Simulation of the economic impact of proliferative enteritis on pig production in Australia

PK HOLYOAKE*, BP MULLAN† and RS CUTLER*

SUMMARY: The economic impact of proliferative enteritis (PE) on an ‘average’ pig farm was calculated using the AUSPIG decision support system. Inputs were modelled on actual cases of PE, in which affected herds suffered from depressed growth rate, decreased feed efficiency and stock losses. The costs associated with non-haemorrhagic PE and proliferative haemorrhagic enteropathy ranged from $15/sow/yr to $141/sow/yr, respectively, depending on the clinical severity of the disease, incidence of infection and the type of medication strategy used to treat and control the disease. 

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Introduction

Proliferative enteritis (PE) is a disease of intensively-reared pigs. The non-haemorrhagic form of the disease occurs most often in 6- to 20-week-old pigs resulting in reduced growth rate and diarrhoea (Gogolowski et al 1991). Severe dysentery and acute deaths due to proliferative haemorrhagic enteropathy (PHE) occur in 15- to 30-week-old finishing and breeding pigs (Love et al 1977). The disease is characterised by hyperplasia of immature intestinal crypt epithelial cells containing curved, non-membrane-bound bacteria (Rowland and Lawson 1975a,b; Barker and Van Dreumel 1985). These bacteria, known previously as Campylobacter-like organisms, have been given the vernacular name ileal symbiont intracellularis (ISI) (Gebhart et al 1993). The ability to reproduce PE in conventionally-reared pigs with pure cultures of ISI suggests that this organism is necessary for development of the disease (McOrist et al 1993).

There is no ante-mortem diagnostic test for PE. Diagnosis of the disease is based on the demonstration of proliferative intestinal lesions in affected pigs at necropsy. The prevalence, and therefore the economic impact, of PE on pig farms in Australia has not been assessed accurately due to this lack of a diagnostic test. Proliferative enteritis may go unnoticed on farms where antibacterial feed additives are used, because these medications prevent clinical PE (Love 1981). High concentrations of antimicrobial products may also prevent immunity developing in pigs, resulting in severe clinical outbreaks of the disease when medication is removed from the diet (Love 1981; Holyoake 1993).

The economic impact of PE was calculated using the AUSPIG decision support system. The AUSPIG system incorporates a growth and production model (Black et al 1986) of a pig from birth to maturity in response to its intake of nutrients, the animal’s physical, climatic and social environment, and the animal’s genetic potential. The system also includes a piggy maximisation model. AUSPIG was used to assess the costs associated with PE ‘outbreaks’ on an ‘average’ pig farm, as done previously for transmissible gastroenteritis (Mullan et al 1994). The clinical manifestations of non-haemorrhagic PE and PHE and the resultant costs of treatment and long-term control were considered. Production values and the cost of production were drawn from the Australian Pig Industry Reference Manual (Anon 1989, 1991).

Materials and Methods

Simulation 1 (Non-haemorrhagic PE)

The parameters used in the simulation of 3 typical outbreaks (A, B and C) of non-haemorrhagic PE were based on field studies of the disease occurring in southern Australia. Incidence rates were drawn from intestinal lesion prevalence data collected at slaughter (Holyoake 1993). Non-haemorrhagic PE ‘affected’ pigs for either 2 weeks (simulations A and B) or 4 weeks (simulations C and D), resulting in reductions in growth rate and feed efficiency. Estimates of the body weights of affected pigs at the end of the infection periods were based on the degree of growth depression included in the model. By knowing the actual growth rates of pigs and simulating their performance with the AUSPIG model, assessments of relative feed efficiencies were made and represented by increased feed wastage. Feed wastage of ‘unaffected’ pigs was assumed to be 15% (Table 1).

Simulations A and B represented outbreaks of non-haemorrhagic PE ‘affecting’ pigs from 8 to 10 weeks and 14 to 16 weeks of age, respectively. In each simulation, 12% of pigs suffered a 23% decline in growth rate over a 14-day period (Gogolowski et al 1991; Holyoake 1993). Simulations C and D represented outbreaks of non-haemorrhagic PE in which pigs were ‘affected’ from 8 to 12 weeks and 14 to 18 weeks of age, respectively. In each simulation, 12% of pigs were affected, 4% experienced a growth rate depression of 35%, while 8% experienced a growth rate depression of 23%. The ‘outbreaks’ affected the growth performance of pigs for 28-day periods.

