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The economics of preventing disease introduction

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Introduction

The introduction of a disease is one of the numerous operational risks facing virtually all intensive swine operations. With most, the introduction into naive populations may result in significant losses to productivity. With some diseases, such as PRRS, there is even risk of introducing new and potentially devastating strains into herds that may already harbor endemic strains that have been previously stabilized. As swine units become larger and more concentrated, the management of disease prevention becomes increasingly important, largely because the financial consequences of a new disease can be catastrophic. Yet all disease prevention strategies have associated costs and, in times of declining margins, must be justified in terms of their effectiveness. The objective of this paper is to evaluate four specific disease prevention strategies relative to the estimated costs of three disease scenarios. The three diseases have been selected based on their significance to the swine industry. For the purpose of this paper, the calculations and concepts are illustrated using a 2,500 sow, 3-site, early-wean operation presently in full production in western Canada. The production data is typical of such operations (**Table 1**). Unlike operations in the USA and in Eastern Canada, the nursery and finisher barns are large single-sourced buildings (4,000 head nursery, 8,000 head finisher) operated all-in/all-out by room. All buildings are mechanically ventilated, two-by-six stick-frame construction, and less than five years old. The breeding, gestation, and farrowing of all 2,500 sows are in one building.

The large land mass and low hog density of western Canada results in the freedom from many diseases typically endemic in the higher pig density rearing areas of the world. With the exception of PRRS, most intensive swine operations in western Canada remain free of the

Table 1: Baseline productivity of example 2,500 sow farm

Performance category	Parameter
Breeding herd	2,500 sows, stalled gestation, natural/AI mating program
	2.5 litters/sow/year
	80 % farrowing rate
	120 farrowings/week @ 10.5 liveborn/litter
	9% pre-weaning mortality
	1,145 pigs weaned/week
Nursery	twice weekly weaning of ~570 pigs, 51 days in nursery
	~5 kg entry weight
	1.5% nursery mortality
	450 grams/day ADG
Finisher	1,130 pigs entered/week @ 28 kg entry weight
	4% finisher mortality
	800 grams/day ADG to 110 kg live weight
	1,085 pigs marketed per week
	79% dressed yield, 87 kg dressed weight, average index 110
Farm	22.6 pigs marketed per female per year (56,400/yr)
	whole farm FCR @ 3.1, average diet cost @ $180/tonne
Financial	base market price $1.55/kg
	income/hog $148.33 CAD (equivalent to $43.00 US $/CWT)
	earnings per pig (before income taxes) $1.453M or $25.76/hog CAD
	feed cost per hog $62.24
	operating costs per hog $39.92
	fixed costs per hog $20.76
	break even price $1.28/kg dressed

major enteric and respiratory diseases. Furthermore, the strains of PRRS circulating in PRRS-positive herds tend to be of low virulence and easily controlled with or without vaccination. Thus, remaining free of those diseases of significant economic impact is an achievable objective for most units.

Western Canada is certainly not immune to new disease introductions, however. During the past decade, the most frequent introductions that have occurred include *Mycoplasma hyopneumoniae* (MH), transmissible gastroenteritis (TGE), and porcine reproductive and respiratory syndrome virus (PRRS). Although it is not always possible to determine the exact source of each break, most can be traced to contaminated replacement breeding stock, semen, or fomites. In comparison to other regions, fewer introductions are the result of local aerosol spread from neighboring units.

The costs of disease

Following the introduction of disease into a naive herd, the population experiences a period of mushrooming exposure of virtually all animals. Over time, with decreasing numbers of susceptible animals remaining, the disease enters an "endemic" period where the incidence of disease is usually limited to each new batch of susceptible pigs entering the unit from, for example, the nursery. The cost of disease introduction is therefore the sum of "productivity loss" and "incurred expenses" during both the acute and endemic periods. Estimating these costs over a 12 month period following introduction is obviously dependent on many factors, including the susceptibility of the population, farm compartmentalization, virulence of the organism, feed costs, mortality and the recommended veterinary procedures associated with treatment and stabilization. Estimating the disease cost is a prerequisite to prioritizing the best disease prevention strategy for the farm. Using the 2,500 sow multiple site farm described above as an example, the estimated cost of disease over a 12 month period following introduction has been made for PRRS, MH, and TGE (**Tables 2 & 3**).

