

Economic impact of Bluetongue: a review of the effects on production

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Keywords

Bluetongue,
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Production losses.

Summary

Bluetongue (BT) is often said to be a disease of severe economic consequence with a global estimate of US\$ 3 billion. This review describes the most relevant contribution in the extant literature on production related losses due to BT. In summary, the impact of the endemic situations appears to be relatively small and surrounds the impacts on flock and herd fertility. The largest and most serious impact with BT in the epidemic situations has been in the reactions to the presence and risk of the disease. Such a reaction, in hindsight, has been far greater than the production losses caused by the disease. More data are required with more careful analysis to provide better impact assessment for BT. This would offer the ground for research prioritisation and the rebalancing of resource allocation. Such an economic impact assessment should follow scientific methods mirroring the careful and thorough biological work on BT.

Impatto economico della Bluetongue: analisi degli effetti sulla produttività

Parole chiave

Bluetongue,
Impatto economico,
Produttività.

Riassunto

La Bluetongue (BT) è conosciuta come una malattia dalle severe conseguenze sanitarie, il cui impatto economico globale è stimato intorno ai 3 miliardi di dollari. L'articolo descrive i contributi più salienti della letteratura concernente i danni causati alla produttività evidenziando come gli scenari endemici abbiano conseguenze relativamente circoscritte e affliggano per lo più le greggi e la loro fertilità. L'articolo evidenzia che le conseguenze maggiori della malattia siano determinate dalle reazioni alla presenza, o al rischio di estensione, dell'epidemia. Un'adeguata valutazione dell'impatto della BT necessita di maggiori dati e analisi accurate. In questo modo si potranno definire le aree di ricerca da sviluppare e una più adeguata allocazione delle risorse.

Introduction

Bluetongue (BT) is a disease caused by the Bluetongue virus (BTV), a double stranded RNA virus classified within the *Reoviridae* family and *Orbivirus* genus. There are at least 24 serotypes (denoted BTV 1-24) and infection leads to lifelong protection to that serotype, although there is no apparent cross-serotype protection. Transmission is predominantly through a biological vector of the genus *Culicoides*. Other vectors and routes have

also been reported, though these are considered of relatively minor importance.

All ruminants are susceptible for BTV although disease is most commonly reported in sheep. Typical clinical signs include fever, hyperptyalism, nasal discharge, hyperaemia, oedema, and ulceration of the oral mucosa. Pregnant animals may also abort or deliver a deformed foetus. Infection may also be subclinical with severity mainly determined by the species affected, breed, age, immune status and serotype/strain of the virus (Caporale *et al.* 2014).

Goats appear to be relatively less susceptible to infection and show less severe disease. Disease may be seen in cattle although it is often subclinical. The prolonged viraemia in cattle means they have an important role in the transmission. In the European BTV-8 epidemic milk drop and teat lesions were commonly seen in diseased cattle (Dercksen and Lewis 2007, Williamson *et al.* 2008).

The virus is widely distributed and has been recorded on all continents except Antarctica. Traditionally the global range is between latitudes 40-50°N and 35°S, this is consistent with the distribution of the vector and temperatures required for viral replication (Mellor *et al.* 2008). Extensions beyond this area have been reported in recent years, and it has been proposed that Global Warming has contributed to increased transmission; although opinions on this issue are mainly conjecture (MacLachlan and Guthrie 2010). Since 1998, BTV has been present in Southern Europe and in the Mediterranean, since then it has moved as far North as Norway in 2009 (Sperlova and Zendulkova 2011). The European BTV-8 epidemic occurred between 2006 and 2008 was notable due to its widespread distribution, the severity of disease in cattle, and the virus re-emerging after the Winter period ('overwintering') due to vector survival, previously considered unlikely. Transplacental transmission of virus is also thought to have contributed to this process.

