

The control of bovine viral diarrhoea virus in Europe: today and in the future

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Summary

This paper summarises the views of a European group of scientists involved in the control of bovine viral diarrhoea virus (BVDV), as part of a European Union Thematic Network. The group concludes that the technical tools and the knowledge needed to eradicate BVDV are at hand, as proven by successful national control schemes in several European countries. A generic model for BVDV control is presented, which includes biosecurity, elimination of persistently infected animals and surveillance as central elements. These elements are termed 'systematic', in contrast to control efforts without clear goals and surveillance to evaluate progress. The network concludes that a systematic approach is needed to reach a sustainable reduction in the incidence and prevalence of BVDV in Europe. The role of vaccines in systematic control programmes is considered as an additional biosecurity measure, the effect of which should be evaluated against cost, safety and efficacy.

It is also concluded that active participation by farmers' organisations is a strong facilitator in the process that leads up to the initiation of control, and that public funding to support the initiation of organised BVD control programmes can be justified on the basis of expected wider societal benefits, such as animal welfare and reduction in the use of antibiotics. If applied successfully, the focus on biosecurity in systematic BVD control programmes would also reduce the risk of the introduction and spread of other epizootic and zoonotic agents, thereby improving both cattle health and welfare in general, as well as increasing the competitiveness of the cattle industry.

Keywords

Cattle – Diagnostic – Epidemiology – Eradication – Genome – Pestivirus – Risk – Socio-economic – Surveillance – Vaccination.

Introduction

Infections with bovine viral diarrhoea virus (BVDV) are endemic in most cattle-producing countries throughout the world, causing significant economic losses to the cattle industry (32). Based on antigenic and genetic properties, two species of the causative virus can be distinguished, BVDV-1 and BVDV-2. Their prevalences vary across the world: BVDV-2 represents around 50% of the isolates in North America, whereas BVDV-1 dominates in Europe, with more than 90% (69, 97).

Most isolates of both viral species are well adapted to cattle and acute (i.e. transient) infections with such low-virulent strains generally go unnoticed unless there are other complicating factors. However, BVDV virulence varies markedly, and due to a transient immunosuppression acute infections are often exacerbated by secondary infections. This is how BVDV plays its role in other disease syndromes, including respiratory and enteric conditions. The effect of the virus on the immune system can also lead to lethal haemorrhagic disease (3). Bovine viral diarrhoea virus also interferes extensively with reproductive functions. Depending on the time of infection, there may be a significant reduction in conception rates and an increased number of abortions, malformations, stillbirths or births of persistently infected (PI) calves (15, 52, 73). The latter are immunotolerant to the persisting virus. As these animals constantly shed virus, they are the key to the spread of BVDV and consequently their detection plays a pivotal role in any control or eradication programme. Many PI animals die of mucosal disease (MD), but more often they leave the herd at an early age due to other complications. Despite this, a few may survive for many years (30, 72).

The repeated cycle of PI animals being born, infecting susceptible animals in early pregnancy, and leaving the herd for different reasons (sale or death) is typical for endemic BVDV infections. In herds of limited size, the infection is often eliminated without intervention ('self-clearance'), provided the virus is not reintroduced. However, larger herds may remain infected for long periods of time if no measures to eradicate the virus are taken (45).

Prevalence

A review of prevalence surveys performed in Europe from the late 1970s and into the 21st Century shows that BVDV is/has been endemic in all countries where no systematic control has been initiated (50). Under such conditions, approximately 50% of all herds have PI animals, and 90% of all cattle become exposed during their lifetime. In endemic areas, a high correlation between BVDV prevalence and cattle density has been shown (34).

Even though extensive surveys have been carried out, knowledge of the overall BVDV situation in Europe is still not complete. A few countries lack reports on prevalence and representative estimates of incidence have only been reported from countries that have systematic control in place. Also, the prevalence of different genetic groups has not been estimated through formal surveys; thus, the information available is more of the type present/not present. So far, the presence of BVDV-2 has been reported from Germany, Belgium, France, the Netherlands, Austria, Slovakia, Italy and the United Kingdom (UK) (4, 42, 66, 94, 95, 96, 100, 102), but not from Sweden, Norway, Spain, Slovenia or Denmark (2, 77, 81, 87, 88, 93).

Economic impact

The overall importance of a particular infection depends on the weight that is put on different aspects of disease impact, such as production/economics, animal welfare or human safety (101) and how this ranks relative to other animal health concerns. Until now, quantitative assessments of the importance of BVDV infections have almost entirely relied on economic aspects. It should be noted that BVDV also has a significant impact on animal welfare, e.g. the stress and pain associated with MD. The welfare implications have never been quantified in a systematic way.

Calculations of the herd level losses due to so-called 'classical' outbreaks of BVDV, where most transient infections go unnoticed, and where most losses are associated with reproductive disorders and PI animals, have fallen within the range of 21 euros to 135 euros per cow in the outbreak herd (32). (Estimates in other currencies have been converted to euros, conversion rate as per February 2006. The major variation in economic estimates is believed to be due to biological variation rather than currency fluctuations.) In contrast, losses from outbreaks due to BVDV occurring simultaneously with other infections, or to highly virulent strains causing severe disease and high mortality (also among transiently infected animals), have been estimated to be more than 340 euros per cow in the outbreak herd (13, 32, 67).

At the herd level, most calculations have been based on case histories and therefore they do not reflect average values. Calculations of the so-called 'outbreak losses' are somewhat artificial since 'an outbreak' is not very well defined. The incidence of BVDV-related clinical manifestations during such outbreaks will often be higher than the average losses.

As an alternative to calculating losses observed in real cases, mathematical modelling has been used to estimate

the mean losses over several years. For beef herds, an estimated mean loss of 54 euros per cow per annum has been calculated (24).

Calculations at the national level performed to date have been based on estimated parameters of incidence risks and probabilities of losses due to different types of outcomes of BVDV infection. Based on estimations from the UK, Norway and Denmark, the national losses at the population level, under endemic conditions, have been estimated to be in the range of 8.5 euros to 34 euros per calving (6, 27, 33, 89). The losses due to the occurrence of a highly virulent strain in a population have been estimated as 48 euros per calving (31). However, the latter should be considered as a theoretical situation as no region has reported that only virulent strains prevail. By nature of the calculations, the variation in estimates at the national level is smaller than at the herd level. In any case, it is clear that BVDV infections have a significant impact on the competitiveness of European cattle industries. It should be noted that many of the economic estimates mentioned above are based on publications older than ten years. It is therefore reasonable to assume that the figures would be considerably higher today.

