Bioeconomic analysis of Uruguayan cow-calf systems using a simulation model

J.M. Soares de Lima
Instituto Nacional de Investigación Agropecuaria
INIA Tacuarembó, Ruta 5 km 386, Tacuarembó 45000, URUGUAY
jsoaresdelima@tb.inia.org.uy

ABSTRACT

Uruguay is one of the major beef and sheep meat exporters countries. Its economy is highly dependent on livestock production, and cow-calf systems (CCS) are mainly carried out by small farmers under grazing conditions and consequently under the influence of a large number of interacting variables affecting productivity and especially the economic profit of the production systems. Compared to many other countries, fat cow/calf price ratio in Uruguay is significantly higher. Under the assumption that pregnancy diagnostic defines whether a cow is retained on the herd or cull to be fattened, and that those are sold with relatively high values, the hypothesis is that calf production and cow fattening are antagonistic activities inside the system. The aim of this study was to analyze the effect of some key variables in CCS using a bioeconomic simulation model, with special emphasis on the interactions between pregnancy rate, age at first mating (AFM) and the relationship between calves and fat cow prices. The defined CCS has enough forage to fatten all cull cows and to rear heifers (15-17 % of improved pastures). Three AFM were compared; 14 months old, 26 years old and 50% of heifers at 14 months old and 50% at 26 months. In addition, two market scenarios defined by different calf/cow price ratios were assessed (1.49 vs 1.27). Results showed that increase on pregnancy has its economic counterpart reducing cull cows for fattening. In economic terms, the importance of pregnancy as an indicator of the farm success should be relativized, especially when the fattening system component is assisted by a favorable prices relationship and an efficient process of females replacement in the herd (early AFM). Simulation models are a useful tool to identify critical points and inefficiencies in Uruguayan's livestock systems, and to feedback research when looking for alternatives to overcome these limitations.

Keywords: cow-calf systems, livestock, pregnancy rate, mating age, profit, Uruguay

1. INTRODUCTION

With only 176,215 km2 of territorial extension, Uruguay is one of the largest meat exporters countries, being the 5th in beef meat exportations in 2013 (USDA, 2014) and the 12th in sheep meat exportations in 2012 (UECBV, 2014).

Meat production systems are mainly based on rangeland/native pastures (80 % of the Uruguayan territory) but during the last years, international meat prices and the opening of new markets have provoked the intensification of fattening systems in order to improve animal performance and fulfill different market requirements. These intensive systems include a wide range of feeding alternatives between pasture and concentrate utilization.

Livestock in Uruguay has also a social paramount importance, with 48,000 farms. While the livestock sector has gained competitiveness in recent years, global productive indicators have not changed accordingly. In order to illustrate both concepts, figure 1 shows the calf price evolution and the percentage of calves achieved per mated cow.

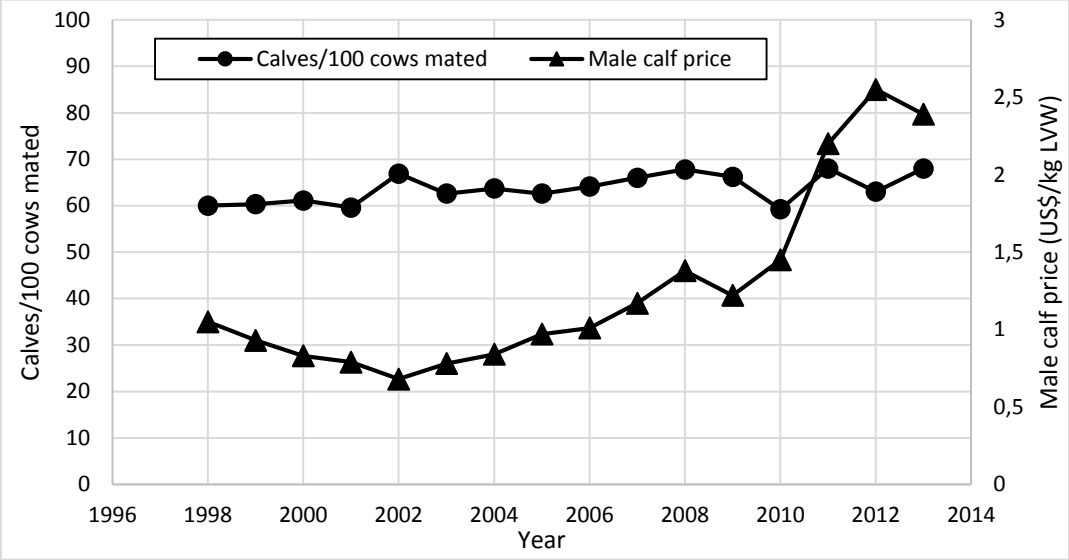

Figure 1. Male calf price and reproductive rate evolution over the last 15 years.

