SimHerd ArlaFlex documentation

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The overall aim of SimHerd ArlaFlex

The aim with the SimHerd ArlaFlex is to estimate how much a reduction of cow mortality changes production parameters and net return in the herd. In the model, we calculate this by assuming that for instance a 50% reduction of mortality implies a 50% reduction of the underlying disease that causes mortality.

A mini-version of SimHerd:

A specially designed algorithm is powering SimHerd ArlaFlex. This algorithm has been created by SimHerd and can be best described as a mini-version of the full SimHerd model. The technical term of this mini-version is a Response Surface Model (RSM). An RSM is a set of equations that describes the behaviour of the full SimHerd model as good as possible, while easier and faster to use. Creating RSMs is an acknowledged discipline in computer science. For a more thorough description of the theory behind RSMs please see the appendix.

The key-assumptions of SimHerd ArlaFlex:

Considering that the RSM is a mini-version of the full-version of SimHerd, we need to look into the most important assumptions in the full-version of the SimHerd model. The assumptions can be divided into three categories:

1) The relationship between mortality and underlying incidence of diseases
2) The risk factors of the diseases in question
3) The effect of the diseases in question on the cow's performance (yield, fertility, culling)

Key-assumptions

The relationship between mortality and underlying diseases

The ArlaFlex user starts with entering input in the column of “% cows dying now”. This is the proportion of cows in the herd that dies with the main cause of death being injuries, lameness, mastitis and metabolic diseases. In the column “Reduction target”, the user enters his ambitions for how much the mortality due to a specific cause should be reduced (Figure 1).

Mortality causes (% of cows) and reduction targets

	% cows dying now	Reduction target
Injury	3.0	50 %
Metabolic diseases	3.0	50 %
Lameness	2.0	50 %
Mastitis	1.0	50 %
Other cause	1.0	

Figure 1: Input of mortality causes in the application.

The user is not asked to give input for the incidence of diseases. Instead, the user enters the incidence of mortality where e.g. lameness is the primary cause. This input is used to estimate the underlying lameness incidence in the herd. Here, we assume that for every cow in the herd that dies with lameness as the primary cause, there are 12 lame cows in the herd. In the same way, we assume that for every cow in the herd that dies because of mastitis and metabolic diseases, the underlying incidence of these diseases is 15 and 9, respectively. For the injuries, it is not assumed that there is an underlying incidence and therefore, the model only considers the proportion of injuries given by the user input.

So, by entering that 2% of the cows die of lameness, it is assumed that herd incidence of lameness is 24 cases per 100 cows. With a reduction target of 50%, it is assumed that the incidence of lameness is reduced from 24 to 12 cases. This doesn’t only result in 1 fewer dead cow, but also in 11 fewer lame cows that suffer from milk yield reduction, lower fertility and earlier culling.

The risk factors of the diseases in question

The probability of getting a disease is calculated every week for every cow. Weekly risks are calculated because diseases' risks are not stable throughout the lactation, as illustrated in

Figure 2 for mastitis.

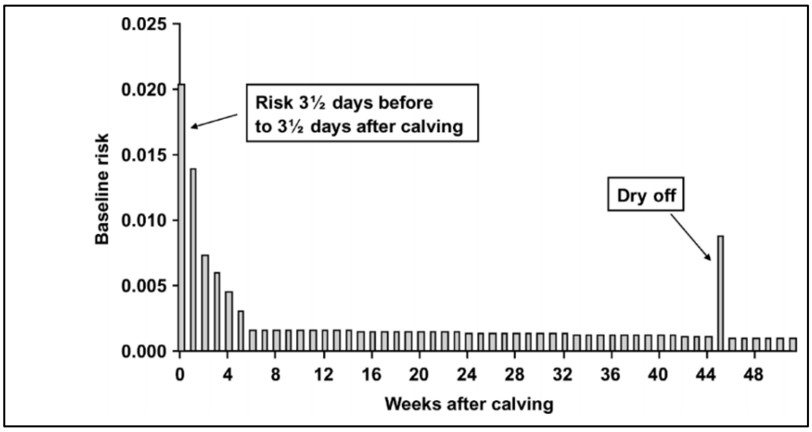

Figure 2: Example of baseline risk function in mastitis (weekly risk). From Østergaard et al., 2005.