Bluetongue is often said to be a disease of severe economic consequence qualifying it to a notifiable disease by the World Organisation for Animal Health (OIE). A global estimate of the impact of Bluetongue was US\$ 3 billion (Bath 1989). Southern regions of the US are endemic for some types of Foot and Mouth Disease (FMD), which restricts trade of livestock and related products. This indirect cost has been estimated at US\$ 125 million annually (Tabachnick 1996). With regards to the BTV-8 outbreaks, Wilson and Mellor stated that the "BTV-8 epidemic in Northern Europe has probably caused greater economic damage than any previous single-serotype Bluetongue outbreak" (Wilson and Mellor 2009, p. 2669).

Losses due to any livestock disease may be classified as losses in production (direct losses), expenditure and lost revenue (indirect losses) (Rushton 2009). The former may be visible losses, such as reduced milk yield or increased mortality, weight loss, reduced fertility rate, abortion, reduced meat production efficiency and death (Sperlova and Zendulkova 2011). Indirect losses include costs of vaccines or lost revenue, such as through trade restrictions limiting access to higher value markets. An understanding of these processes and quantifying production losses is essential to develop relevant economic models when considering the implementation of a control strategy and allocation of resources. The objective

of this review was to appraise the literature for evidence on the impact of BT on production and identify further research requirements.

Production impact of BTV

Various estimates of morbidity and mortality have been presented in the literature although the impact of disease on production has been poorly documented until the European BTV-8 outbreak in 2006-2008. Initially studies focussed on economic models in order to estimate the impact of putative control measures. Later studies gave empirical estimates on the impact on mortality, milk yield, and fertility. In 2007, overall estimates on the financial impact in France and the Netherlands were US\$ 1.4 billion and US\$ 85 million, respectively. The costs are largely ascribed to the trade restrictions that were present during the outbreak period.

Economic models

A study commissioned by the Scottish Government led to the development of a model to estimate the economic impact of different incursion scenarios and the benefit-cost ratio of various control scenarios¹. The assessment of the impact on production was based on expert opinion. The direct costs, which incorporated reduced milk production, weight loss, mortality, veterinary treatments, and animal testing were estimated at £ 30 million per year.

Velthuis and colleagues (Velthuis *et al.* 2010) constructed a deterministic economic model to determine the cost of the BTV-8 epidemic in the Netherlands during 2006 and 2007. Cattle, sheep, and goat sectors were incorporated and the model considered the impact of production, treatment of diseased animals, diagnostic, and control measure costs. The criteria to assess the impact on production included mortality, early culling, decreased milk production, weight loss, no gestations, postponed gestations, abortions, stillbirths, decreased fertility of rams, and lower birth weights (Table I). All parameters were based on expert opinion of private and government veterinarians, who were involved in the epidemic. The overall cost was estimated to be € 32.4 and € 164-175 million in 2006 and 2007, respectively. The authors estimated that control measures made up 91% of the cost in 2006. In 2007, due to the relaxation of control measures and the greater number of farms affected, production losses and

¹ Scottish Government. 2008. Assessing the economic impact of different Bluetongue Virus (BTV) incursion scenarios in Scotland. Technical report Commission Number CR/2007/56 (<http://www.gov.scot/Resource/Doc/241420/0067122.pdf>, accessed on March 2015).

Table 1. The considered parameters for assessing the production impact in cattle, sheep, and goat sectors used in the analysis of the Bluetongue economic impact in the Netherlands provided by Velthuis and colleagues (Velthuis *et al.* 2010). 2006: estimate from July 2006 to July 2007. 2007: estimate from July 2007 to July 2008.

