Popma and P.A. Van Rijn, 2008. Validation of a commercial ELISA for the detection of bluetongue virus (BTV)-specific antibodies in individual milk samples of Dutch dairy cows. Veterinary microbiology, 130(1): 80-87.
32. Lewerin SS, Hallgren G, Mieziewska K, Treiberg Berndtsson L, Chirico J, Elvander M (2010). Infection with bluetongue virus serotype 8 in Sweden in 2008. Vet. Record. 167:165–170.

33. Lysyk, T.J. and T. Danyk, 2007. Effect of temperature on life history parameters of adult Culicoides sonorensis (Diptera: Ceratopogonidae) in relation to geographic origin and vectorial capacity for bluetongue virus. Journal of Medical Entomology, 44(5): 741-751.
34. Maan, N.S., Maan, S., Belaganahalli, M.N., Ostlund, E.N., Johnson, D.J., 2012a. Identification and differentiation of the twenty six bluetongue virus serotypes by RT-PCR amplification of the serotype-specific genome segment 2. PLoS One 7 (2), e32601, http://dx.doi.org/10.1371/journal.pone.003260.
35. Maclachlan, N.J., C.P. Drew, K.E. Darpel and G. Worwa, 2009. The pathology and pathogenesis of bluetongue. Journal of comparative pathology, 141(1): 1-16.
36. Maclachlan, N.J., 2011. Bluetongue: history, global epidemiology, and pathogenesis. Prev. Vet. Med. 102, 107–111.
37. Mars, M.H., C. Van Maanen, P. Vellema, J.A. Kramps and P.A. Van Rijn, 2010. Evaluation of an indirect ELISA for detection of antibodies in bulk milk against bluetongue virus infections in the Netherlands. Veterinary microbiology, 146(3): 209-214.
38. Mauroy, A., H. Guyot, K. De, D. Cassart, E. Thiry and C. Saegerman, 2008. Bluetongue in captive yaks. Emerging Infectious Diseases, 14: 675-676.
39. Mayo, C.E., B.M. Crossley, S.K. Hietala, I.A. Gardner, R.E. Breitmeyer and N. James MacLachlan, 2010. Colostral transmission of bluetongue virus nucleic acid among newborn dairy calves in California. Transboundary and emerging diseases, 57(4): 277-281.
40. Meiswinkel, R., G.J. Venter and E.M. Nevill, 2004. Vectors: Culicoides spp. Infectious diseases of livestock, 1: 93-136.
41. Menzies, F.D., S.J. McCullough, I.M. McKeown, J.L. Forster, S. Jess, C. Batten and P.S. Mellor, 2008. Evidence for transplacental and contact transmission of bluetongue virus in cattle. The Veterinary Record, 163(7): 203.
42. Merck, 2014. Overview of Bluetongue in: Merck veterinary manual: Last full review/reversion October 2014 copyright, Merck and co. Inc, Kenilworth NJ, USA.
43. Murphy, FA.,E.P.J. Gibbs, M.C. Horzinek and M.J. Studdert, 2011. Reoviridae Diseases Caused By Members of the Genus Orbivirus, Bluetongue. In: Veterinary Virology, 3rdEdn. Elsevier, San Diego, California USA, pp: 398-400.
44. OIE, 2014. Bluetongue. OIE: Terrirorial Manual, Office International des Epizootics (OIE). Paris, France, pp. 1-18.
45. Osmani A, Murati B, Kabashi Q, Goga I, Berisha B, Wilsmore AJ., 2006. Evidence for presence of bluetongue virus in Kosovo between 2001 and 2004. Vet. Record 158:393–396.
46. Radostits OM., Gay CC., Hinhcliff KW., and Constable PD., 2006. A Textbook of the Diseases of Cattle, Horses, Sheep, Pigs and Goats. 10th ed. VB Saunders Company Ltd., pp. 1300-1304.
47. Roy, P., M. Boyce and R. Noad, 2009. Prospects for improved bluetongue vaccines. Nature Rev. Microbiol, 7: 120-128.
48. Saegerman, C., B. Bolkaerts, C. Baricalla, M. Raes, L. Wiggers, I. De Leeuw and K. De Clercq, 2011. The impact of naturally-occurring, trans-placental bluetongue virus serotype-8 infection on reproductive performance in sheep. The Veterinary Journal, 187(1): 72-80.
49. Sanchez-Cordon PJ, Rodriguez-Sanchez B, Risalde MA, Molina V, Pedrera M, Sanchez-Vizcaino JM, Gomez Villamandos JC (2010). Immunohistochemical detection of bluetongue virus in fixed tissue. J. Com. Pathol. 143:20–28.
50. Santman-Berends, I.M., L. Van Wuijckhuise, P. Vellema and P.A. Van Rijn, 2010. Vertical transmission of bluetongue virus serotype 8 virus in Dutch dairy herds in 2007. Veterinary microbiology, 141(1): 31-35.
51. Savini, G., M. Goffredo, F. Monaco, A. Di Gennaro, M.A. Cafiero, L. Baldi and V. Caporale, 2005. Bluetongue virus isolations from midges belonging to the Obsoletus complex (Culicoides, Diptera: Ceratopogonidae) in Italy. Veterinary Record, 157(5): 133.
52. Schmahl, G., S. Klimpel, V. Walldorf, S. Al-Quraishy, B. Schumacher, A. Jatzlauand H. Mehlhorn, 2009.Pilotstudyondeltamethrin treatment of cattle and sheep against midges (Culicoides species, Ceratopogonidae). Parasitology research, 104(4): 809-813.
53. Singh, K.P., S. Maan, A.R. Samuel, S. Rao, A.J. Meyer and P.P.C. Mertens, 2004. Phylogenetic analysis of bluetongue virus genome segment 6 (encoding VP5) from different serotypes. Vet. Ital, 40: 479-483.
54. Takamatsu H, Mellor PS, Mertens PPC, Kirkham PA, Burroughs JH, Parkhouse RME, 2003. A possible overwintering mechanism for bluetongue virus in the absence of the insect vector. J. Gen. Virol. 84:227–235.
55. Tweedle N, Mellor PS, 2002. Technical review–bluetongue: The virus, hosts and vectors. Version 1.5. Report to the Department of Health, Social Services and Public Safety U.K. (DEFRA),