There has been much debate in Uruguay in relation to possible causes of this "Livestock Standstill", where even though the market signals are favorable (calf prices to rise), this does not imply a significant and sustained increase in reproductive efficiency.

The hypothesis that this work attempts to check, is that the vision of the productive process, many times lacks an integrated approach that will enable to analyze at a global level, a production system that presents a much greater complexity than it is assumed and where other variables in addition to the prices of the calf are also important.

The essential premise of this approach is that the behavior of a system can not be understood through an understanding of isolated elements. From a systemic point of view, the response to alterations on the production unit should be studied by the evaluation of the impact of each decision on the system running as a whole. It is postulated that such behavior is determined by the interactions between their elements and is not a direct response to the alteration of an isolated component (Feldkamp, 2004).

Simulation models are an important conceptual tool which enables the development of theories and hypotheses, particularly in highly complex systems (Peck, 2004).

In this work, is presented a bioeconomic analysis of production systems for breeding in Uruguay using a simulation model (Soares de Lima, 2009). The objective was to highlight the main variables that determine the productive and economic outcomes in these highly complex systems and each variable action mode on the behavior of the system as a whole.

2. MATERIALS AND METHODS

A simulation model was used (Soares de Lima, 2009), reproducing the behavior of a livestock production system in all its stages (breeding and fattening), and considering animal performance, the dynamic of the herd, management strategies and the economic component. The model was developed in Microsoft Excel, with components created in Visual Basic for Applications (VBA), specifically functions and iterative procedures.

It is a dynamic model and basically deterministic. However, for the simulation of some processes such as fattening and sales to slaughterhouse, stochastic criteria are handled, regarding to the group of animals as a population whose liveweight follow a probability distribution.

2.1. Model Structure

To facilitate the understanding of the model operation, it has been divided in three main blocks: a) Animal Model, including the mechanisms of growth, reproduction and fattening that determine the productive behavior of animals, (b) Population-based model, including the dynamics that determines the evolution of the number of animals, defined by reproductive coefficients, mortality, sales and purchases by categories and, c) Economic model, consisting of a profit function that will determine the economic outcome of the system. As an example, Animal Model with its variables and relationships are shown (Figure 2).