Parameter	Cattle		Sheep		Goats	
	2006	2007	2006	2007	2006	2007
Early culling (%)	3	3	3	0	0	0
Weight loss (%)	7.0	7.0	8.1	8.1	-	-
No gestation (%)	5.2	9.9	5.0	9.8	-	-
Postponed gestation (%)	36.9	53.5	0.0	10.0	-	-
Abortion (%)	2.0	6.2	1.9	3.2	-	-
Reduced fertility rams (%) ^a	-	-	0.0	75.0	-	-
Reduced birth weight (%)	2.6	6.7	-	-	-	-
Stillbirths (%)	0.0	5.3x10 ⁻⁴	-	-	-	-
Average daily milk production (kg/day)	26.9	26.9	2.0	2.0		2.48
Relative reduction milk production (%)	20	20	20	20	-	80

^a Percentage of sheep farms that needed 1 extra ram.

veterinary treatment fees made up 92% of the total costs. In response to uncertainty over the availability of vaccines, the same model was used to assess the relative benefits of different vaccine strategies for controlling a BTV-8 epidemic in 2008 (Velthuis *et al.* 2011). Whereas, the production losses were the same as those estimated in 2007 with the original model, although the mortality, morbidity, and number of infected farms varied in the 2 scenarios. The overall financial impact (including production losses, diagnostics, treatment, and control measures) ranged from € 40.9 to € 41.3 million, with most losses being estimated to occur on sheep breeding farms, dairy export firms, and dairy firms (€ 12.6, € 12.6 and € 11.3 million respectively). The highest impact was ascribed to production losses at 52.8% and 55.2% of the total net costs for the 2 scenarios under consideration.

As part of an evaluation of the surveillance and control program in Switzerland, Häsler and colleagues (Häsler *et al.* 2012) used a stochastic economic model to compare hypothesised baseline strategies with the interventions actually employed as part of retrospective (2008-2009) and prospective (2010-2012) analyses. In the retrospective baseline scenario, the mean estimated disease costs in 2008 and 2009 were € 12.2 million and € 3.6 million, respectively. In the 2011 and 2012 prospective baseline scenarios the mean costs ranged between € 2.6 million and € 6.6 million per year, depending on the scenario being considered. As with the other studies, production losses were based mainly on expert opinion. The authors remarked that "one major limitation of the present model was the lack of reliable data to estimate total disease costs" (p. 109).

Mortality

Mortalities have been reported in sheep and cattle in different settings. A case-fatality rate of 31.4% representing an overall mortality of 6% was reported during the 1964 outbreak of BTV-4 (Shimshony 2004) in Israel. Vaccination began the same year.

In 2000, an outbreak of BTV-2 on the Balearic islands led to a mortality of 7.8% among sheep, with vaccination used in response (De Diego *et al.* 2013). A subsequent outbreak of BTV-4 in 2003 on Minorca island only resulted in 19 deaths. An incursion in 2001 of BTV-2 into Corsica saw a mortality of 40% in unvaccinated sheep flocks. This was compared with 5.1% on vaccinated flocks (Breard *et al.* 2004).

Giovannini and colleagues (Giovannini *et al.* 2004) reported a mortality rate among sheep and goats of 3.3% when BTV-2 occurred in Sardinia, Sicily, and Calabria in 2000. The following year a more widespread epidemic mainly due to BTV-9 was associated with a mortality of 5.2%. Subsequently during 2002-2003 a mortality of 6.2% was recorded on affected flocks in Italy in a mostly vaccinated population (Giovannini *et al.* 2004, Patta *et al.* 2004). The serotypes present at this time were mainly BTV-2 and BTV-9, although BTV-4 and BTV-16 were also detected but restricted in their distribution (Giovannini *et al.* 2004).

A study from the Netherlands rested on official reports from farms to estimate the mortality in cattle attributable to the BTV-8 epidemic in 2007 (Santman-Berends *et al.* 2011b). On confirmed infected herds, they reported a mortality rate ratio of between 1.2 (95%CI 1.1-1.3), 1.3 (95%CI 1.1-1.5), and 1.4 (95%CI 1.2-1.6) for age categories <3 days, 3 days-1 year, and >1 year, respectively. This estimate was based on a comparison between BTV-8 affected

months and non-affected months in the same herd adjusted for relevant confounders.