The productivity and profitability changes on a 100-sow farm resulting from (1) a mild outbreak of non-haemorrhagic PE, (2) a severe outbreak of non-haemorrhagic PE, and (3) the use of antimicrobial products for the long-term control of non-haemorrhagic PE, were estimated in simulations E, F and G. Simulation E represented an outbreak in which 12% of pigs suffered a 23% decline in growth rate during the 14-day period between 8 and 10 weeks of age. There were no deaths. Olaquindox* was added to the weaner (4- to 10-week-old) and grower (10- to 16-week-old) diets at 50 g/t and 25 g/t, respectively. Any growth benefits from olaquindox inclusion were ignored. Simulation F represented a more severe outbreak, resulting in a decline in growth rate of 35% and 23% among 4% and 8% of pigs, respectively during the 28-day period between 8 and 12 weeks of age. Mortality among 4- to 10-week-old pigs increased from 4% to 6%. There were additional veterinary costs totalling $65.00 associated with injecting 37 pigs (4%) with tetracyclines‡ and adding 22 g/t of

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‡ Bayo-n-ox®, Bayer Australia Ltd, Botany, NSW
§ Terramycin LA®, Pfizer Agricare Pty Ltd, West Ryde, NSW

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Before outbreak not applicable

### Simulation group
- **Age of infection (days)**
- **Feed wastage (%)**
- **Feeding level of females/entire males (kg/day)**

#### Before outbreak
- not applicable
- 15
- ad libitum

#### After outbreak
- **Simulations**
- **A** (8 - 10 wk)
  - 56
  - 40
  - 0.86/0.95
- **B** (14 - 16 wk)
  - 98
  - 40
  - 1.72/1.83
- **C** (8 - 12 wk)
  - 56
  - 40
  - 0.86/0.95
- **D** (14 - 18 wk)
  - 98
  - 30
  - 1.85/1.95

* Feeding level (kg/day) included intake unaffected not applicable M

Infection Sex Average daily Body weight Backfat

<table>
<thead>
<tr>
<th>PE status</th>
<th>Infection period (days)</th>
<th>Sex</th>
<th>Average daily weight gain (g/d)</th>
<th>Body weight (kg)</th>
<th>Backfat (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>unaffected</td>
<td>not applicable</td>
<td>M</td>
<td>590</td>
<td>91</td>
<td>11.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F</td>
<td>560</td>
<td>86.2</td>
<td>13.1</td>
</tr>
<tr>
<td>A</td>
<td>56 - 70</td>
<td>M</td>
<td>560</td>
<td>86.2</td>
<td>11.7</td>
</tr>
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<td></td>
<td></td>
<td>F</td>
<td>540</td>
<td>83.1</td>
<td>12.8</td>
</tr>
<tr>
<td>B</td>
<td>98 - 112</td>
<td>M</td>
<td>566</td>
<td>87.1</td>
<td>11.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F</td>
<td>542</td>
<td>83.5</td>
<td>13</td>
</tr>
<tr>
<td>C</td>
<td>56 - 84</td>
<td>M</td>
<td>540</td>
<td>83.1</td>
<td>11.6</td>
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<td></td>
<td></td>
<td>F</td>
<td>520</td>
<td>80.2</td>
<td>12.5</td>
</tr>
<tr>
<td>D</td>
<td>98 - 126</td>
<td>M</td>
<td>540</td>
<td>83.1</td>
<td>11.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>F</td>
<td>517</td>
<td>79.6</td>
<td>12.6</td>
</tr>
</tbody>
</table>

* At sale (154 days old)

**TABLE 2**
Growth rate (from 28 to 154 days of age) of pigs affected with mild (A and B) and severe (C and D) non-haemorrhagic proliferative enteritis (PE)

**TABLE 3**
Productivity and profitability changes resulting from stock losses and treating pigs affected with mild (E) and severe (F) outbreaks of non-haemorrhagic proliferative enteritis, and long-term control measures (G) on a 100-sow farm

<table>
<thead>
<tr>
<th>Item</th>
<th>Simulations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Annual profit summary ($)</strong></td>
<td></td>
</tr>
<tr>
<td>total income</td>
<td>258 812</td>
</tr>
<tr>
<td>total feed costs</td>
<td>133 933</td>
</tr>
<tr>
<td>total other costs</td>
<td>85 973</td>
</tr>
<tr>
<td>total net revenue</td>
<td>38 845</td>
</tr>
<tr>
<td>net revenue/bow</td>
<td>388</td>
</tr>
<tr>
<td>net revenue/pig</td>
<td>21.5</td>
</tr>
</tbody>
</table>

Marketing strategy
- pigs sold 1 768 1 768 1 740 1 754
- average dressed wt (kg) 69.5 66.9 66.0 66.9
- average price/kg (net) ($) 2.03 2.03 2.05 2.03

Productivity
- pigs sold/sow/yr 17.7 17.7 17.4 17.6
- grower feed conversion 2.39 2.39 2.39 2.39
- herd feed conversion 3.97 3.98 4.01 3.99
- average feed cost ($/kg) 262.21 263.73 281.97 263.70

* Productivity and profitability estimates for ‘unaffected’ pigs (pre-outbreak) were calculated from data drawn from the Australian Pig Industry Reference Manual (Anon 1989, 1991).