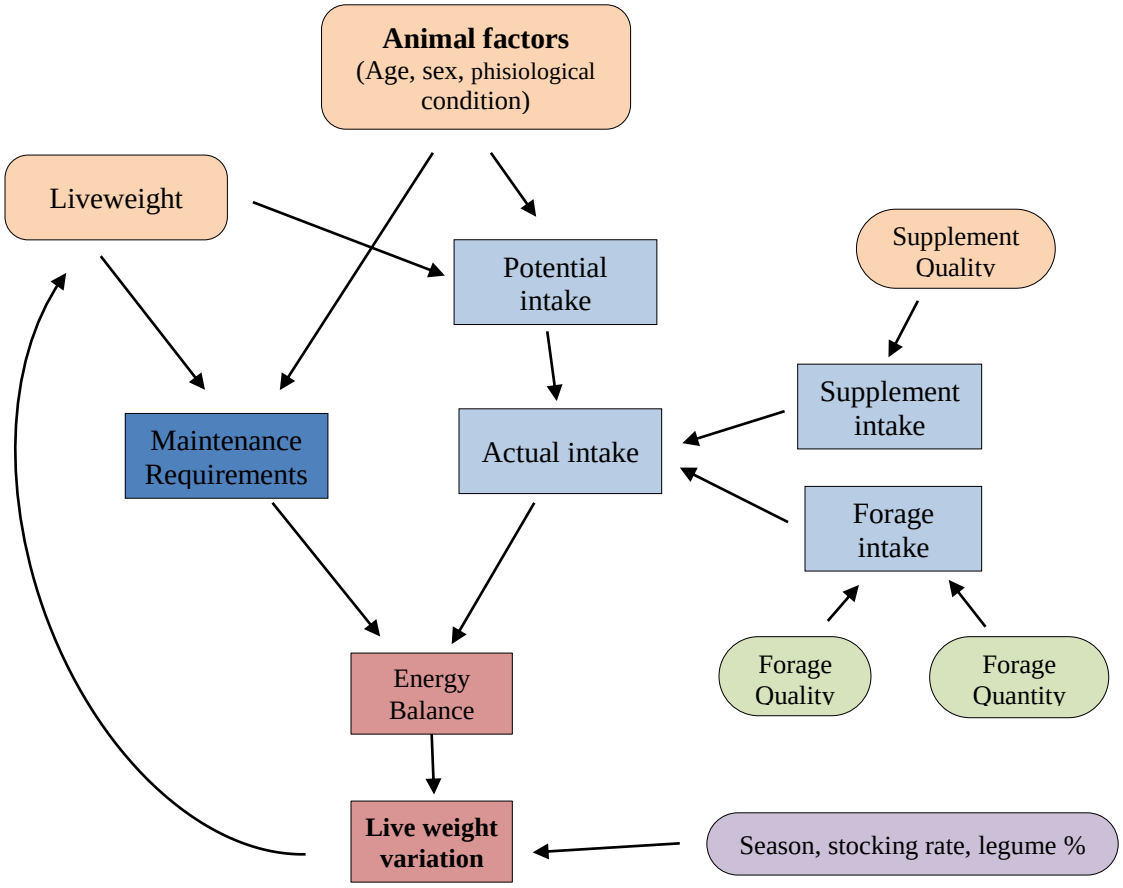

Figure 2. Animal model. Components and relationships modeled.

The methodology consisted in modelling a basic livestock system and assessing both productive and economic results. From this basic system, it is proposed to carry out changes in some variables considered to be the most relevant (because of their impact on the system) and to evaluate their direct impact on production and profit as well as their interactions (if any) with other variables.

2.2. Description of the modeled system

Through the use of the model is intended to represent a cow-calf system, defining it as a system that sells male calves at weaning and also the female surplus calves. This is a usual system in Uruguay, mainly associated with farms with soil quality restrictions, being not possible to have enough forage production (nor quality) to finish males.

Cows culled from the herd because of their age or because they were not pregnant, are often fattened for meat production. In general, if is possible to do it at the same farm, it represents an important economic incentive to sell an animal heavier and of a greater value per kg, compared to the option of selling it to be fattened by another farmer. As a negative counterpart, the fattening process determines the stay of the cows on the farm during the autumn and winter, seasons in which forage production is the lowest of the year in Uruguayan conditions. Due to the inability to assess all the variables involved real systems, this model will consider that all the cows are fattened for all the simulations that will be performed.

In order to understand the effect of the analyzed variables, is important to minimally describe how a typical cow-calf system works in Uruguay. Form March to June (autumn) pregnancy diagnosis is performed on cows mated form December to February. The physiological status of the cow at this moment, will trigger different processes and, in some way antagonistic, in the system: (a) if the cow is diagnosed as pregnant, will remain in the farm, it will produce a veal calf in September-November which will be weaned and sold in April/May. Prior to that in December the cow will be mated again; (b) If the diagnosis indicates that the cow is not pregnant, a process of fattening will be initiated, which, depending on the farm forage production, it may last between 2 to 6 months. As this fattening animal leaves the breeding herd, is necessary to enter another female in order to maintain the herd size. According to this, is important the age at first mating, since it will be very different if takes 3 years a female to enter the breeding herd that if the first mating is achieved at one year of age.

The third variable to analyze is the price of the fat cow compared to the price of the calf. In this sense, market conditions in Uruguay shows particularly high prices for the culling cows in relation to the price of the calf, in relation to most countries. However, is important to mention that this relationship is decreasing (figure 3).

