ESTIMATING THE YOUNGSTOCK REARING COSTS IN THE NETHERLANDS USING MONTE CARLO SIMULATION

Norhariani Mohd Nor [1,2], Wilma Steeneveld [2] and Henk Hogeveen [2,3]
[1] Department of Veterinary Preclinical studies, Faculty of Veterinary Medicine, University Putra Malaysia, 43400 Serdang, Selangor, Malaysia.
[2] Department of Farm Animal Health, Utrecht University, Utrecht, The Netherlands
[3] Chair Group Business Economics, Wageningen University, Wageningen, The Netherlands

ABSTRACT
A dynamic and stochastic Monte Carlo model to calculate the youngstock rearing costs in an average Dutch dairy farm which include four important youngstock diseases; Calf Scours (CS), Bovine respiratory Diseases (BRD), Subclinical Parasitic Gastroenteritis (SPGE) and Bovine Lungworm (BL) was developed. The uncertainties of disease probabilities, growth and reproduction are able to be resolve by different distributions in the model, as well as establishing the indirect cost when diseases and mortality occurred. For Dutch conditions, the average total costs of youngstock rearing simulated with all the diseases were €1364.

Keywords; Dynamic and stochastic Monte Carlo, youngstock rearing, average total cost

INTRODUCTION
On average 25% to 35% of dairy cows are culled each year in The Netherlands and have to be replaced. As replacement for culled dairy cows is crucial, this makes the youngstock rearing as an essential part in the dairy cows farm management. However, in The Netherlands 5.6% of calves die within the first two years of life (Mourits et al., 2000) especially due to diseases. Since youngstock rearing costs are often being overlooked by the dairy farmer (Mourits et al., 1997, Groenendaal et al., 2004) the estimation of the costs of youngstock rearing must be established. Knowing the costs of rearing a youngstock will be an important starting point towards optimizing the viability of the youngstock enterprise in the dairy farm.

For an optimal dairy cow replacement management, it is important that the youngstock on the farm reach first-calving age at a predetermined time with an optimal growth rate (Place et al., 1998; Mourits et al., 1997). Any delay in first calving extends the non-productive rearing period and cause extra costs (Mourits et al., 1997). The success of youngstock rearing depends on the management of youngstock diseases, nutrition, reproduction and environment. It is known that youngstock diseases reduce growth and daily weight gain (Hawkins, 1993; Virtala et al., 1996; Van der Fels-Klerx et al., 2002; Gulliksen et al., 2009) and affects first calving age (Waltner-Toes et al., 1986). Waltner-Toes et al. (1986) mentioned that the presence of diarrhea and/or respiratory diseases before 90 days of age affects the performance of the animal later in life and is associated with a higher age at calving. In addition, calf diseases increase morbidity and mortality rates, reduce feed conversion, increase the need for culling, reduces fertility, increase veterinary expenses, reduce milk production, reduce carcass quality and increase the risk of disease later in life (Waltner-Toes et al., 1986; Hawkins, 1993; Van der Fels-Klerx et al., 2002; Gulliksen et al., 2009). Yet, the effects of calf diseases, both direct and indirect, have rarely been measured under field conditions (Waltner-Toes et al., 1986).

No study estimated the costs of youngstock rearing which include the uncertainties (e.g. incidence of diseases, growth and reproduction probabilities). In our study, a stochastic Monte Carlo model was developed to simulate a calf from birth until first calving age. Four important calf disease (calf scours (CS), bovine respiratory disease (BRD), subclinical parasitic gastroenteritis (SPGE) and bovine lungworm (BL) were included, as well as a growth function and reproduction probabilities. Subsequently, this model was used to determine the total costs of youngstock rearing for each simulated calf.

MATERIALS AND METHODS

Model development

A dynamic and stochastic Monte Carlo model was built using Microsoft Excel with @Risk add-in software (Palisade, 2009) to calculate the costs of the youngstock rearing. Model outcomes were generated in 2 steps. First, calf life from birth until first calving age which include calf disease incidence, growth and reproduction were simulated by using the Monte Carlo model. Subsequently, the total costs were calculated from each simulated calf. All needed inputs were based on literature, expert knowledge and author's expertise.

Simulating diseases

States were healthy, diseased (CS, BRD, SPGE or BL) or mortality (Table 1). CS was characterized by infectious gastroenteritis caused by bacteria, virus and parasite. Other clinical signs under this state include diarrhoea, enteritis, septicaemia and navel ill. Next, BRD was denoted by respiratory syndrome caused by bacteria, virus and mycoplasma. Nematode *Ostertagia ostertagi* resulted in SPGE infection and caused weight loss, whereas BL was denoted as a disease caused by the nematode *Dictyocaulus viviparous* with coughing symptom and weight loss.

Transition matrix

There were 56 stages, 18 weekly stages from birth until 4 months of age, while stages 19 to 56 were in 3 weeks intervals from 5 months of age until first calving age. A transition matrix includes probabilities for getting diseased from one stage to the next stage was built at every stage in order to adapt for infections variations from birth until first calving age.

