Economic comparison of the monitoring programmes for bluetongue vectors in Austria and Switzerland

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With the bluetongue virus serotype 8 (BTV-8) outbreak in 2006, vector monitoring programmes (according to EU regulation 1266/2007) were implemented by European countries to obtain information on the spatial distribution of vectors and the vector-free period. This study investigates the vector monitoring programmes in Austria and Switzerland by performing a retrospective cost analysis for the period 2006–2010. Two types of costs were distinguished: costs financed directly via the national bluetongue programmes and costs contributed in-kind by the responsible institutions and agricultural holdings. The total net costs of the monitoring programme in Austria amounted to €1,415,000, whereby in Switzerland the costs were valued at €94,000. Both countries followed the legislation complying with requirements, but differed in regard to sampling frequency, number of trap sites and sampling strategy. Furthermore, the surface area of Austria is twice the area of Switzerland although the number of ruminants is almost the same in both countries. Thus, for comparison, the costs were normalised with regard to the sampling frequency and the number of trap sites. Resulting costs per trap sample comprised €164 for Austria and €48 for Switzerland. In both countries, around 50% of the total costs can be attributed to payments in-kind. The benefit of this study is twofold: first, veterinary authorities may use the results to improve the economic efficiency of future vector monitoring programmes. Second, the analysis of the payment in-kind contribution is of great importance to public authorities as it makes the available resources visible and demonstrates how they have been used.

Generally, vector-borne diseases present a (re-)emerging threat to Europe (Schaffner and others 2013), the most prominent recent example of this is bluetongue disease, an arboviral disease among ruminants, transmitted by biting midges of the genus Culicoides. In 2006, bluetongue virus serotype 8 (BTV-8) emerged for the first time in Europe between the neighbouring countries the Netherlands, Belgium, Germany and Luxemburg (Glister and others 2007, Mehlhorn and others 2007, Elbers and others 2008, Saegerman and others 2008) and tens of thousands of farms were affected (Robin and others 2014). In order to provide information about BTV-8 transmission dynamics or the freedom of BTV-8 in the European countries, monitoring and surveillance programmes were initiated in 16 regions in accordance with EU regulation 1266/2007 (Häsler and others 2012). In general, both monitoring and surveillance systems include a systematic data collection and provide valuable information for veterinary authorities about transmission, distribution of or freedom from diseases (Vázquez-Prokopec and others 2010). A monitoring programme, in contrast to surveillance, does not contain possible subsequent interventions (Drewe and others 2013b, Hoinville and others 2013). In the context of BTV-8, for example, a vector monitoring programme was implemented by a number of European countries. The midges were captured by light traps to obtain information on their distribution and seasonal activity. Nonetheless, the limited resources in the veterinary public health sector raise the question whether the information gained from such monitoring programmes is in adequate balance with the associated costs (Stärk and others 2006, Drewe and others 2015b, Hoinville and others 2015). For example, in the study by Drewe and others (2013a), gaps in the resource allocations for livestock health surveillance programmes in Great Britain were identified.

It is well recognised that an evaluation of such programmes is important for public authorities (Haghparsad-Bidgoli and others 2014); first, to analyse whether the objectives of monitoring have been achieved (effectiveness), and second, whether the objectives of monitoring activities have been realised in an efficient manner (Drewe and others 2013b) without wasting resources.
With an area of around 83,850 km², Austria is more than twice as large as Switzerland (41,200 km²), whereas the size of the human population is 10.1 million in Austria and 2.07 million in Switzerland. Climate zones and Culicoides species distribution in Europe is provided, for example, by Goffredo and others (2004), Ander and others (2010), and Brugger and Rubel (2013a).