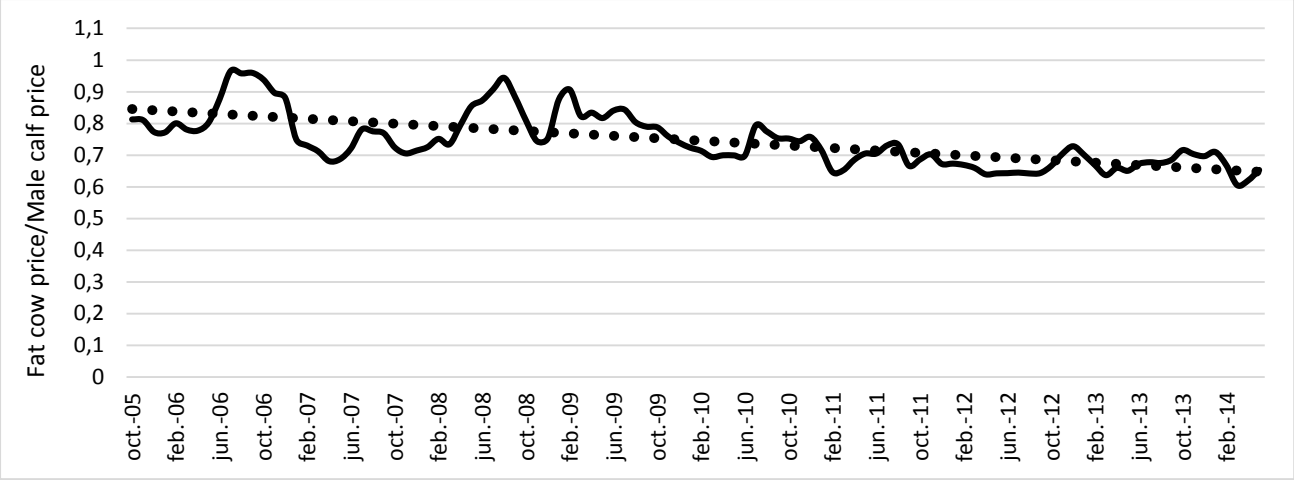

Figure 3. Monthly evolution of the relationship of prices fat cow/calf in the last 9 years and average trend.

It is likely that different prices or price relationships between the two main products of the system (fat cow and calf) defines important variations on system's profit.

The aim of this work is to analyze and quantify the productive and economic effect of the following variables on a typical cow calf system in Uruguay: 1) pregnancy rate, which defines the proportion of females that remain in the farm and produce a calf and the proportion destined to meat production and determining a replacement process in the herd, Percentages considered are 75, 80, 85 and 90%, 2) the age at first mating, defined as the age at which the female can be entered at the breeding herd and thus begins to play a role in the reproductive system. First mating ages compared was 14, 26 months (2 years) and an intermediate option where half of the females was mated at 14 months and the other half at 26 months, option identified as 20 months. 3) prices and price relationships between the two main products of the system: the calf and the fat cow. It's considered a series of average prices for the period 2005-2010, representing a period of low prices and with a relationship between the price of the calf and the price of the cow of 1.27, compared with a series of recent prices (2011 until today) where they have been stabilized on high values. That relationship is 1.49.

3. RESULTS AND DISCUSSION

The conjunction effect of the rate of pregnancy and the first mating age on liveweight production of an intensive cow-calf system with fattening of culled cows, is shown in Figure 3.