Transition matrix provides model stochasticity by using discrete probability function. Based on Table 1, H1 was the probability of the calf remains healthy in next stage and was calculated from 1 minus total morbidity. S1, B1, SP1 and L1 were the probabilities of the healthy calf becoming diseased in the next stage. Cure probabilities from previous diseased state were H2, H3, H4 and H5. The probability a calf will remain diseased from previous stage was S2, B3, SP4, and L5 and was calculated from 1 minus the sum of cure rate and mortality rate. M1 and M4 was determined as 0.

Only one state can occur for every stage. Furthermore, one diseased status did not change to a different disease status in the next stage.

Table 1. Example of transition matrix

Period= t+1

	States	Healthy	Calf scours	BRD[1]	Subclinical PGE[2]	Bovine lung worm	Mortality
	Healthy	H1[3]	S1[3]	B1[3]	P1[3]	L1[3]	M1[3]
	Calf scours	H2[3]	S2[3]	B2	P2	L2	M2[3]
	BRD[1]	H3[3]	S3	B3[3]	P3	L3	M3[3]
Period=t	Subclinical PGE[2]	H4[3]	S4	B4	P4[3]	L4	M4[3]
	Bovine lungworm	H5[3]	S5	B5	P5	L5[3]	M5[3]
	Mortality	0	0	0	0	0	1

[1] Bovine respiratory disease
[2] Parasitic gastroenteritis
[3] The probability depended on previous state at period=t, calf age and season which was based from literatures (CS and BRD) and expert opinion (SPGE and BL)

Simulating growth

To calculate the weight for each simulated calf, the model adapted the two phase growth function (Koenen and Groen, 1996). The parameters in the growth function used the normal distribution function to provide stochasticity in this model. In this model, a healthy calf had no weight loss. Weight loss for CS is between 1.57g/day to 2.46g/day while BRD caused reduced weight between 13g/day to 86g/day (Virtala et al., 1996; van der Fels-klerx et al., 2001). Daily weight loss for SPGE was 150g/day and BL was 110g/day. The calculation for milk replacer quantity, net energy requirement and net energy from feed was adapted from PR, 2006 and CVB Table booklet feeding of ruminants, 2008.

Simulating reproduction

Oestrus detection in this model is 80% while conception rates were based from Bage, 2003 and Brickell et al., 2009. Both reproduction rates used discrete probability function to determine if the calf is pregnant or not.

The input costs in youngstock rearing

The calculation of the average total costs in the youngstock rearing is the sum of healthcare costs (Table 3), feed costs, barn costs, and artificial insemination costs (Table 2). The calculation took into account mortality costs and reproductive failure costs (Table 2).

Table 2. Input prices for estimating the total cost of youngstock rearing in The Netherlands.

Input variable	**Price (€)**	**Source**
Farmer labour	18/hour	Huijps et al., 2008
Veterinarian labour	100/hour	Expert
Milk replacer	0.41/litre	Expert
Milk replacer feeding labour	6/day[1]	Expert
Concentrate	0.174/kg	Expert
Hay	0.15/kg[2]	Expert
Silage	0.08/kg[2]	Expert
Fixed feeding labour	1.20/day[3]	Expert
Artificial insemination	27/ insemination [4]	Expert
Calf market	110/calf [5]	Expert
Heifer market	960/heifer [6]	Expert
Barn	92/calf/year	Expert

[1] The price was for twice/day feeding with 10 minutes allocated for a milk replacer feeding

[2] The price was calculated by substituting the amount of silage (850NE/kg DM, 0.45DM/kg) or hay (834 NE/kg DM, 0.85DM/kg) needed to fulfill the same net energy requirement if the youngstock is fed with concentrate (940 NE/kg DM, 0.9 DM/kg). Therefore, the roughage prices depended on the concentrate price.

[3] The price was for twice/day feeding with 2 minutes time allocated for a feeding session of the roughages and concentrate

[4] The price was from the sum of artificial insemination dosage, visit cost and the technician labour cost

[5] The price was used when mortality occur with the assumption that farmer needed a replacement. The total cost calculation when mortality occurs is the sum of costs to rear until the age of mortality and calf market cost.

[6] The price was used when there is reproductive failure occur. It is the value of revenue forgone when the youngstock was sold as a heifer at 24 months old. The total cost calculation when reproductive failure occur is revenue forgone minus the sum of costs to rear until reproduction failure occurs and calf market cost.

Table 3. The input prices for healthcare costs.

Healthcare variables	**Price (€)**	**Source**
Preventive treatment	85[1]	Expert
Farmers treatment		
Calf scours	36[2]	Expert
Bovine respiratory disease	5.60[2]	Expert
Subclinical Parasitic Gastroenteritis and bovine lungworm	33[3]	Expert
Veterinary treatment [4]		
Calf scours	186 [5]	Expert
Bovine respiratory disease	62.10 [5]	Expert
Subclinical parasitic gastroenteritis and bovine lungworm	30 [6]	Expert

[1] The price was from the sum of BRD vaccination and parasite prevention using bolus anthelmintic

[2] The price was from the sum of treatment regime and farmer labour cost for twice/day for 3 days treatment with 10 minutes/treatment session for CS and 1 minute/treatment session for BRD.

