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# Towards a decision support tool with an individual-based model of a pig fattening unit

A. Cadero[a,b], A. Aubry[a], J.Y. Dourmad[b], Y. Salaün[a], F. Garcia-Launay[b,*]

[a] IFIP – Institut du porc, 35651 Le Rheu, France
[b] PEGASE, Agrocampus Ouest, INRA, 35590 Saint-Gilles, France

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ABSTRACT

European pig production is encountering many economic and environmental challenges. To address these challenges, farmers need tools to assess the sustainability of their production systems and to make changes to ensure their sustainability. Decision support tools can help farmers to simulate and understand the influence of their management practices on production system performance. In a previous article, we described a dynamic pig fattening unit model that considers individual variability in pig performance, farmers' practices and animal management and estimated environmental impacts (through Life Cycle Assessment) and economic results of the unit. This model is intended to be included in a decision support tool, which requires appropriate parameterisation for on-farm application and assessment to guarantee the quality of predictions. The objective of the present article is to develop a process to adequately parameterise a model for on-farm use, apply it to the pig unit model, and evaluate it using external data from commercial farms. Twenty-one pig farms were surveyed in western France in 2015 to collect data on animal performance, batch and shipping management, and farming practices. The parameterisation process was divided into six steps which correspond to incremental parameterisation of the model using data collected in the survey. The first step consists of parameterising the inputs related to farm infrastructure and management. The second step consists of setting initial mean weight and age of pigs at the beginning of fattening equal to those observed on each farm. The third step consists of three successive parameterisations for targeted slaughter weight, mean protein deposition, and mean feed intake. Steps four, five and six are iterations of step three. Each input parameterisation step improved predictions, with a decrease in the squared bias, non-unity slope and lack of correlation between predicted and observed data. For slaughter weight (SW), the root mean squared error (RMSE) decreased from 3.25 to 0.83 kg (i.e. from 2.8 to 0.7% of mean SW). For average daily gain (ADG), the RMSE decreased from 58.9 to 14.3 g live weight (LW)/day (i.e. from 7.3 to 1.8% of ADG). For the feed conversion ratio (FCR), the RMSE decreased from 0.22 to 0.03 kg feed/kg LW (i.e. from 7.8 to 1.1% of mean FCR). Considering the final RMSE values, the parameterisation process developed appears suitable for calibrating the model for future use in a decision support system.

## 1. Introduction

European pig production is encountering many economic and environmental challenges. To address these challenges, farmers need tools to assess the sustainability of their production systems and to make changes to ensure their sustainability. Decision support systems developed from models can help farmers to simulate and understand the influence of changes in their management practices on the economic and environmental performance of their production system (Gouttenoire et al., 2011; Prost et al., 2012). Most published pig fattening models do not simultaneously predict technical, economic and environmental results (Pomar et al., 2003; Halas et al., 2004; Lurette et al., 2008; Niemi et al., 2010; Chardon et al., 2012), being developed only for research and not as a tool for on-farm application. We developed a dynamic pig fattening unit model that considers individual variability in pig performance, farmers' feeding practices and animal management, and which predicts environmental impacts (through Life Cycle Assessment (LCA)) and economic results of the unit (Cadero et al., 2017). The model was built for two purposes. The first was for research, to quantify interactions among farm management practices, animal characteristics, and farm infrastructure, and their influence on technical results, economic results, and environmental impacts of the unit. This should help to identify actions that will improve performance of pig production. The second was to incorporate this model into a decision

* Corresponding author.
*E-mail address:* florence.garcia-launay@inra.fr (F. Garcia-Launay).

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support tool for on-farm advice, in order to assess the influence of changes in farm management practices or pig characteristics on performance of the farm. It is important to assess the predictive ability of the model before using it as a research model or as a decision support tool. In previous steps of the modelling process, model predictions were assessed using the authors' expert knowledge (Cadero et al., 2017) and mean indicators of technical and economic performance available for French pig fattening units (IFIP, 2015). A detailed sensitivity analysis was also performed (Cadero et al., submitted for publication). After verifying adequate behaviour of the model, formal comparison between predicted and observed values using independent data is an essential step in model evaluation (Bellocchi et al., 2010; Hauschild et al., 2012; White et al., 2015). Objectives of the present article are (i) to develop a process to parameterise the model for a specific commercial farm in order to simulate its performance, and (ii) to compare model predictions of technical indicators to observed data.

