FOOD/FARMEDE ANIMALS

General evaluation of the economic impact of introduction of *Chlamydia abortus* to a Scottish sheep flock

Abigail Robertson, Ian Handel, Neil Donald Sargison

**SUMMARY**

The investigation of an outbreak of chlamydial abortion in a Scottish sheep flock in which there was an overall abortion rate of 12.2 per cent was used as an example to highlight the potential economic impact of the new introduction of an infectious disease. Farm accounts, excluding forage costs, were analysed for the year preceding and the year in which a chlamydial abortion outbreak occurred. The highest contributing factor to the cost of abortion was the loss of lamb sales; nevertheless, veterinary fees, investigation costs, prevention through vaccination and carcase disposal also contributed. Forage costs vary greatly between years, illustrating the need for caution in interpreting gross margin alone as an indicator of disease cost. Subsidy payments were not included in the economic analysis as they were not influenced by the disease outbreak, but it is noted that they would have buffered its impact. The estimated cost of this chlamydial abortion storm based on the comparison of overall lamb losses before and during the year following the probable introduction of *Chlamydia abortus* was £2163 per 100 ewes. The high estimated cost of a chlamydial abortion outbreak shown by the present study outweighs the cost of routine preventive management, involving investment in good biosecurity including sourcing replacements from accredited disease-free sources and vaccination.

**BACKGROUND**

Knowledge of the economic impact of livestock diseases at the farm level is needed to inform investment in their control. Most published estimates are based on theoretical models and national surveillance data to show the cost of diseases to the industry as a whole. There is a paucity of data based on actual farm records to show the impact of disease on individual producers.

*Chlamydia abortus* is a common and important cause of abortion in UK sheep flocks, causing the premature birth of weak or freshly dead lambs during the final three weeks of pregnancy. The main source of infection for naïve sheep is environmental contamination arising from products of abortion and vaginal discharges from infected ewes. Surviving lambs are infected from birth. Following infection, *C. abortus* remains latent and undetectable until about the 90th day of the first or next pregnancy, when the organism invades the placenta, causing a parulent placentitis and abortion in primiparous animals and in ewes that have not been infected during a previous pregnancy. Typically only small numbers of abortions are noted during the first year after the introduction of the disease to a naïve flock, and abortion storms occur during the subsequent lambing period. In the absence of any proven effective treatment, abortion outbreaks are often managed using metaphylactic oxytetracycline drug treatments in the desperate hope of reducing the severity of the disease. Subsequent control in infected flocks can be achieved using attenuated live 1B temperature-sensitive mutant strain *C. abortus* vaccines. These strategies are perceived to be expensive; hence, it is helpful to first show their potential cost benefits. In this study the authors analysed farm records alongside published economic data with the aim of approximating the economic impact of a new outbreak of chlamydial abortion on a sheep flock.

**CASE PRESENTATION**

The upland sheep-only farm in the south-west of Scotland had 573 Lleyn and easy-care breeding female sheep in 2015 and 2016. These were mated by Lleyn, Texel and Suffolk rams to produce most, but not all, of their own replacement females and finished lambs. Two-year-old primiparous ewes (gimmers) routinely lambed in March, three weeks ahead of the main ewe flock at the beginning of April. There was no history of abortion losses in recent years. In March 2016, 70 of 198 gimmers aborted shortly before and at the start of the predicted lambing period. Abortions were not reported for any of the 375 ewes. This figure represented 35.4 per cent of the gimmers, or 12.2 per cent of the total female breeding flock. Aborted gimmers and the products of abortion were isolated, and the remaining gimmers and ewes were injected with 20 mg/kg oxytetracycline (Alamyacin LA; Norbrook Laboratories).

Three aborted lambs and four placentae were submitted to SAC Consulting for laboratory investigation to diagnose the cause of abortion. Two of these placental smears were positive on modified Ziehl-Neelsen staining for *C. abortus*, while microscopic examination of Gram-stained smears and bacterial culture of fetal stomach contents and placenta, and fluorescent antibody tests on peritoneal or pleural fluids for *Toxoplasma gondii* failed to identify any other causes of abortion. Serum samples were collected during May 2016 from 10 gimmers that had aborted, and 10 gimmers and 10 adult ewes that had not aborted, and submitted
to the MSD Flock Check Scheme to establish the extent of the problem. All the sampled gimmers (both aborted and non-abortion) were seropositive (titres ≥4/32) in the complement fixation test for chlamydial abortion. Four ewes from the main flock were seropositive, implying recent exposure. Only one gimmer was also seropositive to *T. gondii*, implying that toxoplasmosis did not contribute to the abortion storm.