[3] The price was from the sum of pour on anthelmintic price, veterinarian prescription cost and farmer's labour cost

[4] Veterinary call probability for CS, BRD, SPGE and BL are 0.25, 0.5, 0.05 and 0.15 respectively.

[5] The price was from the sum of treatment regime cost, veterinarian labour cost and farmer labour cost when treatment is done for twice/day for 3 days treatment with 45minutes/ treatment session for CS and 15 minutes/ treatment session for BRD

[6] The price was from the sum of anthelmintic injection, veterinarian visit and veterinarian labour cost

PRELIMINARY RESULTS

From the simulated Monte Carlo model, the non economic output of rearing a youngstock is presented in the table 4. The result showed that on average, a calf had a birth weight of 47kg. A calf has less than 1 artificial insemination because there is mortality of the calf in the model.

Table 4. Mean non-economic output values of the Monte Carlo model. (5% and 95% percentiles are given between brackets)

Output variables	Value
Birth weight (kg)	47 (40-54)
Weight (kg) at 10 weeks	80 (71-90)
Weight (kg) at 15 months	331 (314-348)
Artificial inseminations times	0.8 (0-3)
Pregnancy age (month)	18 (16-19)
First calving age (month)	26 (25-28)

The simulations of the Monte Carlo models for the Dutch average farm give the average costs of the youngstock rearing and are presented in table 5 below. The average total cost for youngstock raising was estimated as €1364.

Table 5. Economic output values for rearing youngstock (5% and 95% percentiles are given between brackets)

Output variables	Mean Costs (€)
Farmer's treatment	34 (0-69)
Veterinary treatment	46 (0-62)
Feed	1005 (864-1118)
Artificial insemination	22 (0-81)
Barn	178 (169-191)
Total	1364 (1152-1517)

CONCLUSIONS

The average total cost for youngstock raising was estimated as €1364. The model result showed the future use of this model in optimizing the costs in youngstock rearing.

REFERENCES

Brickell J.S., Bourne N., McGowan M.M., Wathes D.C., 2009. Effect of growth and development during the rearing period on the subsequent fertility of nulliparous Holstein-Friesian heifers, Theriogenology 72, 408-416

Bage R., 2000. Conception Rates after AI in Swedish Red and white dairy heifers: Relationship with Progesteron concentrations at AI, Reprod. Dom. Anim. 38, 199-203

CVB, 2008 Table Booklet Feeding of Ruminants; Feeding standards, feeding advices and nutritional values of feed ingredients. CVB-series no. 43, 12-17

Gulliksen, S.M., Lie, K.I., and Østerås, O., 2009. Calf health monitoring in Norwegian dairy herds. J. Dairy Sci. 92 :1660–1669

Groenendaal, H., Galligan, D.T., and Mulder, H.A. 2004. An Economic Spreadsheet Model to Determine Optimal Breeding and Replacement Decisions for Dairy Cattle, J. Dairy Sci. 87:2146–2157

Hawkins, J.A., 1993. Economic benefits of parasite control in cattle. Veterinary parasitology, 46: 159-173.

Huijps, K., T. Lam, et al. (2008). Costs of mastitis: facts and perception. Journal of Dairy Research **75**(1): 113-120.

Koenen, E.P.C., Groen, A.F., 1996. Genetic Analysis of Growth patterns of Black and White dairy heifers, J Dairy Sci 79:495-501

Mourits, M.C.M., Dijkhuizen,A.A., Huirne, R.B.M., and Galligan, D.T., Technical and economic models to support heifer management decisions: Basic concepts. 1997. J Dairy Sci 80:1406-1415

Mourits, M.C.M, Van Der Fels-Klerx, H.J, Huirne, R.B.M, and Huyben, M.W.C. 2000. Dairy Heifer Management in The Netherlands, Preventive Veterinary Medicine 46(2000) 197-208

Palisade, Monte Carlo Simulation; How Monte Carlo Simulation works?. Assessed 17th July, 2009. http://www.palisade.com/risk/monte_carlo_simulation.asp

Place, N.T, Heinrichs, A.J., and Erb, H.N. 1998. The effects of disease, management, and nutrition on average daily gain of dairy heifers from birth to four months, Journal Dairy Science 81:1004-1009

PR, 2006 Handboek Melkveehouderij. Zutphen 192

van der Fels-Klerx, H.J., Saatkamp, H.W., Verhoeff. J., Dijkhuizen, A.A., 2002 Effects of bovine respiratory disease on the productivity of dairy heifers quantified by experts. Livestock production science 75 (2002) 157-166

Virtala A.M.K., Mechor, G.D., Grohn, Y.T., and Erb, H.N., 1996. The effect of calfhood diseases on growth of female dairy calves during the first 3 months of life in New York state, J Dairy Sci. 79:1040-1049.

Waltner-Toews, D., Martin, S.W., and Meek, A.H., 1986 The effect of early calfhood health status on survivorship and age at first calving, Can J Vet Res 1986; 50:314-317