This was the first vector monitoring programme in Austria. Consequently, at the time of the BTV-8 outbreak in Europe in 2006, only rudimentary knowledge about the vectors was available (Anderle and others 2008). In order to obtain information on the abundance, the geographical distribution (particularly of Culicoides obsoletus as the main vector for transmission of BTV-8) and the vector-free period, a total number of 54 trap sites were selected in Austria (Fig 1). Trap sites were chosen by the application of 40×40 km² grids, within which one farm with at least 10 cattle was allocated. The responsible institutions were the Federal Ministry of Health (Bundesministerium für Gesundheit (BMG)), the International Research Institute of Entomology of the Natural History Museum Vienna (NHM) and the Austrian Agency for Health and Food Safety (Agentur für Gesundheit und Ernährungssicherheit (AGES)). After the initiation of the planning phase in October 2006, the monitoring began in June 2007 and continued until June 2010. Midges were collected weekly on Mondays from dusk till dawn with black-light traps from the Onderstepoort Veterinary Institute (Sehnal and others 2008). The official veterinarians of each Austrian district were instructed to operate the traps and to send the collected midges to the NHM for morphological determination and counting.

Results of the Austrian monitoring programme were summarised in the project reports (Loitsch and others 2009, 2010).

In Switzerland, the vector monitoring programme was run by the Swiss Veterinary Office (Bundesamt für Lebensmittelsicherheit und Veterinärwesen (BLV)) and the Institute of Parasitology at the University of Zurich (IPZ) and the Institute of Tropical Medicine and Global Health at the University of Basel (ITMB). The results of this monitoring programme were summarised in the project reports (Loitsch and others 2009, 2010).

Materials and methods

Vector monitoring programmes in Austria and Switzerland

In both countries, Austria and Switzerland, the national vector monitoring programmes were established in accordance with EU regulation 1266/2007 (http://eurlex.europa.eu) to investigate the occurrence and geographical distribution of midges in European countries. A review of Culicoides species distribution in Europe is provided, for example, by Goffredo and others (2004), Ander and others (2010) and Brugger and Rubel (2013a).

FIG 1: Locations of the 55 Austrian (red dots) and 19 Swiss trap sites (blue dots). Note that each programme also operated a trap in Liechtenstein.
and others (2008), BVET (2009) and Schorer and Schwermer (2012). Each year a trainee uninstalled seven traps after the catching period and reinstalled the traps at the beginning of the next catching period in Switzerland. These and other differences between the two monitoring systems in Austria and Switzerland are summarised in Table 1. It should also be noted that both Austria and Switzerland operated one additional light trap in the neighbouring country of Liechtenstein.

Cost calculations

In a first step, the major cost factors were determined by analysing the activities needed to establish and run a vector monitoring programme (see online supplements). These comprised costs for planning, implementation, analysis, documentation and finalisation. Generally, this study differentiated the major costs into labour, material and other costs. Cost calculations for the five monitoring stages are summarised in Table 2 and explained in more detail in the following.

The net labour costs were calculated by the number of man-hours multiplied by the official hourly wage rate. In Austria, two different hourly wage rates were applied. The first hourly wage rate of €45.00 was based on the signed contract for employees of the NHM, the second hourly wage rate of €71.70 represents the average for an Austrian veterinary officer of BMG, AGES and federal states, estimated from the national pay grade level. Time sheets of the involved employees (as far as available) were used for calculating the labour costs for specific activities. If data were missing, values from the staff involved were used. Corresponding hourly wage rates in Switzerland were €19.20–25.70 for non-academic staff and €72.60 for academic staff.

Labour costs for the planning phase CP comprised costs for budget calculation, review of literature and selection of trap locations, procurement and distribution of traps and related equipment, training events for employees from involved institutions and meetings. Labour costs for the implementation stage CI comprised costs for installation of new traps, maintenance and repair of traps, collection and preparation of samples, as well as meetings. Labour costs for the analysis phase CA comprised costs for morphological determination of midges and virus detection. Additional labour costs arose for documentation CD and finalisation CF of the vector monitoring. The latter included, for example, labour costs for dismantling traps after the collection period.