Disease prevention strategies

Within the industry today, there is wide variation in the type and complexity of disease prevention strategies in use. Although pre-entry quarantine with multiple serologic testing of every batch is ideal, it is not routine. More commonly, various combinations of veterinary visits, slaughter checks, and sporadic serologic sampling are used in the source herd(s). With the industry becoming increasingly cost conscious, the success of any disease prevention strategy must be scrutinized relative to its cost effectiveness and risk reduction capabilities. Furthermore, each strategy must be compared to the estimated cost of a disease outbreak, should it occur in a susceptible population.

For the purpose of this paper, I have compared the cost and effectiveness of four disease prevention strategies, typical of those employed in the industry today. All strategies are designed to prevent the introduction of PRRS, MH, and TGE.

Strategy A: Monthly veterinary visit with quarterly slaughter check for pertinent respiratory diseases

Strategy B: Monthly vet visit with monthly pre-dispatch serology of ten gilts at the source

Strategy C: Monthly vet visit and 30-day off-site pre-entry quarantine period at the recipient

Strategy D: Monthly vet visit with monthly pre-dispatch serology of 10 gilts, plus a 30 day off-site pre-entry quarantine including pre-entry serology of 10 quarantine gilts

For this example, the 2,500 sow multiple site farm will be used as the recipient herd. Replacement females are sourced from a 600 sow, single-site multiplication unit. All matings are performed via AI, thus no live boars are introduced on farm. The costs of veterinary visits and serologic testing are borne by the recipient herd and all serologic testing is performed by a commercial diagnostic laboratory.

Factors affecting the effectiveness of disease prevention strategies

The success of any disease prevention strategy is dependent on its ability to detect disease prior to disseminating to downstream recipient herds. Factors that must be considered in the development of any program include the following:

- The detection pressure exerted in the source herd
- The prevalence of the disease in the region of the source herd
- The biosecurity of the source herd
- The isolation/quarantine procedures of the source and recipient herds
- The incubation period and disease characteristics

Detection pressure in the source herd

Detection pressure reflects the intensity of surveillance used in the source herd and takes into account the disease characteristics and the sensitivity of the serologic assay used for testing. Using mycoplasma as an example, it reflects the vigilance of the barn management to respond to a clinical suspicion during the period of time from exposure to clinical expression. When using a strategy de-

Table 2: Estimated effects of disease case scenarios on production over first 12 month

Mycoplasma hyopneumoniae

Acute phase (3 months):

5% increase in grow-finish mortality
2.5% reduction in farrowing rate (abortions/NIPS/repeats resulting from pyrexia/anorexia)
0.2 point increase in farm FCR (3.1 to 3.3)
150 gram/day reduction in GF ADG (800 to 650), resulting in lower market weights
5% injectable treatment rate in breeding herd
2% injectable treatment rate in feeding herd
Continuous feed grade anti-microbials (Denagard/CTC; 31.2/220 g/T, $45/T) for 3 weeks in breeding herd
Pulsed feed grade anti-microbials (Denagard/CTC; 31.2/220 g/T,$45/T, 1 wk on/1 wk off) for 8 weeks in grower pigs (9-17 wks of age)
Continuous feed grade anti-microbials (Lincomix; 1 kg/T, $13/T) for 7 wks in finisher pigs (17-24 weeks of age)
MH vaccination of breeding and feeding herds @ $1.20/dose

Acute phase (3 months):

MH vaccination of progeny @ $1.20/dose
Pulsed feed grade anti-microbials (Linco/CTC; on wk 1, 4 and 7 of grower)
0.1 point increase in farm FCR (3.1 to 3.2)
50 gram/day reduction in grow-finish ADG (800 to 750)
1% increase in grow-finish mortality
1% injectable treatment rate in feeding herd

PRRS (Virulent strain)