Control

At present, in most parts of Europe, BVDV is being controlled mostly on a voluntary basis. Vaccines are available in many countries, but the take-up rate is very varied – from below 20% up to 75% (56). In the UK, Ireland, the Netherlands and Slovenia, only killed BVDV vaccines are licensed. The Scandinavian countries and Austria do not permit the use of BVDV vaccines; instead, large-scale eradication schemes are in place. The first large-scale eradication schemes were launched in 1993–1994 in the Shetland Islands, Denmark, Finland, Norway and Sweden (1, 8, 60, 85, 99). Despite different preconditions in terms of legal support, and with initial prevalences of herds with PI animals varying from < 1% in Finland to 50% in Denmark, it has taken all countries approximately ten years to reach their final phases (36, 61, 71, 98).

In Austria, the regional control scheme launched in 1997, which was similar in design to the Scandinavian model, was extended to the entire country in 2004 (74).

Large-scale control efforts have also been implemented in Brittany in France (37), in the Netherlands (53), in Germany (55) and in the Lecco and Como regions of Italy (51). Time-limited, project-type control efforts have also been implemented in the Rome area (18) as well as in Greece (7), and Galicia in Spain (E. Berriatua, personal communication).

A European Union network for bovine viral diarrhoea virus control

To build upon the growing interest in BVDV control, as well as the various experiences within Europe in this respect, a Thematic Network (TN) on BVDV Control, funded by the European Union (EU) Commission's 5th Framework Programme (each of the EU's consecutive four-year research programmes are called Framework Programmes), was formed in December 2002 (www.bvdiv-control.org). The network has explored a range of aspects of BVDV control, with the work being divided into four main areas: genome and diagnostics; epidemiology and risks; vaccines and vaccination strategies; and socio-economic aspects of BVDV control. Almost all EU member states participate in the network: only Luxembourg and the member states that joined in 2003 (with the exception of Slovakia and Slovenia) are not represented. Norway and Switzerland also participate in the network's activities.

The objective of this paper is to summarise the conclusions and recommendations from the TN and its activities.

Materials and methods

The network has been active for a period of three years, concluding its work in the autumn of 2005. The work has been carried out within four work packages, covering the four main areas mentioned above. Each work package has produced a detailed paper where positions on different aspects of BVDV control have been expressed as a guidance for future initiatives within the EU (50, 56, 75, 78). Also, for each work package, research needs have been identified and highlighted.

Six larger meetings have been held, of which one was an international symposium attracting close to 200 delegates from Europe as well as North and South America. Papers from this meeting, which was held in Portugal in 2004, were peer-reviewed and were published in 2005 in a special issue of *Preventive Veterinary Medicine*.

By means of plenary discussions and questionnaires the network has been able to gather data and expert knowledge on numerous occasions. The information has partly been used as input into the position papers, but also for carrying out specific activities. Examples of such activities include an exploration of the economic and social pressure to control BVDV within Europe using an existing model for the estimation of economic losses in dairy cattle, and a semi-quantitative assessment of regional risk factors for introducing and maintaining BVDV infection across Europe. In addition to compiling knowledge within the network, a pan-European web survey was carried out with the objective of exploring attitudes towards BVD

eradication and control on a wider basis. For this survey, government and private-sector veterinarians, representatives of farmers' organisations and policy-makers across Europe were identified by network partners, and invited to participate.

In addition to the scientific discussions, the network has carried out a BVDV serology ring test involving 23 laboratories from 18 partner countries. A demonstration version of a database for entering, storing and querying BVDV genome information has been set up (<http://viro08.tiho-hannover.de/eg/bvdv/>, password protected). Also, one participating country has been inspired by the network to develop a BVDV learning tool (available through <http://www.bvd-info.ch>) as a source of information for farmers and others involved in BVDV control.

The methods used in these studies are described in more detail on the web page of the network, www.bvdv-control.org. Also, other material presented by participating countries at network meetings can be accessed through the same site.

Results and discussion

The work within the network has been aimed at providing guidance to EU member states on the future management of BVDV infections and also on what research is needed to support this. A major part of the work has dealt with issues pertaining to the process that leads up to the initiation of control. The network has also set out to formulate a general model for BVDV control and describe how the different elements of this model can increase the probability of a long-term reduction in the prevalence of BVDV. This paper is a synthesis of the opinions and recommendations expressed within each of the four position papers that the network has prepared in relation to these issues. The full position papers are available through the BVDV control website.

Initiation of control

Saatkamp *et al.* (75) give a general framework for decision making on disease control, showing the process by which a particular disease should be evaluated before measures to control it are implemented. In the first stage, the relevant authorities ascertain whether the disease is indeed a problem and/or is a priority for other reasons. Secondly, the desired disease status (e.g. reduced prevalence/eradication) is defined. Finally, an evaluation is made of whether it is possible/desirable to achieve, maintain and restore this status, with the tactical means at hand.

One can look upon this decision process as a kind of threshold that has to be overcome in order to embark on control. The process is the same irrespective of the level of implementation, be it the herd, a region or a country. However, the criteria for evaluation differ. At the herd level, farm economy and animal welfare may be of greater interest, whereas at higher levels the regional or national economy, as well as societal considerations, come into play.

From a theoretical point of view, one would expect this 'control initiation threshold' to be lower in countries or regions where BVDV is highly prevalent and consequently imposes a high economic pressure on the farmer and the industry. However, as demonstrated by Gunn *et al.* (25), strictly economic incentives do not seem to explain why countries with a fairly low initial prevalence, like Norway, have embarked on national control, whereas a country such as the UK (Shetland excluded) is still hesitating to do so.

To understand this paradox further, an exploratory evaluation of stakeholder attitudes and values toward BVD control in Europe was performed by means of a pan-European web survey in which 14 countries were represented (28). As expected, the preliminary analysis of the responses indicate that any attempt at an EU-wide strategy for BVDV control must also account for the social and political differences that influence disease control in general. Furthermore, it is clear that there are differences in how stakeholders across Europe interpret BVDV as a problem and how they communicate about BVDV control. These differences may in themselves constitute a constraint to reach any form of collective action regarding BVD. More specifically, the analysis revealed how the experiences gained from Scandinavia and Austria were acknowledged to be useful by many countries, but maintaining the notion that this is the 'best' or 'only' way to achieve eradication will never lead to group cohesion. These cognitive patterns must be significantly altered to better support mutual acceptance of the situation by stakeholders from both Northern and Southern European countries.