The incorporation of this profile allows SimHerd to simulate that an improvement in fertility (something positive) results in more calvings, and thereby more cows in the high-risk period for mastitis on herd level (something negative). SimHerd considers both positive and negative aspects when simulating cow-level as well as herd-level performance. Other relevant risk factors for the diseases incorporated in ArlaFlex are presented in Table 1.

	Milk fever	Displaced abomasum	Ketosis	Mastitis	Lameness	Injuries[5]
Base risk, % [1]	0.13	0.07	0.05	0.02	0.01	0.001
Risk for a 1st parity cow [2]	0.01	0.5	0.3	0.6	0.43	1
Risk for a 2nd parity cow [3]	0.25	1	0.7	0.75	0.48	1
Risk of recurrence [4]	4	1.1	3	2.5	3.2	-

Table 1: A number of risk factors for the selected diseases on cow-level in SimHerd.
1: the weekly-risk of a 3rd parity cow to get a disease in week 1 of lactation; the development of how the risk changes throughout the lactation is described with a separate function, illustrated in example 2.
2. The odds of getting a disease for a 1st parity cow compared to a 3rd parity cow.
3. The odds of getting a disease for a 2nd parity cow compared to a 3rd parity cow.
4. The odds of getting a second case of a disease after the occurrence of the first case of the disease

5: All cows affected by injuries leave the herd (dead/euthanised) in the moment an injury occurs. Therefore, recurrence risk is irrelevant.

The effect of the diseases in question on the cow's performance

In the previous paragraph it was described how the probability of getting a disease is calculated every week for every cow. The disease actually occurring for a cow, is triggered in the model by drawing a random number from the relevant probability distribution. In case a cow gets the disease in SimHerd, it is simulated how the diseases affect the cow's milk production, feed intake, reproduction, other diseases, culling risk, and mortality. The parameterisation of the diseases incorporated in ArlaFlex are shown in Table 2.

	Milk fever	**Displaced abomasum**	**Ketosis**	**Mastitis**	**Lameness**	**Injuries[5]**
Yield loss, % [1]	1.0	4.0	2.2	7.7	4.0	-
Reduced conception rate [2]	1	1	0.28	1	0.43	-
Duration of reduced conception [3]	0	0	63	0	140	-
Withdrawal of milk, days	0	6	7	7	0	-
Mortality risk [4]	0.13	0.07	0	0.02	0.042	1
Risk for involuntary culling [4]	0	0.13	0	0.06	0.036	-

Table 2: Effects of the selected diseases on cow-level in SimHerd. The effect on the cow's cell count, feed intake, weight and insemination period are also included in the model, though not presented in this table.
1: Yield loss (as a % of lactation yield) depends on the time where the disease occurs in the lactation. A profile for milk loss is represented in the model for each disease. The cow's feed intake is reduced proportionally to the drop in milk yield.
2: Conception rate (CR) for healthy cows (50% for example) is reduced by this factor.
3: How many days the cow is affected by the reduced CR, whereafter the cow returns to previous CR level.
4: Risk of dying or getting culled involuntarily in the week of disease occurrence.
5: Injuries have a mortality risk of 1, meaning that cows leaves the herd (dead/euthanised) in the moment an injury occurs. Therefore, the other disease effects are irrelevant.

Simulating disease effects on cow-level, gives a result on herd level. In case 20% of the cows get lame and their milk yield is 4% lower during the remainder of their lactation, these lame cows are simulated alongside the healthy cows in the model hereby resulting in a reduction of the average milk yield. The technical performance of the herd (yield per cow-year or replacement rate) is simulated indirectly through the simulation of all the individual cows, but also youngstock. The economic performance of each simulated scenario is calculated by multiplying the relevant technical output from the model (milk yield per cow year, slaughter cows per year and feed intake e.g.) with the relevant prices (milk price, slaughter price and feed costs, respectively). The Gross Margin (GM) of each scenario is calculated as the revenues from milk and meat minus the variable costs of feed, veterinary treatment, breeding and bedding.

Literature

Literature references documenting the incorporation of the disease effects into the SimHerd model are:

- A paper describing the **original mechanisms of the model** are described in Sørensen et al. (Sørensen, J.T., Kristensen, E.S., Thysen, I., 1992. A stochastic model simulating the dairy herd on a PC. Agric. Syst. 39, 177–200.)
- **Metabolic diseases (milk fever, ketosis and displaced abomasum (DA):** Østergaard et al. 2003 (Preventive Veterinary Medicine, vol. 58, page 125-143).
- **Mastitis:** Østergaard et al. 2005 (Journal of Dairy Science, vol. 88, page 4243-57).
- **Lameness (hoof horn diseases):** Ettema et al. 2010 (Preventive Veterinary Medicine, vol. 95, page 64-73).
- The **effects of using beef semen in a herd and the potential for reducing methane emission** are described in Ettema et al. (Journal of Dairy Science, vol. 100, page 4161-71).