**TABLE 1**
Assumptions for feed wastage by female and entire male pigs of various ages in simulations A, B, C and D as a result of non-haemorrhagic proliferative enteritis

**TABLE 3**
Productivity and profitability changes resulting from stock losses and treating pigs affected with mild (E) and severe (F) outbreaks of non-haemorrhagic proliferative enteritis, and long-term control measures (G) on a 100-sow farm

lincomycin/spectinomycin\(^1\) to the feed of pigs more than 4 weeks of age. Simulation G represented a long-term control strategy for PE with a monthly mortality rate among 4- to 10-week-old pigs of 5%. There were additional veterinary costs totalling $65.00 associated with injecting 37 pigs (4%) with tetracyclines. Olaquindox was added to the weaner and grower rations at 50 g/t and 25 g/t, respectively. The growth rate depression of pigs was as for simulation F.

**Simulation 2 (Proliferative Haemorrhagic Enteropathy)**

The effect of PHE on production was determined from observations of 7 affected pig farms in Victoria (Holyoake 1993). Morbidity averaged 6% (range 5% to 15%), and mortality 2% (range 3% to 6%) on these farms. Pigs were affected between 11 and 32 weeks of age and died suddenly when treatment was not undertaken early in the course of the disease.

A range of mortality rates and treatments over this age range were included in the simulation to represent common manifestations of the disease among a 100-sow herd with a susceptible population of 880 weaners, growers and finishers. Simulations A and B represented PHE 'outbreaks' with mortality rates among 11- to 32-week-old pigs of 3% and 6%, respectively. Simulations C and D represented outbreaks in which either 5% or 15% of weaner, grower and finisher pigs, respectively, received 2 treatments with injectable long-acting tetracycline at a cost of $10.00/pig, including materials and labour.

\(^1\) Linco-spectin\(^\text{®}\), Upjohn Pty Ltd, Rydalmere, NSW

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TABLE 4
The predicted impact of proliferative haemorrhagic enteropathy on the productivity and profitability of a 100-sow farm

<table>
<thead>
<tr>
<th>Simulation</th>
<th>Total costs ($/yr)</th>
<th>Total income ($/yr)</th>
<th>Net revenue ($/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before outbreak</td>
<td>26 222</td>
<td>262 688</td>
<td>36 466</td>
</tr>
<tr>
<td>After outbreak</td>
<td>644</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A (3% mortality)</td>
<td>225 574</td>
<td>254 696</td>
<td>29 125</td>
</tr>
<tr>
<td>B (6% mortality)</td>
<td>224 932</td>
<td>261 818</td>
<td>21 886</td>
</tr>
<tr>
<td>C (5% injectable antibiotic)</td>
<td>226 700</td>
<td>262 699</td>
<td>35 999</td>
</tr>
<tr>
<td>D (15% injectable antibiotic)</td>
<td>227 583</td>
<td>262 699</td>
<td>35 116</td>
</tr>
<tr>
<td>E (feed medication)</td>
<td>229 220</td>
<td>262 699</td>
<td>33 478</td>
</tr>
</tbody>
</table>

Simulation E represented an outbreak in which 100 g/t chlortetracycline was added to the feed of all pigs at a cost of $7.50/t.

Results

Simulation 1 (Non-haemorrhagic PE)

Proliferative enteritis 'reduced' average daily weight gain and, as a consequence, feed efficiency (Table 2). In simulation F, carcase weight declined by 1.5 kg from 69.5 kg to 68 kg (Table 3). The model partly compensated for this by an increased return per kilogram of carcase due to reduced backfat measurements. Profitability was reduced further in simulations F and G as a consequence of higher mortality rates and treatment and control costs that varied with infection severity and the antibiotic strategy selected (Table 3). A mild outbreak of non-haemorrhagic PE (simulation E) reduced profitability by $140/sow/yr, whereas a more severe outbreak reduced profitability by $140/sow/yr (simulation F) or $28/sow/yr (simulation G) depending on the type of antibiotics used.