On the other hand, arguments were given in the survey, by countries where there is no control today, as to why the results seen in Scandinavia and Austria would not or could not be replicated in their own country. However, the investigators conclude that on strictly scientific grounds, this does not hold and that much of the reluctance appears to be associated with an underlying belief that the primary stakeholders – the farmers – cannot or will not comply. At the same time, only a few of those countries seem to have addressed this issue, e.g. by putting effort into educating and informing farmers. Given this paradox, the investigators finish by questioning the underlying attitudes and commitment of many of the respondents toward sustainable BVD control and they conclude that many respondents remain unaware of the level of

training/education that has been required in those countries where eradication has been successfully implemented.

The perception that social and political differences largely determine the European BVDV situation as we see it today is also supported by looking at some common denominators for nations and regions that have embarked upon large-scale control. One is that, to a large extent, the process of initiating control programmes has been driven by, or in collaboration with, cooperative or semi-cooperative organisations that represent the farmers themselves. Some examples of such organisations include the Fédération Nationale des Groupements de Défense Sanitaire in Brittany, France, the Servizio di Assistenza Tecnica agli Allevamenti in Italy, as well as breeding organisations in Austria and cooperative dairy associations in Scandinavia and Finland. These organisations have large networks for providing support to farmers, and have gained the expertise to assist with BVDV control through collaboration with research institutions and diagnostic laboratories. In areas where supportive legislation has been drafted, another common finding is a fairly conflict-free relationship between stakeholders and authorities.

Consequently, it appears that although the incentives to initiate control may be present at the farm level, as well as at higher levels in many regions, control programmes are more likely to actually be put in place if organisations that directly or indirectly represent the primary stakeholders take responsibility for getting them started. The findings by Hovi *et al.* (35) based on discussions within farmer focus groups in the UK, post-foot and mouth disease, provide further insight. Quite typically, they identified that one of the key factors in the successful implementation of a higher level of biosecurity (for example, in order to prevent the introduction of BVDV) is that 'others do their bit', i.e. farmers are more prone to engage in large-scale disease control if they are confident that any restrictions will apply equally to all and that any risks taken are shared.

Paterson *et al.* (65) point out how investments into disease control, including improved biosecurity, may create a 'public good' through improved animal welfare and the decreased risk of acquiring and perpetuating exotic disease in the event of an introduction. In the BVDV context, private investments in establishing a BVDV-free herd lead to both private and public good, because neighbouring and contact herds experience a reduced risk of acquiring BVDV infection. Correspondingly, the investment made by the farmer is better protected if others do the same. This model gives further explanation as to why farmers may be hesitant to control BVDV on a herd to herd basis, but may go ahead if it is in the form of a concerted action. Underlying the economic motives is also the social pressure to conform with any collective efforts. This factor has been suggested as one reason as to why there is such a

variation in disease status between countries and regions (25). Thus, the social pressure for disease control, and attitudes based on it, is likely to enhance any already existing differences in epidemiology and economics.

So, is it reasonable to believe that there could be a pan-European approach to BVDV control? Could BVDV be eradicated from Europe? The conclusions from the web survey and from the discussion above indicate that there may be attitude barriers that need to be overcome if there is to be a concerted action. However, if BVDV is acknowledged as a problem by policy-makers at the EU level, one way forward may be to create incentives for farmers' cooperative bodies or similar organisations to drive the issue of initiating control. Also, Gunn *et al.* (25) point out that the use of public support (funding) to get control initiatives started could be justified in terms of the wider societal benefits, for example to animal welfare.

Furthermore, international trade in livestock and livestock products is affected by differences in health status between nations and these differences can also affect the economic and social pressure for BVDV control. Bovine viral diarrhoea virus was recently added to the World Organisation for Animal Health (OIE) list of 'priority' diseases for international trade. The consequences of this are yet to be seen, but it is likely that it will lead to a reconsideration of the BVD situation in countries in which the disease is currently endemic, possibly creating a common target for a pan-European strategy.

Formulation of a general model for bovine viral diarrhoea virus control

An issue that has given rise to lively discussions within the network is the role and efficacy of vaccines versus zoosanitary approaches in BVDV control. Initially, vaccination and non-vaccination approaches were contrasted as either/or, largely reflecting the background of the network members. However, after realising that the basic views were very similar, the network has initiated a move away from this terminology. It now suggests that control strategies, for the sake of a constructive discussion, are better described as being non-systematic or systematic. In this new context, non-systematic approaches are measures lacking an organised effort to achieve and maintain freedom from BVDV, and where there is no surveillance in place to evaluate the effect of the interventions and to intervene if necessary. Examples are immunisation strategies using live or killed vaccines, and/or the test-and-slaughter of PI animals without implementing biosecurity measures, and without measures in place to evaluate the efficacy of the strategy. Systematic control, on the other hand, implies that there is a goal-oriented reduction in the incidence and prevalence of BVDV infections, implemented on any level from herd to

national, where the status of herds is being monitored so progress can be evaluated.

Three central elements of systematic control approaches can be identified:

- a) biosecurity aimed at preventing re-/introduction of the infection in free herds
- b) elimination of PI animals from infected herds
- c) surveillance to monitor the progress of interventions and to rapidly detect new infections.

If one or more of these elements are lacking in a BVDV control approach, it is by definition non-systematic.

In this context, the term 'biosecurity' involves all measures targeted at preventing between-herd transmission, but with strong emphasis on avoiding:

- contacts with PI animals
- introduction of PI animals or dams carrying PI foetuses.

However, there are other dimensions of biosecurity that should be considered when evaluating alternative ways of controlling disease and these are elaborated in further detail in the next section under the sub-heading 'Level of implementation'.

The role of vaccines in the systematic control context is that of an additional biosecurity measure. A number of pros and cons are associated with adding a vaccination regime to a systematic BVDV control scheme, and these should be considered before implementation (see section entitled 'Vaccination').

Using this new terminology, it can be concluded that systematic approaches historically have been successful in rapidly reducing the impact of BVDV infections in a manner that subsequently has led to eradication (36, 61, 98), whereas non-systematic approaches do not consistently achieve this. Also, systematic control and eradication programmes have been shown to be highly cost-effective (90). When unsuccessful attempts to control BVDV have been analysed, a common finding is that they lack one or more of the three elements mentioned above, i.e. the design of the scheme has either failed to prevent the introduction of infection, to remove all PI animals and/or to provide sufficiently updated and accurate information on the BVDV status of the herds.