Acute phase (3 months):

15% reduction in farrowing rate
10% increase in pre-weaning mortality (9 to 19%)
0.7 pig reduction in liveborn/litter (10.5 to 9.8) resulting from stillbirths and mummies
5% increase in post-weaning mortality/suboptimal (cull) pigs
PRRS vaccination of females pre-breeding (1 dose/breeding, $1.35/dose)

Endemic phase (9 months):

PRRS vaccination of females pre-breeding (1 dose/breeding, $1.35/dose)
No loss of reproductive performance

TGE (PRCV negative herd)

Acute phase (4 months):

100% mortality of all suckling piglets for 3 weeks
10% reduction in farrowing rate for 4 months
0.5 pig reduction in liveborn/litter (10.5 to 10.0)
Feedback program implementation (without vaccination) - labor/supplies etc. @ $20,000

Endemic phase (8 months):

None assuming eradication in breeding herd, no contamination of nursery

Table 3: Summarized financial performance of disease case scenarios

(In $000's)	Baseline	MH	PRRS	TGE
Gross income ($)	8,386	7,754	7,481	7,081
Less: feed costs	3,510	3,454	3,131	2,963
Income net of feed	4,876	4,300	4,351	4,118
Operating costs	2,251	2,424	2,240	2,239
Fixed costs	1,171	1,171	1,171	1,171
Earnings before taxes	1,453	705	940	708
Net income	783	375	510	378
Break even price (CAD/kg dressed)	1.28	1.41	1.36	1.40
Break even price (US $/CWT live)	32.20	35.47	34.16	35.17
Total cost of disease	-	(408)	(273)	(405)

pendent on serologic monitoring, it represents the incubation period (time from infection to the first evidence of seroconversion), the sample size confidence, the frequency of serologic testing, and the sensitivity of the serologic assay used. Sample size confidence, or the lack thereof, is a notable risk in any disease prevention strategy. For any one sampling period, sample size confidence is dependent on the proportion of animals in the group that are tested. However, for the disease prevention strategy as a whole, the sample size confidence is also dependent on the frequency of testing (i.e., weekly, monthly, quarterly, etc.) By manipulating the sample size and frequency of testing, a balance can be struck between the cost and confidence of the disease prevention strategy. Increasing the frequency of testing is one way of compensating for reduced sample sizes.

Prevalence of disease in region of source herd

Although in some parts of the globe diseases such as mycoplasma are endemic, other areas are essentially serologically free, due either to a low hog density or well established SPF programs. Thus, an essential element in all disease prevention strategies is to recognize these regional differences and refrain from purchasing replacement stock from areas of high pig density.

Source herd biosecurity

Evaluating the biosecurity of the source herd(s) is also an essential component in all disease prevention strategies. Any objective and valid biosecurity scoring system can be used, but those with question/answer formats and numeric scoring systems are preferred. Furthermore, all areas of herd biosecurity should be assessed including the following:

- Genetic introduction procedures
- Operations (herd entry, feed, manure, etc.)
- Slaughter transportation and load-out procedures
- Location

Isolation/quarantine procedures of the source and recipient herds

The effectiveness of off-site quarantine barns have been proven in the field on numerous occasions over the last decade. More recently, the functional role of quarantine barns have been combined with either gilt development/breeding or acclimation units; however these systems are designed to provide a balance between biosecurity and acclimation. In most situations, combined units result in a poorer biosecurity when compared to quarantine alone. Thus, the needs and objectives of the production system must be clearly understood. To be effective as biosecurity units, quarantine barns should be operated in an all-out basis, offer completely separate air space , and be a safe distance from the main unit.

Incubation period and disease characteristics

Biosecurity programs are most effective for diseases with short incubation periods. For example, a clinical TGE outbreak in an PRCV-negative herd is likely to be recognized within days of initial exposure, whereas a subclinical break of PRRS may not be recognized for months. For this reason, the incubation period and dynamics of seroconversion are important aspects worthy of consideration of all disease prevention strategies. The use of a quarantine barn in any disease prevention strategy benefits primarily in terms of extending the "observation" time during which any disease may be undergoing incubation.