Simulation 2 (Proliferative Haemorrhagic Enteropathy)

Weekly calculations of the impact of PHE on the net revenue of pig farms were used to determine the costs incurred during 'typical' outbreaks of the disease (Table 4). Mortalities due to PHE were higher (at 3% and 6%) than non-haemorrhagic PE and feed intake was subsequently reduced. Total income declined because fewer pigs were sold at the end of the production period. The use of injectable and/or in-feed antibiotics also increased total production costs. Increased mortality had a greater impact on net revenue (total income and/or in-feed antibiotics also increased total production costs. In-feeding medication practices instituted to prevent recurrences. The costs associated with non-haemorrhagic PE ranged from $15 to $141/sow/yr, depending on the costs of the antimicrobial products used during an outbreak. This is largely determined by the morbidity and mortality rate among pigs and the effectiveness of the antimicrobial products chosen. On farms where pigs are affected by inter-current disease(s), antibacterial products used to control PE also improve growth rate and feed efficiency by suppressing clinical signs of other diseases.

Stock losses were the main contributor to the annual cost of PHE and ranged from $30 to $34/sow/yr. In contrast to the protection afforded by antibiotics against non-haemorrhagic PE, outbreaks of PHE are reported to occur after the withdrawal of continual-use medication at therapeutic concentrations (Love et al. 1977; Holyoake 1993). These antibacterial strategies may increase the susceptibility of pigs on ISI-infected farms by preventing infection and the development of immunity. Therefore, continuous use of in-feed antibacterial products may be contra-indicated on farms with no intercurrent disease.

Surveys of producers, veterinarians and abattoirs have provided us with the only estimate of the prevalence of PE in Australia (Pointon 1989; Holyoake et al. 1994a). Holyoake et al. (1994a) reported that between 1988 and 1990, producers in Victoria observed clinical signs typical of non-haemorrhagic PE more frequently (41% of herds) than PHE (14% of herds). Veterinarians had diagnosed PE in 28% of these herds. Survey data also suggested that most pigs-specialist veterinarians diagnose PE on the basis of clinical and gross pathological examination of affected pigs, without laboratory confirmation (Holyoake et al. 1994a). These prevalence rates may lack accuracy due to the difficulties with detecting subclinical PE, and from probable misdiagnoses.

Profitability calculations using the AUSPIG model demonstrated that non-haemorrhagic PE resulted in a loss ranging from $0.80/pig sold (simulation E) to $5.75/pig sold (simulation F), depending on the severity of the outbreak. Surveys data suggest that non-haemorrhagic PE affects about 41% of herds in Australia, assuming that producers diagnosed clinical non-haemorrhagic PE with 100% accuracy (Cleary and Ransley 1994). Assuming a within-herd prevalence of 5% (Holyoake et al. 1994b), this form of the disease may have affected 58 198 pigs in Australia in 1994 (41% of herds x 5% of pigs x 2 838 964 pigs) (Cleary and Ransley 1994). Therefore, non-haemorrhagic PE may have cost the Australian pig industry between $46 559 and $440 564 in 1994, depending on outbreak severity. Assuming PHE occurred on 10% of farms, and affected 6% of sows (Holyoake 1994a, b), this form of PE would have affected 1917 sows in Australia in 1994 (10% of herds x 6% of sows x 319 534 sows) (Cleary and Ransley 1994). Assuming a loss of $30 sow due to PHE, the disease cost the Australian pig industry $57 510 in 1994.
We can conclude from these calculations that PE is a significant disease of pig herds in Australia. The true cost of PE can only be determined when an accurate ante-mortem diagnostic test for the disease is developed, and the relative occurrence of mild/severe disease is measured. A polymerase chain reaction (PCR) test to detect IS1 in swine faeces is a potential method for ante-mortem diagnosis for PE (Jones et al. 1993). Assessments of the prevalence of PE using the PCR test, coupled with detailed information on the severity of PE in affected pig herds, may provide a more accurate measure of the cost of PE in Australia.

Acknowledgments
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References
Love RJ (1981) In Pig Production, Post-Graduate Committee in Veterinary Science, University of Sydney, Proceedings No 56, p 407

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Order of Australia Awards

The awards in Order of Australia announced on Australia Day 26 January 1996 included:

Dr David Field Mahoney AM of Taringa, Queensland, for service to veterinary science, particularly research into and the development of vaccines against serious cattle diseases.

Dr Mahoney is a veterinary graduate of the University of Queensland 1950. He was President of the AVA Queensland Division 1970-76 and was until he retired in 1994, Chief of the CSIRO Division of Tropical Animal Production.

Dr Bruce Charles Eastick AM of Gawler, South Australia, for service to the Parliament of South Australia, local government and the community.

Dr Eastick is a veterinary graduate of the University of Sydney. He was national President of the Australian Veterinary Association 1966-67 and he has practised in Gawler for many years.