Features of systematic bovine viral diarrhoea virus control schemes that sustain good progress

The underlying problem in areas with non-systematic control is that there are no measures in place aimed at

breaking the infectious cycle within and between herds in a sustainable manner, and therefore no progress is made in decreasing prevalence and incidence. More specifically, the real problems are failure to completely remove PI animals from infected herds and failure to prevent (re)introduction of the infection into herds that are (temporarily) free from the infection. Due to the continuous process of waning immunity (maternal or induced) in calves and vaccinated animals, immunity to BVDV at the herd level is rarely 100%. Persistently infected animals exert an enormous infectious pressure, and failure to remove them will inevitably lead to continued reproductive failures, including births of new PI animals, thereby maintaining the infectious cycle (49). Also, when there is a lack of awareness, limited implementation of biosecurity measures, and no systematic control framework, and trade in PI animals of all ages (and dams pregnant with PI foetuses) continues unhindered, BVDV is usually (re)introduced into herds that, for the moment, are free of the virus.

Once the decision to initiate control has been taken, different technical aspects of the design of the scheme will have to be explored, ranging from field organisation to the choice of diagnostic tests and test schemes. Below the authors discuss some aspects of the design of systematic control schemes, with a focus on those that appear to be important for the efficiency (and therefore the costs) of the scheme.

As with disease control efforts in general, strategies can be revised and amended over time, as a result of the progress of the scheme and the socio-political climate. Therefore, an initially 'weaker' scheme design can be improved and reach its end objective. However, in order to maintain good support from the stakeholders, and confidence in the measures imposed, promising progress within the first few years is very important.

Level of implementation

Clearly, the risk of contracting BVDV infection is strongly influenced by the prevalence of infected herds, in particular among those that share contact patterns. As mentioned in the previous section, systematic control can, from a technical perspective, be carried out at any level from herd to nation or above, but nevertheless, there is an additional benefit from implementing control at a higher level than the herd. If control measures affect many herds simultaneously, the risk of new infection will be reduced for all, including those that have a lower level of biosecurity. Thus, the organisational level on which systematic control is implemented – herd, compartment, region or nation – will have direct consequences for the risk of (re)infection, cost of biosecurity and, consequently, for the cost-benefit of the measures.

The probability of reinfection after eradication and the efficiency of any biosecurity measures are particularly important in evaluations of whether disease control should be initiated or not. Data provided by network members, describing the first five years of the Scandinavian schemes, show how the incidence was reduced by 50% within two years, and by 90% within five years (50). Historically, researchers may have underestimated the effect that large(r)-scale control has on the incidence risk, consequently, when (realistic) incidence estimates for areas without control are used in a model to evaluate different control options at the herd level, the 'do nothing' option will often turn out as more favourable than control (64).

Similarly, epidemiological factors that are perceived to be associated with a high risk of reinfection in areas without control (such as high prevalence/high herd density/large herds) (23) have not proved in reality to be barriers to systematic eradication. This can be exemplified by areas in Denmark and south-east Sweden, where initial prevalences of infected herds were around 50%, but where the progress of systematic BVDV control schemes has been faster than in low-prevalence areas like Finland and northern Sweden (44). It has even been suggested that given a concerted action to control BVD, the prospects for schemes to be more cost-efficient and successful are better in high density areas than in low density areas, because the preconditions for creating and maintaining awareness among stakeholders are better (see section on biosecurity below). This is counter-intuitive, but it is another situation in which social pressure may come into play, in a positive manner.

Wildlife as a source of virus has not been an issue in any of the areas in which systematic control has been carried out (38, 43, 57) and any exposure of wildlife appears to have been from cattle to wildlife, rather than the opposite.

Biosecurity

The authors would like to expand the biosecurity concept to encompass more than measures that farmers implement to avoid introduction of the virus and instead to include all measures that aid in preventing between-herd transmission. With this very broad definition, four specific factors can be identified that support biosecurity in the BVDV context:

- a) regulations
- b) stakeholder awareness
- c) access to correct/updated information on BVDV status (involving everything from sampling to how and when information is available for those who need it for decision making)
- d) the additional biosecurity gained from vaccination.

These factors are discussed in more detail below.

Regulations

Regulations (voluntary or compulsory) provide a formal framework that outlines what practical measures are required to break transmission between herds (including any additional use of vaccines). They also define what tests need to be undertaken to obtain and sustain a BVD-free status. It is possible to achieve good progress in BVDV control on a voluntary basis (without legally supported sanctions) if stakeholders are sufficiently educated and motivated, and this may be a way forward during the initial stages of a scheme. Also, for eradication on a sectoral basis (dairy/beef/breeders), it is possible that voluntary means could be sufficient to reach the goal. However, to achieve country-wide eradication, the experience has been that legislative support is needed in the end (9, 36, 76). For countries where a major part of the industry is owned by cooperatives, industrial demands and quality schemes may provide an alternative way to formalise participants' obligations to comply with the regulations of a scheme.

Moreover, in some countries without large-scale control, there is legislation that creates incentives to act upon BVD-related problems. For example, in 1985, before national control was being discussed in Germany, compensation for search and removal of PI cattle was available in Lower Saxony. Funding was provided through a partially government-financed body, 'Tierseuchenkasse Niedersachsen', but at first it was not associated with any further demands on biosecurity and sustainable maintenance of the PI-free status. However, since then, the legislation has been amended; it now includes all elements of systematic control (i.e. requirements for biosecurity, continual removal of PI animals, and surveillance) and has become a model for the German national approach to BVDV control (54). Greece also has legislation on BVD, ensuring that farmers are compensated by the government for cattle that die from confirmed MD. To benefit from this compensation, farmers must initiate control measures aimed at removing PI animals from the herd (C. Billinis, personal communication).

Today, eight European States have acknowledged BVD in their legislation by making it a notifiable disease: Austria, Belgium, Denmark, Finland, Germany, Norway, Sweden and Switzerland. In addition, transnational regulations may be introduced as a result of the recent decision by the OIE to list BVDV as a priority disease in terms of animal trade.

Stakeholder awareness

Stakeholder awareness is an important but rather abstract element of biosecurity. Awareness works as a first line of defence, because of the major influence that farmers' management decisions have on the risk of contracting

BVDV, e.g. routines for purchasing/introducing new animals, for pasture usage, vaccination, maintenance of fencing and so on. Awareness also affects the will to comply with regulations and endure any financial consequences during implementation of control.

Awareness of biosecurity is, theoretically, achieved through education and information and the efficiency of such activities are most likely a key factor for the success of these schemes. It is extremely valuable to harmonise the messages conveyed in order to avoid confusion. Once again, this task is made much easier if there is a common organisational framework and/or coordination.