Material costs arose for planning, implementation and analysis, respectively. For the implementation stage, they were divided into costs for traps and related equipment, thermometers, climate data and packing material. Insight into the accounting system of the federal governments allowed us to estimate these costs. However, other costs comprised mainly callout charges for official veterinarians and costs for transport, electricity and catering, which were explicitly displayed for the implementation and included in the lump-sums for planning and finalisation. The calculation of these costs can be found in the online supplements.

Additionally, it was distinguished between costs financed by the bluetongue monitoring programme according to the EU regulations and the payment in-kind contribution of national public institutions such as BMG, AGES, BLV veterinary offices and agricultural holdings. The latter were considered as hidden costs, generally not declared in official reports. Further, the cost fraction co-financed by the EU was estimated, although it is only relevant for the member state Austria. For both programmes, equal effectiveness is assumed, for example, an equally good chance of catching midges.

In the second step, the costs of the programmes were normalised according to trap samples, as both the number of trap sites and the number of sampling weeks differed between the two countries. It should be noted that sampling areas of 1600–2100 km² per trap are similar in both countries. Further, the Bray-Curtis dissimilarity measure \( BC_{m_{A,S}} \) (Bray and Curtis 1957, Clarke 1998) was used to compare the monitoring costs of Austria \( C_{m_{A}} \) and Switzerland \( C_{m_{S}} \) for the five monitoring stages introduced above. If \( BC_{m_{A,S}}(a)=0 \), the activity costs \( a \) within a monitoring stage are similar. Maximal differences in the activity costs were estimated for \( BC_{m_{A,S}}(a)=1 \). The Bray-Curtis dissimilarity measure for each monitoring stage is defined as follows:

\[
BC_{m_{A,S}}(a) = \frac{1}{2} \sum \left( c_a - \frac{c_a + c_A}{2} \right) \]  

where the sum of all cost activities \( a \) is calculated for a specific monitoring stage listed in Tables 2 and 3.

Results

The net total costs for the Austrian bluetongue vector monitoring amounted to €1,414,583 and are depicted in Table 2. A total of €689,660 (48.8 per cent) can be allocated to the national bluetongue monitoring programme and the remaining €724,923 (51.2 per cent) as in-kind contributions of the participating institutions. The costs mainly accrued from the implementation stage with a share of €661,472 (46.8 per cent), followed by analysis costs of €566,948 (40.1 per cent) and to a much lesser extent by documentation costs of €122,269 (8.6 per cent). The lowest costs were calculated for planning with €63,567 (4.5 per cent) and finalisation with €327 (0.02 per cent), respectively. Considering the cost allocation divided by labour, material and others, the largest amount of €1,287,012 (91.0 per cent) was attributed to labour costs, followed by €71,862 (5.1 per cent) for others and €55,709 (3.9 per cent) for material. All material was officially financed by the national bluetongue monitoring programme, but 51.6 per cent of the labour costs and 85.2 per cent of the other costs were estimated as national in-kind support.

In contrast to Austria, a significant lower financial effort was calculated for the bluetongue monitoring programme in Switzerland, resulting in total costs of €95,059 (Table 3). As in Austria, about half of these total costs were accounted for payment as in-kind contributions. The Swiss analysis costs of €37,550 were followed by implementation costs of €35,763 causing together >75 per cent of the total costs. The Swiss costs for labour, material and others were allocated as follows: labour €79,565 (85.5 per cent), material €180 (0.7 per cent) and others

| TABLE 1: Comparison of the Austrian and Swiss vector monitoring programmes for the period 2006–2010 |
|-----------------|-----------------|-----------------|
| Criteria for comparison | Austria | Switzerland |
| Responsible institutions | BMG, AGES, NHM | BLV, IPZ |
| Aims of the monitoring | Obligatory EU regulation | Voluntary EU regulation |
| Previous expert knowledge | Low | High (monitoring since 2003) |
| Exclusive national monitoring | Yes | No |
| Combined with sentinel surveillance | Yes | Yes |
| Virus detection in midges | October 2006–May 2007 | March 2007–September 2007 |
| Planning period | June 2007–June 2010 | October 2007–May 2010 |
| Monitoring period | 52 weeks/year | 34 weeks/year |
| Catching period | 55 | 19 |
| Number of trap sites | 52 weeks/year | 34 weeks/year |
| Take care of traps | Veterinary officer | Farmers |
| Training for trap care | Yes | No |
| Dispatching frequency of samples | 4/month | 2/month |
| Dismantling of traps | After three years | Each year |