pp.25.http://archive.defra.gov.uk/foodfarm/farmanimal/diseases/atoz/documents/bluetongue_technical. PDF (accessed July 28, 2011).
56. Vanbinst, T., F. Vandenbussche, E. Dernelle and K. De Clercq, 2010. A duplex real-time RT-PCR for the detection of bluetongue virus in bovine semen. Journal of virological methods, 169(1): 162-168.
57. Veronesi, E., G.J. Venter, K. Labuschagne, P.S. Mellor and S. Carpenter, 2009. Life-history parameters of Culicoides (Avaritia) imicola Kieffer in the laboratory at different rearing temperatures. Veterinary parasitology, 163(4): 370-373.
58. Verwoerd, D.W. and B.J. Erasmus, 2004. Bluetongue. IN: Coetzer JA, Tustin RC (Eds.), Infectious Diseases of Livestock. 2nd ed. Oxford Press, Cape T658u7hguown, pp: 1201-1220.
59. Wilson A, Carpenter S, Gloster J, Mellor PS (2007). Re-emergence of bluetongue in northern Europe in 2007. Vet. Record 161:487–489.
60. Wilson, A., K. Darpel and P.S. Mellor, 2008. Where does bluetongue virus sleep in winter? PLOS Biology, 6: 1612-1617.
61. Wilson, A.J. and P.S. Mellor, 2009. Bluetongue in Europe: past, present and future. Philosophical Transactions of the Royal Society of London B: Biological Sciences, 364(1530): 2669-2681.
62. Woldemeskel, M., Tilahun, G., Tibbo, M. and Potgieter, L.N.D. (2000): Prevalence of bluetongue virus antibodies in sheep in Central Ethiopia, Deutsche tierärztliche Wochen- schrift, 107: 408-409.
63. Worwa, G., 2009. The pathology and pathogenesis of bluetongue. Journal of comparative pathology, 141(1): 1-16.
64. Wouda, W., Peperkamp, N.H., Roumen, M.P., Muskens, J., van Rijn, A., Vellema, P., 2009. Epizootic congenital hydranencephaly and abortion in cattle due to bluetongue virus serotype 8 in the Netherlands. Tijdschriftvoordiergeneeskunde 134: 422–427.
65. Yilma, M. and M. Mekonnen, 2015. Competitive Enzyme Linked Immuno-Sorbent Assay (c-ELISA) Based Sero-Prevalence of Bluetongue Virus (BTV) on Small Ruminants in Selected Areas of Wolyita, Southern Ethiopia. Virolmycol, 4(148): 2161-0517.
66. Zientara, S. and I. Schwartz, 2011. Bluetongue virus targets conventional dendritic cells in skin lymph. Journal of Virology, 83: 8789-8799.

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