Milk yields

Two studies attempted to use empirical data to quantify the reduction in milk yield due to BTV-8 on immunologically naïve herds. A prospective study in the Netherlands monitored 15 seronegative herds (1,074 cows) for seroconversion from July to December 2008 (Santman-Berends *et al.* 2011a). The authors found that seroconverted cows that produced 52 kg (95%CI 26-76) less milk (between 0.3% and 0.9% less) of the annual production. No effect on somatic cell count was detected. A study from France quantified the mean impact on milk yield at the farm level and the duration of reduction before and after the date disease was detected accounting for the risk of exposure at a district level (Nusinovici *et al.* 2013). Over 3,000 Holstein herds were included in the study and the herds acted as their own controls by comparing data from the same herd pre-outbreak with what was subsequent produced after BTV exposure. This study found that comparing the exposed and unexposed periods in high-exposure areas, the mean cumulative loss was 3.4% of the annual 305-day production. This period of reduction was between 2 months before to 4 months after the reported date of disease detection in the herd.

Fertility

Several studies attempted to quantify the impact of BTV on fertility. Saegerman and colleagues (Saegerman *et al.* 2011) investigated an outbreak on a 355-ewe sheep flock in Belgium of which around 60% had clinical disease from July to September 2007. Data from 4 subsequent lambing periods were also presented (November 2007, January 2008, March 2008, May 2008). A higher rate of abortions of 15.7% was detected in the lambing period in 2008, the rate was higher when compared to the rate of earlier periods, which ranges between 0% and 5.7%. In addition the authors found a reduction of fertility rate (number of pregnant ewes/number of ewes presented to the ram) from 59-75% to 30% (Saegerman *et al.* 2011).

Regarding cattle, Santman-Berends and colleagues (Santman-Berends *et al.* 2010) monitored fertility on the 15 seronegative Dutch herds. They found that infected cows were 5 times (95%CI 1.9-14.3) more likely to return to service (RTS) within 56 days after first insemination and were 1.7 times more likely (95%CI 1.4-2.0) to become pregnant compared to non-infected cows.

On French dairy farms, Nusinovici and colleagues

(Nusinovici *et al.* 2012) looked at the effect of BTV-8 on the 90 day RTS rate after first insemination, revealing an increased rate of between 8% and 21% comparing exposed and non-exposed herds, depending on the time interval between the date of insemination and the date of detection in the herd. In cantons of high exposure this effect was estimated at between 13.5% and 26.8%. In a different study, the same authors also looked at the rate of late return to service between 90 and 200 days and short gestations. The authors reported an average effect of BTV-8 exposure with a 6.7% increase in return to service and 1.9% increase in short gestations when exposed from the third month of gestation onwards (Nusinovici *et al.* 2012b). In Israel, BTV infection has not been associated with fertility problems in cattle (Shimshony 2004).

Summary of the disease impact

The literature provides a range of different data and information on impact, yet few conclusions have been drawn as to where the disease impact lies in different situations. Figure 1 summarises the current debate by describing the figures for the endemic and epidemic scenarios.

The impact in the endemic situations appears to be relatively small and surrounds the impacts flock and herd fertility. There are issues with regards the adoption of improved breeds and there is evidence that where new and more productive breeds are incorporated into livestock systems BT becomes more important.

In an epidemic situation the impacts are much more diffuse. First there are naïve populations of animals and the possibility of deaths of older more valuable animals is possible. Fertility issues also cause problems, particularly in systems where even small losses in calf, lamb, or kid crops can affect the economic viability of a system. There are also well reported losses of milk production. However, the largest and most serious impact with BT in the epidemic situations has been in the reactions to the presence and risk of the disease. Significant findings have been spent on new vaccines, plus there were serious restrictions on animal movements. There were also impacts on markets. In short, the reaction to the disease has been large and perhaps in hindsight far greater than the production losses caused by the disease.