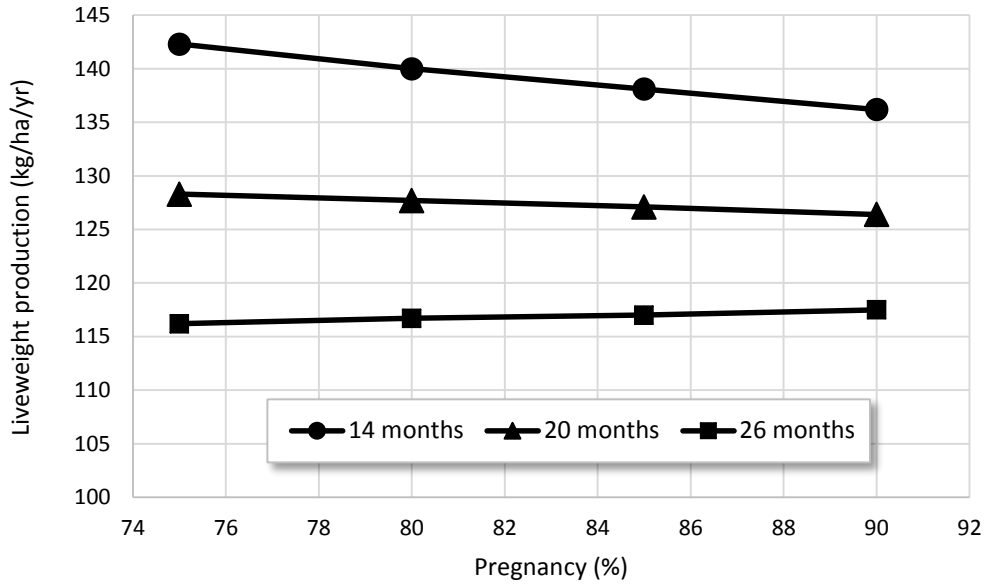

Figure 3. Effect of reproductive rate on the productivity of a cow-calf system with different ages at first mating: 14 months; 50% heifers at 14 months and 50% at 2 years (20 months on average) and 26 months of age.

Is important to highlight that in an intensive production system like the one modeled, by reducing mating age, a significantly increase in productivity could be achieved by eliminating rearing heifers and consequently increasing the number of cows for breeding and the number of calves available for sale. This is consistent for all the pregnancy rates that were analyzed.

The fattening of cattle could be done quickly and efficiently, as far as a good feeding level is achieved as in the case simulated here (quantity and quality of forage). Considering that the gestation-lactation process is inelastic, if the system is intensified and the fattening process is shorter, the former becomes more competitive compared to the calving process, as calves will be available for sale just a year after the pregnancy diagnosis is done.

The lower rate of pregnancy (greater proportion of animals for fattening) determines a higher production in the system, but is important to consider that this happen only with an early mating age (14 or 20 months, Figure 3). Indeed, a non pregnant cow even with a very efficiently fattening process, is still not profitable, if its first mating was performed at 2 or 3 years of age. In this case, the superiority of the fattening process in relation to the breeding one is lost.

Therefore, the higher efficiency of the fattening process is capitalized when the mating age is 14 months old. In that sense, from a productive perspective, is better to obtain lower pregnancy rates and a greater amount of cows to be culled, which are efficiently fattened and also efficiently replaced in the herd.

This productive result usually generates a similar economic result, at certain price ratios.

In figure 4, two parallel graphics are representing the effect of the pregnancy rate and first mating age, on the net margin achieved by the simulated production system. The net margin is defined as the profit resulting from discounting variable and fixed costs from the gross product achieved.

On the left graph (A) the profit achieved when considering 2005-2010 prices is shown. In that period, prices were significantly lower than current prices and calf / cow price rate, was also lower (1,26). On the right one (B), is represented the net margin achieved by the same system with prices from 2011 to the present. In that period, higher prices were verified, and also a higher calf /cow price ratio (1.49).