Note that Switzerland is not a member state of the EU, but signed a bilateral agreement for the implementation of EU regulation 1266/2007 AGES, the Austrian Agency for Health and Food Safety, BLV, the Swiss Veterinary Office, BMG, the Federal Ministry of Health, IPZ, the Institute of Parasitology at the University of Zurich, NHM, the International Research Institute of Entomology of the Natural History Museum Vienna
the question arises whether the costs of these vector monitoring programmes are justified. Specifying these costs, as presented here, may contribute to answering this question.

Our study has shown the financial effort necessary to collect information on the spatial distribution of vectors, their abundance and the vector-free period. In principle, such economic data are rare and difficult to obtain (Drewe and others 2013b). To date, no cost analyses have been carried out for the Austrian monitoring and surveillance systems. In Switzerland, these costs have recently been published by Häslar and others (2012). The costs of the vector programme in Switzerland were calculated to be 3.9 times lower than in this study (Häslar and others 2012). It is important to note that the quantification of the costs is mainly dependent on the provided documents. A certain lack of documentation was found for all in-kind contributions, particularly in the present study. A better documentation of the in-kind performance would be preferable in order to demonstrate the total financial effort in a more convincing way. In this context, the in-kind contribution can also be considered as fixed costs. In contrast to the variable costs, the fixed costs are rarely quantified in the literature (personal communication, 2013). However, the demonstration of the in-kind contribution is beneficial for two reasons. First, it could help to increase the country’s bargaining power vis-à-vis the European Commission with regard to the maximum co-financing rate of the costs for a programme compared with when only the financed costs are shown. Second, the presentation of in-kind contributions is of great importance to public authorities as it makes the available resources/capacity visible and demonstrates how they have been used. Analysing the costs by payment source reveals that the Austrian in-kind contributions were mainly covered by the public (99 per cent) and were primarily allocated to staffing costs (91 per cent). In Switzerland, on the other hand, 26 per cent of the costs were

| Activities | Financed | In-kind | Subtotal |
|------------|----------|---------|----------|
| Planning costs C_P | 22,681 | 40,886 | 63,567 |
| Labour | 15,840 | 40,886 | 56,726 |
| Budget calculation | 2678 | 2367 | |
| Review of literature and selection of trap sites | 2250 | 2367 | |
| Procurement and distribution of equipment | 1530 | 9899 | |
| Training events | 4252 | 12,911 | |
| Meetings | 5130 | 13,342 | |
| Material | 2000 | - | 2000 |
| Other | 4841 | - | 4841 |
| Implementation costs C_I | 39,839 | 621,633 | 661,472 |
| Labour | 765 | 560,427 | 561,192 |
| Installation, maintenance and repair of traps | - | 7532 | |
| Collection and preparation of samples | - | 550,456 | |
| Meetings | 765 | 2439 | |
| Material | 33,586 | - | 33,586 |
| Black-light traps and related equipment | 26,570 | - | |
| Thermometers and climate data | 739 | - | |
| Packing material | 6277 | - | |
| Other | 5488 | 61,206 | 66,694 |
| Callout charges for veterinarians | - | 39,151 | |
| Transport | 5488 | 21,880 | |
| Electricity | - | 175 | |
| Catering | - | - | |
| Analysis costs C_A | 563,363 | 3585 | 566,948 |
| Labour | 543,240 | 3585 | 546,825 |
| Determination of midges | 543,240 | 3585 | |
| Detection of bluetongue virus | - | - | |
| Material | 20,123 | - | 20,123 |
| Documentation costs C_D | 63,450 | 58,819 | 122,269 |
| Labour | 63,450 | 58,819 | 122,269 |
| Finalisation costs C_F | 327 | - | 327 |
| Labour | - | - | |
| Other | 327 | - | 327 |
| Total costs C_Tot | 689,660 | 724,923 | 1,414,583 |
| Financed by the EU | 266,772 | - | 266,772 |
| Financed by national resources | 422,888 | 724,923 | 1,147,811 |