The economics and effectiveness of disease prevention strategies

When determining the effectiveness of various disease prevention strategies, it is first necessary to evaluate the cost of the strategy relative to the cost of the disease (**Figure 1**). This enables the producer to identify the strategies that are the most cost effective for his or her particular circumstances. However, this analysis does not take into account the biologic effectiveness of the strategy, i.e., its ability to detect a disease present in a population of incoming animals on a timely basis. The biologic effectiveness of disease prevention strategies can be compared relative to each other with the knowledge of sample size, confidence, assay or test sensitivity, and the expected number of days from exposure to first detection (clinical expression or seroconversion) (**Table 5**). With this information, a comparison of strategy cost to its relative effectiveness can be undertaken (**Figure 2**). To take this analysis one step further, the strategy cost to disease cost ratio is calculated to identify the strategies of highest financial return. By comparing to the relative effectiveness of each strategy, the most cost effective strategies accounting for biological limitations can be determined (**Figure 3**).

Summary

Selection of the appropriate disease prevention strategy is dependent on the cost of the strategy, the cost of the disease and the effectiveness of the program. With the substantial cost of most strategies, it is essential they be targeted to diseases of concern while considering the biosecurity and disease prevalence in the region of the source and recipient herds. However, the overall cost of any disease prevention strategy is small in comparison to the cost of an acute disease outbreak and must be considered with this in mind. Detailed cost analyses provide an objective means of targeting financial resources on the strategies that are the least expensive, most effective, and that prevent the most economically significant diseases.

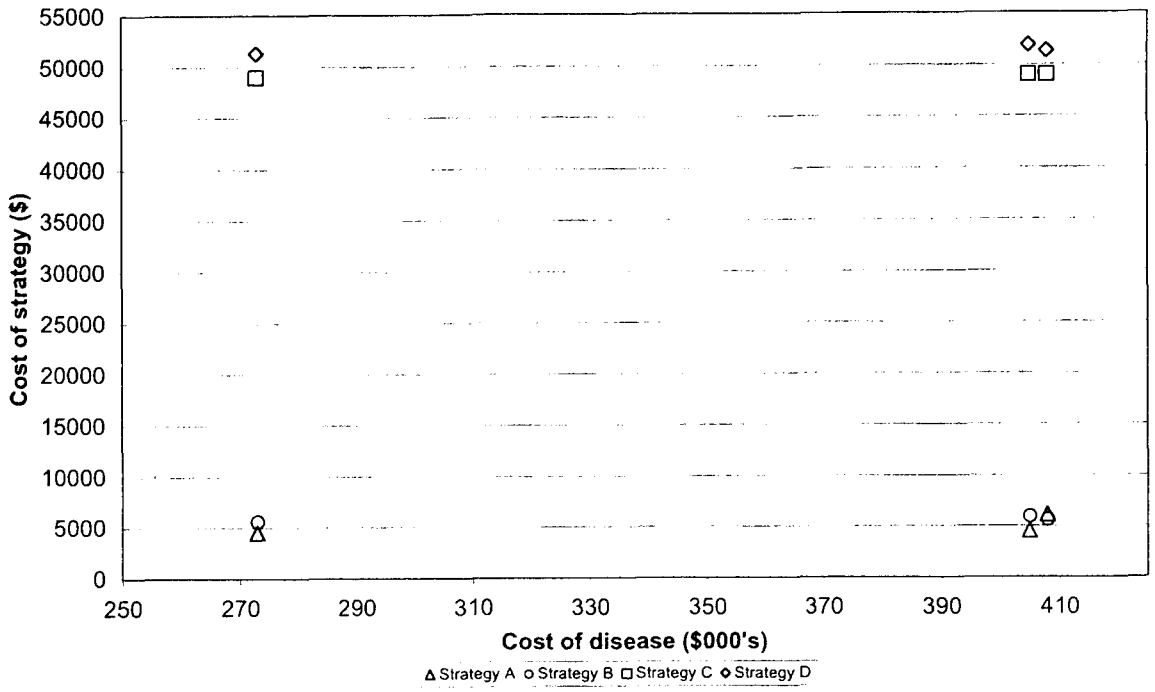

Figure 1: The cost of disease prevention strategies versus the cost of disease
Vertical groupings of a triangle, circle, square and diamond represent a specific diease; PRRS (far left), TGE (right), MH (far right). The cost of each of 4 disease prevention strategies are represented by the four symbols. Data points in the lower right quadrant represent the strategies of lowest cost for the most economically significant diseases.