## 2. Materials and methods

### *2.1. Description of the fattening unit model*

The fattening unit model is a discrete-event mechanistic model with stochastic biological traits (pig feed intake, growth potential, and risk of mortality) and a one-day time step (Cadero et al., 2017). The pig fattening system consists of the pig herd, farm management and farm infrastructure. The pig herd is divided into successive batches of pigs of the same age which are reared in the same room from the beginning of the fattening period until shipping to the slaughterhouse. Each pig is represented using an individual-based model adapted from the InraPorc model (van Milgen et al., 2008, section A of appendices). The InraPorc model simulates feed intake, body protein and lipid depositions, and the resulting growth and nutrient excretion of each pig. Each pig is attributed a profile, which includes initial live weight, mean protein deposition, a shape parameter of the protein deposition function, and two parameters that describe feed intake, to generate the appropriate structure of a pig herd according to Vautier et al. (2013). Farm management is represented by farmer practices and a calendar of events containing tasks to perform. At each time step of the simulation, the events corresponding to the current day are read in the calendar and processed. The practices include batch management, allocation of pigs to pens, feeding practices, and slaughter shipping practices. Farm infrastructure is represented by the number of fattening rooms, each with a number of pens of a given size, which are provided as input parameters. A buffer room can be used to extend the end of the fattening period for the lightest pigs which have not reached the minimum slaughter weight without economic penalties. Once the last pigs in a batch are moved to the slaughterhouse or to a buffer room, the fattening room is considered empty after a disinfection period and is then ready for a new batch. The model calculates technical, economic and environmental results for each fattening pig and for the unit as a whole. Environmental impacts of each slaughtered pig are estimated using LCA and consider impacts from the extraction of raw materials to the farm gate. More detailed description of the model and the LCA are found in Cadero et al. (2017).

### *2.2. On-farm survey database*

Twenty-one pig farms were surveyed in western France in 2015 to collect data on animal performance, batch and shipping management, and farming practices (Aubry et al., 2016). Technical and economic indicators for the 21 farms were collected from GTE, the French technical and economic management database (IFIP, 2015). The number of shipments per batch was calculated from slaughter data (UNIPORC, http://www.uniporc-ouest.com/). Batch management and shipping practices identified in the survey varied (Fig. 1). Nearly half of the farms (10) used a buffer-room to extend the fattening period of the lightest pigs. The feed sequence plan was one-phase for two farms and two-phase for the other 19. For feed rationing, four farms fed *ad libitum*, while the other 17 restricted feed to 2.6 kg/day. The scale of application of these feeding practices was the entire room for eight farms, but the individual pens for the other 13. On average, technical indicators of the 21 farms (Table 1) laid within the ranges of values commonly encountered in France when considering specific production types such as the French "label rouge" or a cross-breeding multiplication farm.

### *2.3. Parameterisation steps for model inputs*

Data collected in the survey were used to parameterise each farm. The parameterisation process is composed of six successive steps (Fig. 2). Step 1 consists of parameterising inputs related to descriptions of farm infrastructure and management obtained from the survey. Farm infrastructure includes the numbers of rooms, pens per room, places per pen, the area allocated per place, and the size of the buffer room. Farm management includes the interval between successive batches, the duration of the disinfection period, the number of pigs per batch, and the maximum time kept in the buffer room before slaughtering. Shipping practices were also parameterised for each farm and include the number of days between counting pigs and shipping them to the slaughterhouse, and between selecting pigs for shipment and shipping them. The survey was also used to parameterise the mortality and loss rate.

The same data-base of animal profiles, corresponding to the profiles used in Cadero et al. (2017, submitted for publication), was used for all farms to create the batches. This population corresponds to (Large White × Landrace) × (Large White × Pietrain) breed and contains 1000 male and 1000 female pigs. To generate an adequate variability among pigs, the profiles were generated using the procedure of Vautier et al. (2013) applied on two mean animal profiles (one male and one female, Brossard et al., 2014).

Since the survey contained no information about feed composition, feed intake and nutrient requirements of female pigs were used as the reference for feed formulation and were estimated with InraPorc® (2006). Two feeds, A and B, were formulated on a least-cost basis to contain 9.75 and 9.82 net energy (NE) MJ/kg respectively and to meet at least 100% of the requirements of standardised ileal digestible amino-acids for the mean female profile at 30 kg live weight (LW) (beginning of fattening) and 120 kg LW (target slaughter weight), i.e. 0.98 and 0.47 g digestible lysine (Dig Lys)/MJ NE, respectively. Using these feeds, two feed sequence plans (one-phase, two-phase) and two feed rationing plans (*ad libitum*, restricted to 2.6 kg/d) were designed, based on the feeding practices of the surveyed farms. Feeds A and B were then combined in proportions necessary to achieve amino-acid requirements of the mean pig profile at the beginning of each phase in the two-phase feed sequence plan. Therefore, the amino-acid requirements are not covered at the beginning of each phase for some pigs and are over covered for some other ones. The two-phase strategy was designed to supply 0.98 g Dig Lys/MJ NE from 70 days of age to 65 kg LW (Feed A) and 0.75 g Dig Lys/MJ NE from 65 kg LW until slaughter (mixture of Feeds A and B). The one-phase feed sequence plan entailed distributing only Feed A. As most farms use liquid feed, the restricted rationing plan begins distributing feed at 4.5% of mean LW at the beginning of fattening, with an increase of 0.2 kg feed/week up to the plateau of 2.6 kg/d (Quiniou et al., 2013).

As sensitivity analysis of the model indicated that mean initial LW had the greatest influence on model predictions (Cadero et al., submitted for publication), step 2 (Fig. 2) consists of setting initial mean weight and age of pigs at the beginning of fattening equal to those observed on each farm. The feed rationing plan was also modified based on the observed mean initial LW to calculate the initial feeding level as a function of pig LW.

Step 3 consists of three successive parameterisations. First, the targeted slaughter weight was parameterised by comparing the predicted