Discussion

Due to the complex epidemiology of Bluetongue and heterogeneous nature of animal populations, the impact in different settings is likely to be highly variable.

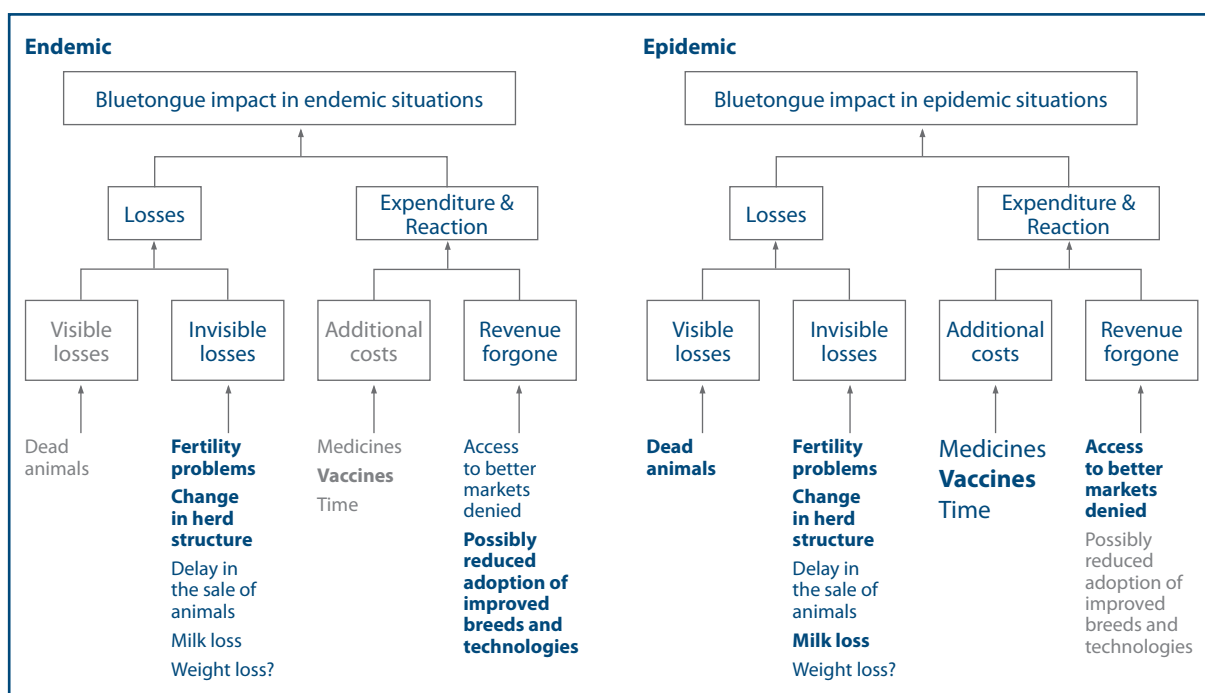


Figure 1. The relative importance of the different aspects of Bluetongue impacts in endemic and epidemic countries.

Therefore, it is important that objective data are collected from the field in a variety of conditions and analysed using rigorous epidemiological methods so that the impact may be accurately quantified and give confidence to the outputs of economic models when predicting the impact of putative control measures.

However, there is very little information on the impacts of BT in endemically stable situations and very little information on the costs of surveillance, control and prevention. The information generated on the costs of reactions in terms of trade is limited and has focused on studies concerning the Americas. Given that the world is facing issues on the need to increase food production, the limits that BT generates for the adoption of improved breeds and production systems are, of course, of greatest concern.

In short more data are required and more careful analysis is needed to provide better impact assessment for BT. Such an economic impact assessment would allow a rebalance of resource allocation in terms of research and disease surveillance, control, and prevention efforts. The impact assessments need to follow repeatable, scientific methods (Knight-Jones and Rushton 2013) and should mirror the careful and thorough biological work on BT over the last few decades.

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