Table 4: Annual costs of four disease prevention strategies assuming a monthly purchase of 100 gilts

	Strategy			
(CAD)	**A**	**B**	**C**	**D**
Monthly vet visit[1]	4,500	4,500	4,500	4,500
Slaughter check[2]	1,600			
Pre-dispatch serology (source herd)[3]				
PRRS		1,140		1,140
MH		1,140		1,140
TGE/PRCV		1,440		1,440
Quarantine				
Total fixed costs[4]			15,000	15,000
Total operating costs[5]			29,500	29,500
Pre-entry serology (quarantine)[6]				
PRRS				1,140
MH				1,140
TGE/PRCV				1,440
Total cost	6,100	8,220	49,000	56,440
Cost per replacement gilt	5.08	6.85	40.83	47.03
Cost per market hog per year	0.11	0.15	0.87	1.00
Total cost (PRRS only)	4,500	5,640	49,000	51,280
Total cost (MH only)	6,100	5,640	49,000	51,280
Total cost (TGE only)	4,500	5,940	49,000	51,880

1 Assumes 1/2 day per month professional services at $750/day including travel, reporting.
2 Quarterly slaughter check of 50–60 hogs at $400, including professional services, transport, and shrink.
3 Monthly testing of ten animals at vet visit or by barn manager with no additional professional service fees levied. Per sample costs (CAD) including assays, couriers, supplies, serum bank are as follows: PRRS, $9.50; TGE/PRCV, $12.00.
4 Includes capitalization and depreciation.
5 Includes utilities, staffing, veterinary, feed, manure disposal.
6 Assumes serology performed on day 21 of quarantine period.

Table 5: The relative effectiveness of four disease prevention strategies

Strategy	# days to first	Sample size confidence[1]	Assay/test sensitivity	Component effectiveness	Relative strategy effectiveness	
Mycoplasma						
A	20 days R=10-30[3]	1	0.5	2.5[2]	A	2.5
Asc	45 days R=1-90	0.99	0.85	1.87	Asc	4.37
B	28 days R=14-42[4]	0.65	0.98	2.3	A+B	6.67
C	1 Detected	1	0.4	40	A+C	44.4
D	10.5 days R=0-21	0.88	0.98	8.0	A+C+D	52.4
PRRS						
A	90 R=10-•	1	0.25	0.28	A	0.28
B	12 R=10-14	0.65	0.95	5.14	A+B	5.42
C	90 R=10-•	1	0.25	0.28	A+C	0.56
D	1 Detected	0.88	0.95	83.6	A+C+D	84.16
TGE (PRCV negative herd)						
A	5 R=3-7	1	0.85	17	A	17
B	7.5 R=7-8	0.65	0.9	7.8	A+B	24.8
C	1 Detected	1	0.9	90	A+C	107
D	1 Detected	0.88	0.9	79.2	A+C+D	186.2

1n=[1-(1-a)^(1/D)]*[N-(D-1)/2], where: n=sample size; a=sample size confidence; P=prevalence; D=no. positive animals in age group; N=no. animals in group.
2Strategy effectiveness defined as: 100*(sample size confidence*assay (or test) sensitivity)/days to first detection, where high scores reflect the preferred strategies.
3Assumes clinical expression and recognition within the population between 10 and 30 days after infection of first animal in the population.
4Assumes seroconversion between 14 and 42 days post infection.