*Labour costs partially/completely estimated by involved staff

Discussion
The results show that the vector monitoring programmes incurred considerable costs in Austria (€1,414,583) and Switzerland (€95,059). These costs must be contrasted with a relatively small number of 28 BTV-8 positive cattle on 14 Austrian farms (Brugger and Rubel 2013b) and 160 infected animals reported on 70 Swiss farms (Schorer and Schwermer 2012). It should also be noted that this small number of cases may be the result of vaccination in the neighbouring Germany, but also to a lesser extent in Austria and Switzerland. Therefore,
borne by the farmers operating the traps. Presumably these costs are underestimated because the income, and thus the hourly wage rate of farmers, can vary widely, for example, depending on the market price performance of agricultural goods offered. In Austria, the proportion of reimbursement by the public is presumably overestimated, on occasion it was found that some farmers operated the traps for the veterinarians (personal communication, 2013). In general, the normalised results show that an almost equal large amount of human resources (88 per cent on average) is needed for monitoring vectors (Fig 2). The allocation of costs in each monitoring stage is quite similar in both countries, with the notable exception of the finalisation of the monitoring (Fig 2). This is expressed by the high Bray-Curtis dissimilarity index and can be explained by the fact that the activities vary significantly in this stage. One example of this is that the traps were dismantled every year after the collecting period (34 weeks) in Switzerland, while the traps in Austria were dismantled only once after three years.

Furthermore, the results of this study indicated that the monitoring in Switzerland was 3.4 times more efficient than in Austria. This could imply that the Swiss programme should be followed in the future, based on the CMA. However, this conclusion and therefore the comparability of the costs of the two programmes is limited for several reasons: first, the Swiss institutions (BLV, IPZ) have previous experience in vector monitoring carried out from 2003 to 2006, which may have affected the CP and CA in this study. The information available from the previous programme led to the need for less information in the present study, reducing its costs (personal communication, 2013). Hence, it is not surprising that the absolute costs for planning and analysis are more than 90 per cent lower than in Austria (Tables 2 and 3), although the surface area of Switzerland is only half the area of Austria (Fig 1). These numbers demonstrate that increased cooperation, including the exchange of information and previous experience, between neighbouring countries could considerably reduce monitoring

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**TABLE 3: Specification of net costs for the Swiss bluetongue vector monitoring 2006-2010**

| Activities | Financed | In-kind | Subtotal |
|-----------|----------|---------|----------|
| Planning costs CP | - | 5340 | 5340 |
| Labour | - | 5310 | 5310 |
| Budget calculation | - | 726 | 726 |
| Review of literature and selection of trap sites | - | 1452 | 1452 |
| Procurement and distribution of equipment | - | 771 | 771 |
| Training events | - | - | - |
| Meetings | - | 2361 | 2361 |
| Material | - | - | - |
| Other | 30 | - | 30 |
| Implementation costs CI | 8130 | 27,633 | 35,763 |
| Labour | - | 24,069* | 24,069 |
| Installation, maintenance and repair of traps | - | 4541 | 4541 |
| Collection and preparation of samples | - | 11,296 | 11,296 |
| Meetings | - | 8242 | 8242 |
| Material | 8130 | - | 8130 |
| Black-light traps and related equipment | 6384 | - | 6384 |
| Thermometers and climate data | 99 | - | 99 |
| Packing material | 1647 | - | 1647 |
| Other | - | 3564 | 3564 |
| Callout charges for veterinarians | - | 219 | 219 |
| Transport | - | 3198 | 3198 |
| Electricity | - | 37 | 37 |
| Catering | - | 110 | 110 |
| Analysis costs CA | 37,350 | - | 37,350 |
| Labour | 37,350 | - | 37,350 |
| Determination of midges | 37,350 | - | 37,350 |
| Detection of bluetongue virus | - | - | - |
| Material | - | - | - |
| Documentation costs CD | 2250 | 4208* | 6458 |
| Labour | 2250 | 4208 | 6458 |
| Finalisation costs CF | 1950 | 6178 | 8127 |
| Labour | - | 6178 | 6178 |
| Other | 1950 | - | 1950 |
| Total costs $C_{total}$ | 49,680 | 43,359 | 93,039 |
| Financed by the EU | - | - | - |
| Financed by national resources | 49,680 | 43,359 | 93,039 |