The desired outcome of information and education efforts to increase awareness is a change in behaviour, i.e. make people implement measures that reduce the risk of between-herd transmission. However, the translation of theoretical knowledge to a desired behaviour is complex and highly individual. Fishbein and Ajzen (19) describe it as a function of an individual's attitudes and his/her subjective norms (social pressure), where the attitude is influenced by personal perceptions (positive/negative) regarding the outcome (in this case, biosecurity), and its importance. Attitudes are important in disease control. For example, a documented risk with vaccines is that they can convey a false sense of security and thereby lead to an increase in risky behaviour (14, 91). In the BVDV control context, this may lead to biosecurity policies being put in second place. The subjective norm – i.e. the perceived social pressure – depends on from whom a message comes and to what extent a person likes/trusts or dislikes/distrusts that source of information. Thus, a good relationship between stakeholders and programme managers is likely to be a key factor in compliance, not only in BVDV control, but for the control of infectious diseases in general (35). As mentioned earlier, this is one of the common denominators of current systematic schemes.

System for obtaining and disseminating information

Timely access to accurate and updated information on BVDV status supports biosecurity by helping people that are aware of BVDV risks to make correct decisions. Therefore, the design of the system for obtaining and disseminating information on herd – and individual – BVDV status is important. A sufficiently large and well-trained field organisation for sampling and competent laboratory services are parts of this system. It also involves the transfer of diagnostic information to those that need it for decision making, i.e. primarily farmers and livestock traders, but also veterinarians and other professionals with ambulatory farm services. The system can be designed in various ways, but the most important feature is that the data is updated and accurate.

Vaccination

In cattle-dense areas with intense animal trading BVD prevalence is usually high and PI cattle provide potent reservoirs for continuous reinfections of susceptible cattle. The lack of compulsory regulations for BVD control makes voluntary and non-systematic control efforts in such environments subject to the constant risk that cleared herds will become reinfected, thus adding excessive and unnecessary costs to the farmers. Thus, one option in the initial stages of control/eradication programmes is to implement systematic vaccination of cattle against BVDV. Herds that have been tested and are free from PI animals would then become engaged in a systematic context and vaccinated, with the goal of inducing and maintaining a high level of immunity against BVDV.

The potential benefits of adding a vaccination regime as a supportive biosecurity measure within a systematic scheme are:

- prevention of accidental (re)infection of herds that are free of PI animals and therefore reduction of direct and indirect losses caused by acute infection;
- prevention of transplacental infection and the genesis of new PI animals in infected herds. If the herd is undergoing virus elimination, this may significantly shorten the clearance period;
- fewer susceptible animals/herds and therefore reduced circulation of field virus and less infectious pressure in cattle populations in general;
- stakeholders in regions where the risk of (re)infection is perceived, or known, to be high, will feel reassured enough to proceed with a control scheme.

In a systematic BVDV control context, the need for including a vaccination regime will differ between countries/regions but it will also change over time, as the prevalence of infected herds decreases. In later stages of the control programmes when the incidence of new herd infections is negligible there is the option to discontinue vaccination in order to achieve full BVD-free status (56). Since adding a vaccination regime also implies an additional cost (for the vaccines themselves, and by hindering the use of cost-effective bulk milk antibody surveillance of dairy herds), it should be evaluated against the expected benefits on a regular basis.

Historically, widespread, non-systematic vaccination against BVDV has been used in many countries without any noticeable overall reduction of BVDV prevalence (62). Before there is data on how vaccines work in a systematic context with the same scale, the perception of their efficacy will run the risk of being confounded by this historical fact. Nevertheless, before implementing vaccination as an additional biosecurity measure in a systematic

control/eradication scheme, vaccination-related problems must be carefully analysed. These problems include the failure to follow vaccine protocols correctly (68). They also include safety and efficacy issues with the vaccines themselves. These limitations and problems are described below, with suggestions given for how they can be mitigated when vaccines are used in a systematic control context.

Antigenic variation

Bovine viral diarrhoea virus displays a significant antigenic diversity, although there are no distinct serotypes and there is cross-reactivity throughout all genetic groups and BVDV species (16, 26). This antigenic variation may interfere with the efficacy of vaccination, since immunity in vaccinated cattle is strongest against the homologous vaccine strain(s) and less pronounced against field strains of differing antigenic makeup. The higher the homologous immune response, the higher the degree of cross-protection. Therefore, any vaccination against BVDV should induce as high an immune response as possible. Frequent revaccination and/or the use of modified live vaccines (MLVs) may be suitable measures to keep immunity high. Also, if vaccines are used in a systematic context it is important to have surveillance of circulating strains in place, in order to evaluate the validity of the antigenic makeup of recommended products.

Incorrect use of live vaccines

The first BVD vaccines were modified live preparations of the cytopathic (cp) biotype of BVDV. In general, these vaccines yielded satisfactory results, however, it took several years before the risk of *in utero* transmission of vaccine virus to foetuses was properly understood. Despite the fact that cpBVDV apparently does not cross the placenta (12), foetal infections after vaccination have been observed. Most probably they were attributable to non-cp contaminants of the vaccine. Furthermore, if PI animals are vaccinated with MLV cpBVDV strains, MD may be triggered due to genetic recombination between the vaccine and the persisting virus (70). Incorrect use of MLVs in pregnant animals and the possibility of vaccine virus being shed by vaccinees and transmitted to pregnant cattle discredited this type of vaccine and led to the increased development of inactivated vaccines.

Goals of vaccination

As control concepts have evolved, the goals of vaccination have changed. For a long period following the registration of the first BVD vaccine, the purpose of vaccination was the prevention of clinical signs, e.g. diarrhoea and respiratory disease. Thus, when testing vaccines in challenge trials, the principal aim was to evaluate the effect of the vaccine in terms of reducing fever and possibly viraemia. However, in terms of the control of BVD infection, the disruption of the infectious cycle, i.e. prevention of the birth of PI animals, has proved to be far more important. The relative

inadequacy of many vaccines and vaccination protocols in preventing infection became apparent when foetal protection was explicitly required by veterinarians and farmers. Where vaccination becomes part of a systematic control programme, the best possible foetal protection will be the most important goal of vaccination.

Failure to elicit an adequate immune response

When the goals of vaccination changed from the rather unspecific claim of preventing clinical disease to the very clear objective of preventing BVDV-related reproductive failure, it became clear that a number of registered vaccines did not fulfil the more stringent requirements. There are doubts as to whether many current vaccines and vaccination protocols are able to fully prevent transplacental infections. In this context van Oirschot *et al.* (92) deplore the lack of reliable in-depth studies on BVD vaccine efficacy. The intensity and mode (humoral, cell-mediated) of the immune response and the duration of immunity after vaccination are salient issues. In the field, the duration and extent of foetal cross-protection, in particular against heterologous strains, is not clear and breakdowns among vaccinated animals have been reported (20, 22, 41). Once again, this is confounded by the fact that the vaccines have not necessarily been applied within a systematic context (with biosecurity and removal of PI animals). In a systematic scheme, surveillance would ensure that vaccine failures leading to the development of PI animals would be detected.