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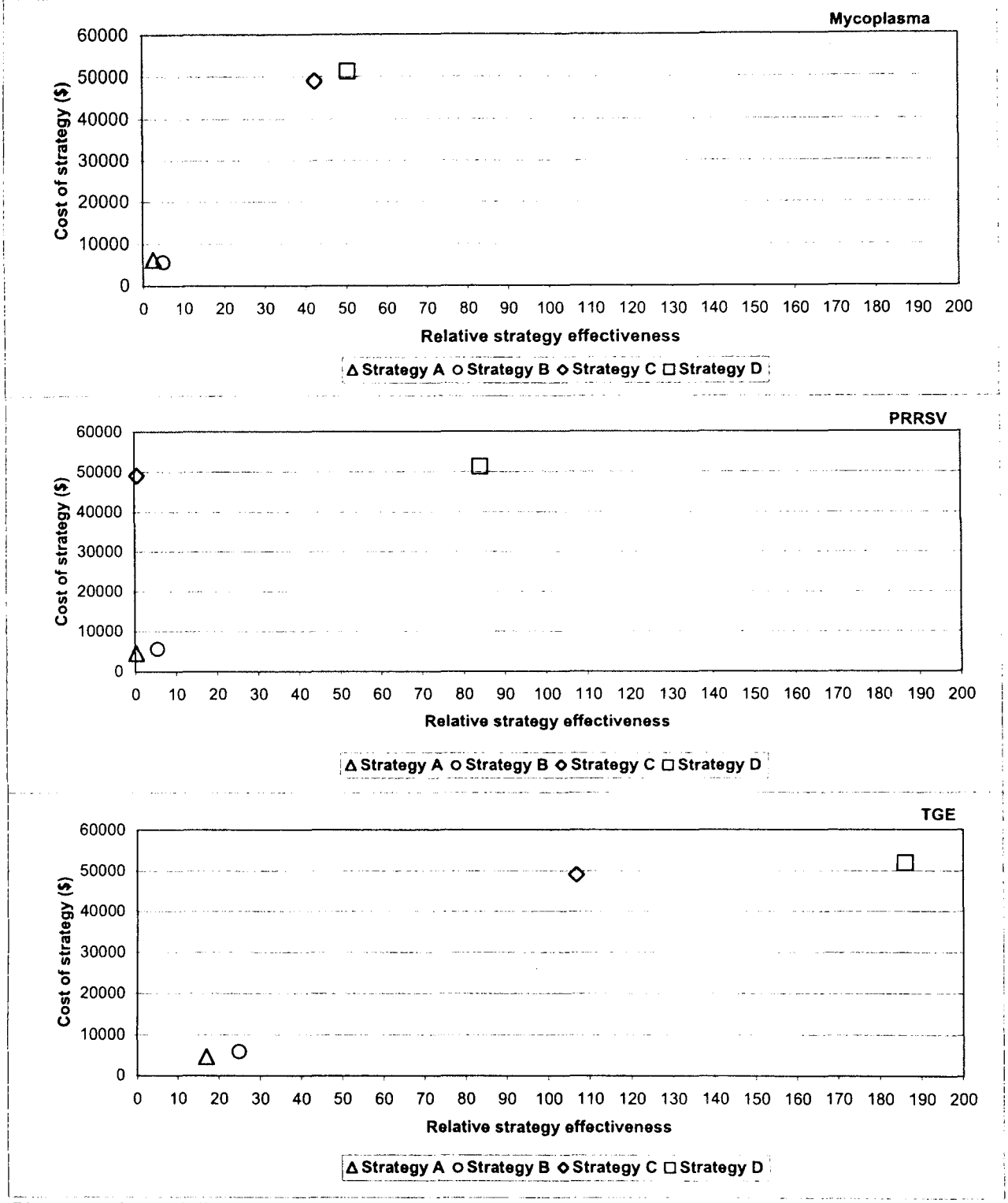

Figure 2: Cost of disease prevention versus the relative strategy effectiveness
Data points represent the cost of each disease prevention strategy relative to the effectiveness of each. Data points in the upper right represent the most effective, but also most costly strategies for each disease scenario. Strategy effectiveness of 100 represents a strategy where the disease is successfully detected pre-entry.