Appendix

How to create a mini-version (RSM) of the full-version of SimHerd

SimHerd-Flex: a Response Surface Model

A SimHerd-Flex application is a light version of the full SimHerd model (see https://simherd.com/en/simherd-expert/). The technical term of this light version is the so-called Response Surface Model (RSM). The RSM is a set of equations that describes the behaviour of the full SimHerd model as good as possible, while easier and faster to use. The benefit of working with a set of equations, is that it can be incorporated in a dashboard or app and give the user immediate answers based on a limited selection of inputs. Figure 3 presents a simplified illustration of how an RSM is created.

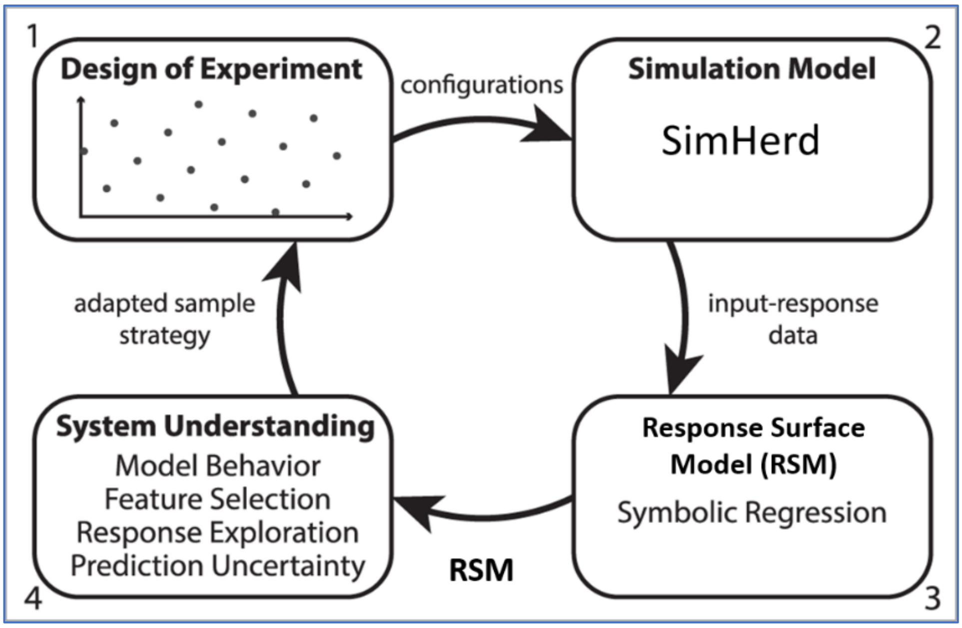

Figure 3: Making a Response Surface Model (RSM) modified after Willem & Stijven (2014)

1) Design of Experiment

Step 1 in the creation of an RSM (figure 1) is the design of a simulation experiment to be executed with the full SimHerd model. The design of this study for the ArlaFlex covered a total of 432 scenarios in which different levels of disease risk, mortality, reproduction performance, culling rate, and milk yield. The 432 combinations of herd-specific settings can be interpreted as having data from 432 different herds. The economic results for these 432 different scenarios were then estimated using two different price levels.

2) Simulation model with the full version of the SimHerd model

In step 2 (Figure 3) each of the 432 scenarios were simulated by SimHerd in weekly steps over a period of 10 years. The simulated technical results (like milk yield per cow-year) and economic results (like Gross Margin (GM) per cow-year) summarised over the last 5 simulation years were used in the next step.

3) RSM or symbolic regression

In step 3 (Figure 3), a regression model was built to describe the simulated output parameters as a function of the model's input parameters. In other words, the regression model describes the simulated GM per cow-year (the dependent variable, y) as a function of the input parameters like the herd's disease risk and milk price (the independent variables, x's). This regression model is also referred to as the RSM.

4) System understanding

In step 4 (Figure 3), it was evaluated to what extent the RSM was able to describe the 432 data points. Furthermore, the behaviour of the RSM was studied when using input parameters (x's) beyond the range of original input parameters from the design of experiment (extrapolation).