### INVESTIGATIONS

Comparison of data routinely collected at the time of ultrasound scanning for pregnancy and the number of live lambs born and surviving until the beginning of July estimated that 103 lambs were aborted and lost to gimmers. The whole flock lambing percentage was reduced from an estimated 170 per cent at scanning to 136 per cent in July (Table 1). However, not all of the lamb losses would have been caused by the abortion storm. Based on the immediate economic, animal welfare and emotive impact of the abortion problem and confirmation of *C. abortus* as the cause, a decision was taken to vaccinate the whole flock with a live attenuated 1B strain of *C. abortus* (CEVAC Chlamydia; Ceva Animal Health), commencing the programme in October 2016 before the mating period.

Farm management data on flock populations, lambing percentages, livestock sales and costs associated with the abortion outbreak (including veterinary fees, fallen stock removal, investigation and prevention costs) were provided by the farmers. These were complemented by figures presented in the available SAC Farm Management Handbooks, showing values for wool sales, forage costs, feed prices, commissions, levies, haulage, shearing, scanning and tagging. The farm accounts were set out as prescribed in the SAC Farm Management Handbooks, showing outputs, inputs and costs associated with the abortion outbreak. Costs pertaining to the flock as a whole that are not directly related to the health status of the flock. Nevertheless, the data underpinning the authors’ conservative estimate of £2163 per 100 ewes, in which there was an overall chlamydial abortion rate of 12 per cent, could be used to produce an economic model to show the impact of different levels of abortion on profit, and to emphasise the cost-effectiveness of vaccination ahead of potentially ineffective and irresponsible metaphylactic antibiotic treatment. The estimated cost of £123 for each of the 70 individual ewes that aborted (£8610 total, or £1502/100 ewes in the flock) is lower than the figure based on the farm accounts (£12,393 total/70 aborted ewes = £177 per aborted ewe), because it does not factor variable costs pertaining to the flock as a whole that are not directly related to the abortion outbreak.

This case report shows the large impact of a chlamydial abortion outbreak on the gross margin of what the authors considered to be a well-managed Scottish sheep flock. Nevertheless, the farm was unable to provide all of the actual expenditure data, hence the need to derive some values from the SAC Consulting handbooks. The authors’ calculations are strongly influenced by the comparison of overall lamb losses between years. These could have been done differently if more precise records had been available, although this is seldom the case where sheep production is just one component of a complex agribusiness. The results Nevertheless show the value of good record-keeping to monitor the impact of management changes and flock health. The authors’ economic evaluation shows the limitations of using gross margin figures alone as a measure of the economic impact of abortion on farm profitability, as the forage costs varied significantly between 2015 and 2016. The authors’ economic analysis did not factor EU Common Agricultural Policy subsidies, which in 2013 contributed to 43 per cent of agricultural income. Subsidy payments were not influenced by the disease outbreak, but would have buffered its impact.

### DISCUSSION

The substantial impact of chlamydial abortion on the gross margin before forage, and factoring both the cost of treatment and future prevention, highlights the importance to naïve flocks of good biosecurity and disease management. The precise impact of disease on gross margin will differ between farming systems and depending on the health status of the flock. Nevertheless, the data underpinning the authors’ conservative estimate of £2163 per 100 ewes, in which there was an overall chlamydial abortion rate of 12 per cent, could be used to produce an economic model to show the impact of different levels of abortion on profit, and to emphasise the cost-effectiveness of vaccination ahead of potentially ineffective and irresponsible metaphylactic antibiotic treatment. The estimated cost of £123 for each of the 70 individual ewes that aborted (£8610 total, or £1502/100 ewes in the flock) is lower than the figure based on the farm accounts (£12,393 total/70 aborted ewes = £177 per aborted ewe), because it does not factor variable costs pertaining to the flock as a whole that are not directly related to the abortion outbreak.