*Labour costs partially/completely estimated by involved staff*
costs in the future. Second, both programmes fulfil the same legislative requirements, but use different sampling strategies. These may have an effect on the outcome of the monitoring. In contrast to the Swiss programme, the determination of the vector-free period was not the primary goal in Austria, where information on geographical distribution and vector abundance were equally important. A quantification of the outcome, such as the assessment of the quality and quantity of collected data, would be necessary to estimate the value of each country’s programme and to put the value in relation to its costs in order to offer conclusions as to whether costs and benefits are in adequate proportion to each other. In our study, the value of the information has not been quantified in monetary terms, because the monitoring programme did not lead to damage limitation, to a reduction of costs of other surveillance systems (e.g. by identifying risk areas for targeted sampling), to intervention measures or to trade facilitation. The major benefits of the vector monitoring programme are the information about the existence of vectors, their spatial distribution and information on the vector-free period. However, a comparison of the outcome of both programmes could provide a different conclusion about the preferred vector programmes in the future.

Conclusions and recommendations

This paper provides insight into the allocation of costs of monitoring systems and assesses the efficiency of such programmes by comparing the costs. It also opens up the opportunity to derive potential economic improvements to increase the efficiency of future vector programmes. However, the comparability of the costs is limited for several reasons. First, the Swiss institutions have substantial experience of vector monitoring through past programmes, which were not captured by the present study. Second, both countries use different sampling strategies, based on their objectives. Third, absolute monitoring costs in each country are influenced by the surface area and the environmental conditions (Mehlhorn and others 2007, Saegerman and others 2008). Therefore, relative (normalised) costs, that is, costs per trapped midges or costs per week and trap, were calculated for comparison.

Recommendations for future vector monitoring programmes, especially in Austria, are (1) to estimate the likely benefits and costs of programmes and to ensure that both are in adequate balance before monitoring programmes are implemented. (2) To better document the in-kind contribution in order to increase the country’s bargaining power vis-à-vis the EC with regard to the maximum co-financing rate of the costs for a vector programme. Our study has shown that a significant proportion of the visible costs was avoided by relying on national resources (unreported costs). (3) To determine only a statistically significant sample of the collected midges morphologically. Dealing with pools considerably reduces the costs without any loss of accuracy. (4) To focus time-wise on specific monitoring programmes and train staff on these. (5) Veterinary authorities should cooperate closer with research institutes, which have an interest in monitoring data. This measure would significantly improve data quality. The Austrian monitoring data, for example, have been shown to be inappropriate for quantitative analyses due to poor data quality (Pacheco 2009). Thus, they may not be used to develop models for midge dynamics and subsequently for epidemic models, a precondition for simulation studies to optimise control strategies.

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Contributors

Conceived and designed the study: BP and JK. Provided and interpreted basic documents on the vector monitoring programmes: BP, SS, HS and AL. Collected and analysed the data: BP Supervised the data analysis: FR. Wrote the paper: BP, FR, KB and HS.

Competing interests

None.

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