Failure to remove persistently infected animals in a systematic manner and to prevent reintroduction

Most non-systematic control attempts do not include the removal of PI cattle. On the contrary, PI animals have been considered to be a cheap means of 'vaccinating' herds. In addition, it was thought that most of them would die anyway within a short time after birth. These strategies have never been proven to be successful. Also, the ethical dilemma with keeping infectious animals for deliberate exposure of susceptible peers has become an issue. In addition, experience suggests that a policy of systematic vaccination alone, i.e. without prior removal of PI animals, fails in the long run to reduce the overall BVD prevalence of a larger cattle population. Apparently, PI animals exert such an enormous infectious pressure, and since only one unprotected animal is required to produce a new PI calf, the infection can continue to persist in the herd even with only limited failure in vaccine protection (49).

Similarly, removal of PI cattle is not sufficient a measure alone to keep a herd free if there are continuous reintroductions. As described earlier, removal of PI cattle has to go hand-in-hand with increased biosecurity, focused on preventing introduction of PI livestock or dams pregnant with PI foetuses (49, 80). Vaccination is, in this context, an additional biosecurity measure to ameliorate the consequences of reintroduction by other means.

Failure to adhere to control strategies

As with other infectious disease control programmes, an uncommitted or non-systematic approach can never be successful. Full commitment to biosecurity routines and adherence to an efficacious vaccination programme are essential for success. The fact that some farmers and veterinarians often do not correctly adhere to vaccination strategies might be an additional interfering factor in the failure of vaccination to reduce the overall BVD prevalence (68). In one large survey in Pennsylvania, only 27% of BVDV vaccines were used correctly in the field; this would have profound effects on the efficacy of any vaccine. Likewise, frequent movement of (unmonitored) cattle interferes considerably with control efforts. Most of these problems go back to the earlier described issues of stakeholder awareness/motivation and the needs for education and information, and this is most likely where the remedy is to be found.

Diagnostic confounding

The current view is that vaccinated animals cannot be accurately distinguished from animals that have undergone natural infection (although enzyme-linked immunosorbent assay [ELISA]s based on p80 monoclonals may provide partial discrimination between natural immunity and immunity induced by [some] inactivated vaccines [21]). Consequently, the use of today's vaccines will confound test results based on serology. One consequence of this is, for example, that the option to use cost-efficient techniques such as antibody testing on samples from older animals for surveillance (e.g. bulk milk) is obliterated. It also removes the option of using serological pre-screening to improve the performance of test strategies aimed at finding PI animals (see the previous section on Biosecurity).

Currently, the alternative to serological surveillance of non-infected vaccinated herds is to keep an unvaccinated group of young animals as sentinels (see later section on Surveillance). Alternatively, the availability of a marker vaccine against BVDV would provide a solution to the above-mentioned limitations. At the time of publication, there is no such product on the market.

Spread of bovine viral diarrhoea virus by injectables and vaccines against other viral infections

It has been shown that injectables contaminated with BVDV have the potential to be vehicles for BVDV transmission from infected to non-infected herds (59). Although the amount of virus may be small, it is sufficient when the natural barrier is overridden. Adding a vaccination regime to a systematic control scheme increases the frequency by which animals are exposed by this route. Consequently, when vaccines are used in a systematic control scheme, a high level of hygiene must be maintained.

The risk of contaminating MLVs with field strains from foetal calf sera remains. Unfortunately, the management of this risk is in the hands of the manufacturers rather than of control programme managers. Since many biologicals intended for veterinary use are manufactured with foetal calf serum originating from different parts of the world, BVDV strains exotic to Europe may be introduced by this route. It would be wise to suggest that programme managers inform stakeholders about this risk when planning to use live vaccines in a systematic BVDV control context. Once again, surveillance should be designed so that any breaches can be detected and investigated.

Naturally, the risk of contamination is not limited to BVDV vaccines. Recently, BVDV was spread in the Netherlands through live, contaminated BHV-1 vaccines (4). The economic impact of this incident was considerable and so was the loss of confidence among veterinarians and farmers in using live vaccines for disease control. Consequently, widespread usage of live vaccines for cattle diseases other than BVDV can be a problem for systematic control of BVDV. In countries where such control programmes are carried out, special requirements regarding freedom from BVDV contamination should be specified for vaccines against other ruminant viral infections.

However, despite these shortcomings, there is evidence that vaccination in conjunction with identification and removal of PI animals on a herd basis can provide additional protection in case of accidental reintroduction of BVDV (86), particularly where there is still a high regional prevalence of BVDV infection. By implementing this strategy, BVD-related economic damage involving PI animals can be prevented (17). The additional cost of including a vaccine regime within a systematic scheme should of course be weighed against this expected benefit. Further details on strategies for implementing vaccination in systematic control, where the above-mentioned issues are taken into consideration, are described in the position paper of the EU TN work package on vaccines and vaccination strategies (56).

Elimination of persistently infected animals

Protocols for eliminating BVDV from infected herds have been described in detail elsewhere (45). In brief, they involve testing all animals in the herd with the purpose of identifying PI animals – through an initial round where the status of all animals present in the herd is determined and subsequently by testing all calves born during the following year.

A diagnostic strategy that has proven to work well in unvaccinated populations is to test for antibodies prior to testing for virus (serological pre-screening), and only test

for virus on animals which have very low or negative antibody levels. The advantages of doing so are:

- a) a reduction in the number of virus tests needed (this is an advantage if virus tests are more expensive than antibody tests)
- b) an increase in the sensitivity of the testing strategy (providing a means to detect false negative PI animals by seroconversions in other, expectedly negative, animals)
- c) a general increase in the positive predictive value by the fact that a high risk population is targeted (78).

In systematic control schemes with vaccination, this option is likely to be less useful, and the most common strategy may be to test for virus only. This approach requires a highly accurate virological test, as otherwise, false negative PI animals may go undetected. A way to mitigate this risk is to regularly perform serological screening on unvaccinated animals (see Surveillance below), as a means of detecting whether PI animals have been missed. There is another potential additional advantage with serological pre-screening in infected herds where vaccination is considered for the first time, in that animals that are antibody positive (from natural infection) can be excluded from vaccination.