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**Table 1** Comparison of 2016 ultrasound scanning for pregnancy and lambing percentage data

|                  | Gimmers | Ewes    | Whole flock |
|------------------|---------|---------|-------------|
| Total number scanned (February 2016) | 198     | 375     | 573         |
| Barren           | 11 (5.6%) | 12 (3.2%) | 23 (4%) |
| Singles          | 92 (46.5%) | 74 (19.7%) | 166 (29%) |
| Twins            | 87 (43.9%) | 258 (68.8%) | 345 (60.2%) |
| Triplets         | 8 (4%) | 31 (8.3%) | 39 (6.8%) |
| Projected number of lambs (projected lambing percentage) | 290 (146.5%) | 683 (182.1%) | 973 (169.8%) |
| Number of lambs at shearing (July 2016) (actual lambing percentage) | 778 (135.8%) |
| Potential lambs lost between scanning and shearing | 195 |
| Difference between scanning and lambing percentage | 34.0% |
| Percentage loss between scanning and shearing | 20 |
TABLE 2  Farm accounts data used to calculate gross margins

|                | £ overall 2015* | £ overall 2016 | £ per 100 ewes 2015†† | £ per 100 ewes 2016†† | £ per 100 ewes 2016 minus 2015 |
|----------------|-----------------|----------------|------------------------|------------------------|-------------------------------|
| **Output**     |                 |                |                        |                        |                               |
| Finished lambs | 62,845.20       | 53,682.00      | 10,967.75              | 9368.57                | −1599.18                      |
| Cast ewes      | 6727.50         | 6800.00        | 1174.08                | 1186.74                | 12.66                         |
| Wool sales††   | 1951.15         | 2028.42        | 340.52                 | 354.00                 | 13.48                         |
| **Total**      | 71,523.85       | 62,510.42      | 12,482.35              | 10,909.32              | −1573.03                      |
| Ram costs      | 3457.51         | 3340.59        | 603.41                 | 583.00                 | −20.41                        |
| **Total output** | 68,066.34     | 59,169.83      | 11,878.94              | 10,326.32              | −1552.62                      |
| **Variable costs** |               |                |                        |                        |                               |
| Barley, protein, minerals‡ | 7502.14     | 6933.30        | 1309.28                | 1210.00                | −99.28                        |
| Veterinary, medicines, dips§ | 3534.60      | 3959.43        | 616.86                 | 691.00                 | 74.14                         |
| Extra veterinary costs from abortion outbreak§ | 3358.57 | 586.14 | 586.14 |
| Bedding straw  | 1595.31         | 1443.96        | 278.42                 | 252.00                 | −26.42                        |
| Commission, levies, haulage, shearing, scanning, tags‡ | 6321.96 | 6646.80 | 1103.31 | 1160.00 | 56.69 |
| **Total**      | 18,954.01       | 22,451.64      | 3307.87                | 3918.26                | 610.39                        |
| Gross margin before forage | 49,112.33 | 36,718.19 | 8571.07 | 6408.06 | −2163.01 |
| **Forage variable** |               |                |                        |                        |                               |
| Silage‡         | 2194.30         | 1363.74        | 382.95                 | 238.00                 | −144.95                       |
| Grazing‡        | 9844.71         | 5993.58        | 1718.10                | 1046.00                | −672.10                       |
| **Total forage‡** | 12,039.01     | 7357.32        | 2101.05                | 1284.00                | −817.05                       |
| **Total variable costs** | 30,993.02 | 29,808.96 | 5408.92 | 5202.26 | −206.66 |
| Gross margin    | 37,073.32       | 29,360.87      | 6470.02                | 5124.06                | −1345.96                      |

*At a discount rate of 3.5%.
†£ overall/5.73. (The flock was reported to be of the same size in both years and held back the same number of replacements.)
‡SAC Farm Management Handbook data.
§including 20% value added tax.

While the present study focused on the economic effects of an abortion outbreak, the mental and emotional cost to farmers suffering abortion in their flock cannot be economically quantified.

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**Contributors** AR undertook the study. iH helped with the analysis. NDS supervised the work. All authors contributed to the preparation of the manuscript.

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**Competing interests** None declared.

**Ethics approval** Ethical approval to undertake the work as an undergraduate BVM&S Student Research Component was given by the R(D)SVS Veterinary Ethical Review Committee. Written permission was given by the farmers, who wish to remain anonymous, and their veterinary practitioner to use the data collected.

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