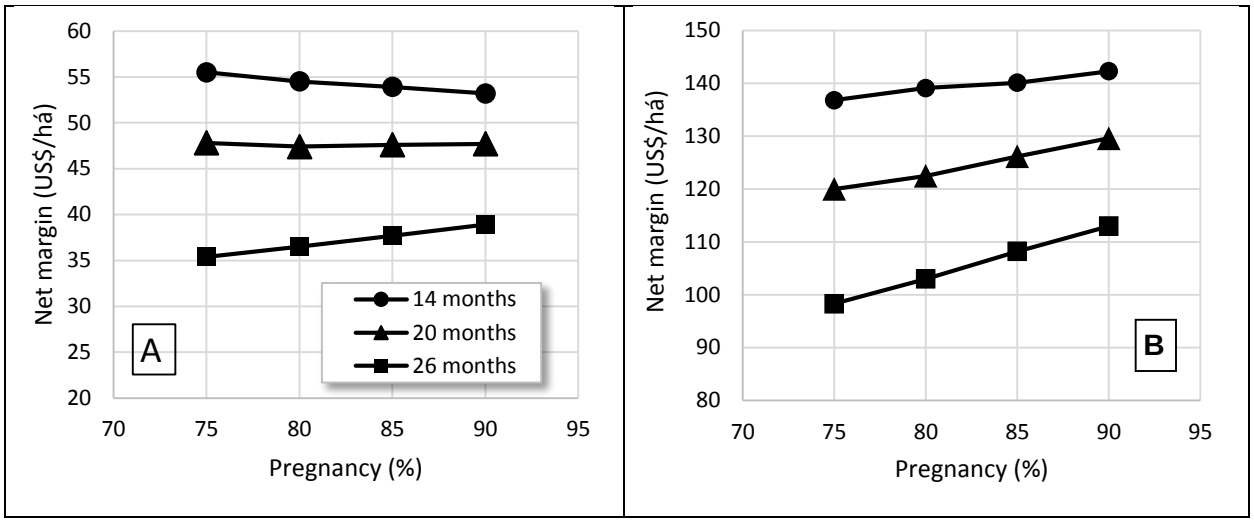

Figure 4. Effect of the reproductive rate (pregnancy) on the profit in an intensive cow-calf system with different ages at first mating and different prices (A) 2005-2010 and (B) 2011-2014.

The main idea intended to highlight is that in a system that cull all empty females, the balance on income obtained from cows or calves sold, is defined by the pregnancy rate.

Regarding the prices and price rates effects on the net margin, in addition to the higher income obtained in the recent period, changes associated to the variable "pregnancy" are observed. While in the past the higher profit was achieved in intensive systems with first mating performed at 14 months old and with the lowest pregnancy values (due to a relative high cow price), at the present stage, the high calf prices imply that is more convenient to maximize pregnancy rates in any situation.

Is usual to assume that in cow-calf systems the only goal is to produce many calves as possible. In an Uruguayan system there are two different biological processes taking place, so is necessary to keep in mind the impact of each one on the system.

The productive potential of fattening is higher than the cow-calf systems and this will remain since there's no chance to reduce the gestation lenght. The efficiency to produce 1 kg of calf through the indirect conversion grass-milk-meat is much lower than the direct conversion from grass to meat.

4. CONCLUSIONS

The sales composition enable us to conclude that in cow-calf system, the contribution of cows sold to the profit is very important, with variations depending on the production system management and price's relations between products.

Anyway, the increase in the pregnancy rate usually means a profit improvement, except in intensive systems with very favorable prices of fat cows, where the high capacity of fattening and early mating age establish advantages of the fattening processes of cows, compared to breeding.

Heifer's mating age is a key variable on system efficiency. Its reduction determines a substantial improvement in the system efficiency, reducing the number of unproductive animals and therefore increasing the number of breeding cows. It should be noted that this effect is consistent in all the situations evaluated in this work.

Simulation is an invaluable tool for research, making it possible to identify and quantify the main factors affecting productivity and profit in highly complex systems as cow-calf systems in Uruguay. Simple conclusions like talking about "Livestock Standstill" may be a consequence of lack of awareness of this complexity.

5. REFERENCES

DI.CO.SE. 2013. Ministerio de Ganadería, Agricultura y Pesca. Online. http://www.mgap.gub.uy/dgsg/DICOSE/Informe2013/DJ2013_TotalNacional.pdf. Access june 2014

Feldkamp, C. 2004. Cow-Calf Operation in Argentina: a Systems Approach to Intervention Assessment. PhD dissertation, Humboldt University, Berlin, Alemania

Peck, S.L., 2004. Simulation as experiment: a philosophical reassessment for biological modeling. Trends Ecol. Evol. 19: 530–534.

Soares de Lima, J.M. 2009. Modelo bioeconómico para la evaluación del impacto de la genética y otras variables sobre la cadena cárnica vacuna en Uruguay. Tesis de doctorado. Universidad Politécnica de Valencia, Valencia , España. Julio 2009. 240 pp.

UECBV (European Livestock and Meat Trading Union). 2012. Online. http://www.uecbv.eu/doc/UECBV note - Meat market outlook 2012-2013.pdf. Access June, 2014

USDA (United States Department of agriculture). 2013. Online. http://apps.fas.usda.gov/psdonline/circulars/livestock_poultry.pdf. Access June, 2014