Most currently used tools for virological diagnosis are impaired by interference with maternal antibodies, which means PI animals cannot be accurately identified until colostral immunity has waned (10, 63). Even if some assays appear to perform better than others on samples from young PI calves with passive immunity, e.g. immunohistochemistry on ear notch samples (11) and antigen ELISAs targeting E^{ns} rather than NS2-3 (39), the diagnosticians need to be aware that they still may get false negative results with samples from such animals. Reverse transcriptase-polymerase chain reaction (RT-PCR) assays seem to overcome this specific diagnostic problem. However, the ultimate goal would be to eliminate PI animals before they are born, so that they cannot start causing damage. Methods for accurately identifying dams carrying PI foetuses have been investigated (foetal fluid sampling/serology), but they have limitations in terms of safety/feasibility on the one hand and sensitivity in early gestation and specificity at later stages on the other (47, 48, 81). Consequently, improvements in this respect would provide a valuable tool for more efficient clearance of infected herds.

Surveillance

The surveillance performed in a systematic BVDV control scheme serves many purposes, for example:

- to identify free herds and confirm their status
- to detect new cases of BVDV infection

- to prevent transmission from infected herds, including introduction of virus through importation

- to monitor strains circulating in the population in order to accurately target further development of diagnostic techniques and vaccines, as well as to detect introductions of exotic BVDV strains.

Identification of free herds, confirmation of their status and detection of new cases of bovine viral diarrhoea virus infection

Activities directed towards the (expectedly) non-infected part of the population are typically based on antibody testing. An exception is the enrolment procedure, i.e. the tests that herds have to go through in order to qualify as BVDV-free. Both serological and virological methods are being used for this purpose; the choice of strategy seems to be dependent on whether the average candidate herd is likely to be infected or not (50). Apart from this exception, sampling methods are based on bulk milk or on samples (serum or milk) from a representative small sub-group of animals, analysed individually or as a pool (5, 29, 58). The ability to use herd level screening tools for surveillance has greatly contributed to the cost-effectiveness and acceptance of systematic BVDV control schemes (90).

In areas without control, or with voluntary control, laboratory investigations into cases of abortion may provide an additional way of identifying (newly) infected herds. However, the sensitivity of BVDV detection in aborted material is sub-optimal and improvements would be of value.

As indicated above, no marker vaccines for BVDV are available. Thus, the current view is that vaccinated animals cannot be accurately distinguished from animals that have undergone natural infection. One consequence of this, as stated earlier, is that the option to use antibody testing on samples from older animals for surveillance, such as bulk milk, is lost. When vaccines are used in a systematic control context, this can be solved by keeping an unvaccinated sentinel group of young animals from the time they are six months of age until the time they need to be immunised before their first pregnancy. By monitoring this group for BVDV antibodies, biosecurity breaches resulting in new infections can be detected. Also, in herds undergoing virus clearance, any residual infectivity resulting from false negative (virological) test results can be rapidly detected. Naturally, such a strategy is dependent on close association between sentinel youngstock and the main herd.

Prevention of transmission from infected herds

Another objective of surveillance activities is to detect incursion and prevent transmission by movements of livestock, semen and embryos from infected to free herds.

For livestock, the status of individual animals can either be assessed based on herd information (free herds that have an updated ascertainment of their status) or by testing individual animals. Current diagnostic tools are quite well adapted to this purpose.

For (international) movements of semen, control measures can be a combination of requirements for information about the status of the bull, and diagnostic testing of the semen itself. Virus isolation or RT-PCR methods can be used for testing semen, but may need improvement if they are to be reliable when using this type of sample material.

Surveillance of imported embryos is more complicated – direct testing of the product is less feasible, as embryos are relatively more valuable and cannot be batch-tested like semen. Also, the inherent risk of contaminating *in vivo* derived embryos by using bovine foetal serum in the washing process suggests that the status of the donor and the semen used is less relevant for assessing the risk of virus transmission via embryo than it is for transmission via semen (46, 84). This is even more relevant for *in vitro* fertilised embryos (83). Sero surveillance by individual testing of recipients is a possible compromise, though it will not prevent infection and possible spread.

Molecular surveillance of circulating strains

Continuous collection and evaluation of genome data on circulating BVDV strains are another important target for surveillance. These activities have numerous advantages (78). Firstly, they provide an early warning system in case exotic BVDV strains are introduced, which would imply breaches in the national or regional biosecurity. Secondly, if vaccines are used, their antigenic appropriateness can be evaluated. Finally, genome data can provide a tool for tracing new herd infections, which is particularly valuable in the final phase of eradication (81).

The genome of BVDV is well characterised, and large numbers of nucleic acid sequences are available from academic databases. However, there is a clear need for standardisation. The standard of genetic typing of new BVDV isolates may be improved if a BVDV sequence database is established. This should include protocols for expert scrutiny of submitted sequences, and also give guidelines on standardised genotyping protocols and interpretation of results. The demonstration version produced by the EU TN could be developed further for this purpose.

Quality assurance and standardisation of diagnostic investigations

Currently, there is no organised assessment of the performance of laboratory diagnostic investigations for BVDV. As mentioned earlier, the OIE recently recognised

BVD as a listed disease, due to its significant international spread and significance for trade. In compliance with the demands for listed diseases, the performance of laboratory diagnostic assays for BVDV needs to be supervised, preferably by an EU community laboratory for BVDV. The authors recommend that such an EU reference laboratory for BVDV is established. It would be the responsibility of this laboratory to prepare sets of biological standards for evaluating tests and make them available to companies and to diagnostic laboratories. Also, the reference laboratory should perform regular proficiency tests. One such test was performed within the network, focusing on serological assays. Preliminary findings are that the overall diagnostic performance was good, but that there are minor areas of improvement or for better calibration of cut-off levels (T. Sandvik, personal communication).

Guidelines for integrated use of diagnostic tests in systematic control schemes

In countries where systematic programmes for BVDV control have been implemented, laboratory diagnostic assays have been selected for surveillance of supposedly free herds, for detection of recent herd infections and for zoosanitary interventions where individual animals are tested. In many cases, the same assays are used for all purposes, albeit with different cut-offs, and in most cases they perform satisfactorily. Nevertheless, to prevent diagnostic errors and avoid reaching conclusions based on erroneous results, it is important to be aware of the possible shortcomings of individual laboratory assays and whether or not they are suited to combined diagnostic use. The authors recommend that guidelines for the performance of diagnostic tests for BVDV should be issued. An expert panel able to give advice on combinations of diagnostic tests to be run in control programmes should be nominated.

Future challenges and conclusions

Recently, a potentially new pestivirus species was detected by German researchers (79). This virus was isolated from a batch of foetal bovine serum imported from Brazil. Clinically, it behaves like most primary infections with BVDVs, producing only mild disease. Antibodies to both BVDV-1 and 2 show limited cross-reaction with this virus and this exemplifies how the introduction or emergence of new BVDV strains could affect the sensitivity of serological and virological assays based on monoclonals or RT-PCR primers for BVDV-1 and 2, and consequently compromise any efforts to control the disease. Similarly, there is the possibility for escape mutants to develop during the implementation of large-scale control. This highlights how

the continuous improvement of diagnostic tests, and monitoring of their performance, is central to sustainable BVDV control. Similarly, where vaccines are used, there will be a constant need to develop and adapt them for use with the evolving strains that circulate in the cattle population.

It is clear that unless BVDV control efforts are harmonised across Europe, there will always be a threat of spreading BVDV, including the less prevalent BVDV-2 and any new types that may emerge, across the continent. Non-systematic use of any type of live cattle vaccine can increase this risk. However, efficient systematic control measures with or without the use of vaccines will provide the necessary protection. A challenge for the future is to find a joint platform where differences in needs and preconditions between member states can be accommodated, while still promoting concerted action on BVDV control.

In 2001, the Academy of Veterinary Consultants, a North American association of veterinarians involved in beef cattle medicine responded to the problems associated with BVDV infections by drafting a policy document with the ultimate aim of eradicating BVDV from the United States of America (40). Since then, the OIE has added BVDV to its list, a strong signal that the disease has become an international priority. With the achievements by member states so far, and with the concept put forward by the TN, the EU is in a good position to meet increased standards. But the Union needs to be proactive, both in the political and scientific field, to retain this position.

A pan-European approach to controlling BVDV should not be seen as a 'mission impossible' but rather as an opportunity to increase the biosecurity standards in cattle operations across the Union in a more general sense. In this way, BVDV control would contribute to overall efforts to prevent the introduction and spread of other zoonotic and epizootic agents. This is in addition to the potential for long-term improvement in bovine health and welfare and consequently, the future competitiveness of Europe's cattle industry.

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La lutte contre le virus de la diarrhée virale bovine en Europe : situation actuelle et perspectives d'avenir

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Résumé

Le présent article résume le point de vue d'un groupe européen de scientifiques qui participent à la lutte contre le virus de la diarrhée virale bovine (BVDV) dans le cadre d'un Réseau thématique de l'Union européenne. Le groupe a conclu que l'on dispose des outils techniques et des connaissances nécessaires pour éradiquer le BVDV, comme le prouvent les bons résultats des programmes nationaux de prophylaxie menés dans plusieurs pays européens. Un modèle

général applicable au contrôle du BVDV est présenté, dont les éléments centraux sont la biosécurité, l'élimination des animaux infectés de façon persistante et la surveillance. Ces éléments sont qualifiés de « systématiques », à la différence des actions de prophylaxie dénuées d'objectifs clairs et d'un suivi des progrès accomplis. Le réseau conclut qu'une approche systématique est nécessaire pour parvenir à une réduction durable de l'incidence et de la prévalence du BVDV en Europe. La vaccination dans le cadre des programmes systématiques de prophylaxie est considérée comme une mesure de biosécurité supplémentaire, dont les effets doivent être évalués par rapport à son coût, à son innocuité et à son efficacité.

Il a également été conclu que la participation active des associations d'éleveurs favorise grandement le processus qui conduit à la mise en œuvre d'une action de lutte et que le financement public visant à appuyer le lancement des programmes organisés de lutte contre la diarrhée virale bovine peut se justifier par l'accroissement des bienfaits sociétaux attendus, tels que le bien-être animal et la réduction du recours aux antibiotiques. La priorité accordée à la biosécurité, si elle est appliquée avec succès, dans le cadre des programmes systématiques de contrôle de la diarrhée virale bovine permettrait également de réduire le risque d'introduction et de propagation d'autres agents épizootiques et zoonotiques, ce qui s'accompagnerait d'une amélioration de la santé et du bien-être des bovins en général, ainsi que d'un accroissement de la compétitivité de la filière bovine.

Mots-clés

Bovin – Diagnostic – Épidémiologie – Éradication – Génome – Pestivirus – Risque – Socio-économique – Surveillance – Vaccination.



Presente y futuro de la lucha contra el virus de la diarrea viral bovina en Europa

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Resumen

En este artículo se resumen las opiniones de un grupo europeo de científicos que interviene en la lucha contra el virus de la diarrea viral bovina (VDVB) como parte de una red temática de la Unión Europea. Dicho colectivo llega a la conclusión de que ya existen los instrumentos técnicos y el conocimiento necesarios para erradicar el virus, como demuestra el éxito de los planes nacionales de control aplicados en varios países europeos. Los autores presentan un modelo genérico de lucha contra el VDVB, cuyos elementos centrales son la bioseguridad, la eliminación de animales con infección

persistente y la vigilancia. Esos elementos se califican de 'sistemáticos', por oposición a actividades de lucha realizadas sin objetivos claros ni mecanismos de vigilancia para evaluar sus efectos. La red extrae la conclusión de que es preciso aplicar planteamientos sistemáticos para reducir de forma duradera la incidencia y prevalencia del VDVB en Europa. Los autores examinan también el uso de vacunas como medida complementaria de bioseguridad en los programas sistemáticos de control, procedimiento cuyos frutos convendría evaluar en relación con su costo y con los niveles de inocuidad y eficacia que ofrezca.

Los autores concluyen asimismo que la participación activa de las organizaciones de productores facilita sobremedida el proceso que culmina con la aplicación de programas de control, y que el uso de fondos públicos para apoyar el inicio de programas organizados de lucha contra el VDVB puede justificarse por los beneficios generales que presumiblemente reportarán a la sociedad, en forma por ejemplo de bienestar animal y de menor uso de antibióticos. Si se hace correctamente, el hecho de prestar especial atención a la bioseguridad en los programas sistemáticos de lucha contra el VDVB reduciría también el riesgo de introducir y diseminar otros agentes epizooticos y zoonóticos, lo que a su vez mejoraría tanto el estado sanitario del ganado como el bienestar en general, además de acrecentar la competitividad de la industria ganadera.

Palabras clave

Diagnóstico – Epidemiología – Erradicación – Ganado bovino – Genoma – Pestivirus – Riesgo – Socioeconómico – Vacunación – Vigilancia.

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