Tropical and

Subtropical

Agroecosystems

STUDY OF THE IMPACT OF BREEDING SEASONS IN THE DYNAMICS OF DAIRY GOAT HERDS

[ESTUDIO DEL IMPACTO DE LA ESTACIÓN REPRODUCTIVA SOBRE LA DINÂMICA DE LOS REBAÑOS LECHEROS]

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SUMMARY

The competitiveness in the animal production field has forced the smaller activities to be more efficient when compared to big business of the agro-industries. The dairy goat production is one of those market niches that need a better understand of its sector. For those reasons it has been proposed that by changing the number of reproduction seasons would increase income of the producers. The objectives of this study were to evaluate the impact of 1 or 2 annual reproductive cycles on production and economical health of dairy goats and to identify differences of production costs and revenues associated with changes in the herd dynamics as predicted by a mathematical model. A previously developed goat model using the System Dynamics approach to study long-term changes in the dynamics of the herd was used in these simulations. The model simulations used feeds, labor, and fixed costs as inputs and the outputs were revenues from milk production sales and sales of animals from all categories of the herd. The simulation time unit was "month" and a long-term horizon of 10 years was considered for these simulations. The model was set up to simulate a free-stall facility of a herd in equilibrium with 100 does in lactation. All parameters considered in this model assumed average values reported in production systems in the Southeast region of Brazil. The simulations results indicated that improvements of 10% in the fertility rate would increase the number animals in the herd up to 185% and 35% for one and two breeding season, respectively. Establishing a milk price as US$0.68 the break even for one and two breeding seasons was respectively US$0.62, and US$0.50, giving the systems with two breeding a capacity to support reductions on milk price up to 26% against 9% with one breeding season. When comparing the models with 1 or 2 breeding seasons was found that models with 2 breeding seasons was considerably more profitable and had a higher turnover than the model with 1 breeding season. The results indicate that the use of a second (artificial) breeding season might be an important management strategy to improve the efficiency of the dairy goat production systems.

Key Words: dairy goats, models, breeding, production

INTRODUCTION

In the past few years some regions in the world have experienced declines in the goat production due to the increased competitiveness of other more profitable activities (de Rancourt et al., 2006). Some measurements have been adopted to enhance the competitiveness of milk and meat productions from goats. These measurements are based on two intrinsic characteristics of goats: the easy adaptability to lands not suitable for other agricultural activities (Santos et al., 2005) and the high prolificacy of the animals (Mellado et al., 1991).

The advancement of new technologies in animal production and the increased competition among products (e.g. milk and meat) from different animal species have been extremely important to enhance production efficiency, to reduce production costs, and to increase profitability in agricultural systems. This situation creates production scenarios that are highly competitive and requires a greater awareness by producers to adapt in different environments and productive cycles.

Nonetheless, understanding changes associated with competitiveness is not an easy task because of the complexity of the production systems, which are comprised of an enormous number of variables and besides their associated interactions (Salinas et al., 1999).

The reproductive cycle plays an important role in determining herd dynamics and milk production, which in turn dictates the success of the activity. However, because of the seasonal characteristic of goats, their reproductive cycle occurs, naturally, at the end of the summer when day light reduces (Guimarães et al., 2006). With no major intervention animals have only one chance during each year to kid, meaning the herd would have a specific period of milk production (Guimaraes et al., 2009). This seasonal characteristic establishes the production behaviour of the herd and farm income when milk production is the main activity.

Based in the importance in the number of reproduction seasons, the objectives of this study were to evaluate the impact of 1 or 2 annual reproductive cycles on production and economical health of dairy goats.

METHODOLOGY

A dairy goat model was built using the System Dynamics approach to study long-term changes in the dynamics of the herd (Guimaraes et al., 2009). System Dynamics allows for a holistic viewpoint, focusing on the behavioural trends of the system and their relationships with managerial strategies (Sonawane, 2004). Simulations were carried out using Vensim® version 5.0 (Ventana Systems Inc., Boston, MA) using a time step of 0.03125 and Euler integration method. A simulation horizon of 120 months (10 years) was considered. The goat model was developed to simulate a free-stall facility assuming an approximately number of 50 Does in lactation. All parameters considered in this study assumed average values found in an intensive production system in the Southeast region of Brazil, obtained from the extension service of the Federal University of Viçosa.

The inputs for the production system were feeds (i.e. concentrate and forage), labour, and fixed costs (Kosgey et al., 2003). The outputs were the revenues from milk sales and sales of animals from all categories in the herd. Seasonal variation in animal performance and prices were not included in the model (Kosgey et al., 2003).

The length of gestation, fertility rate, litter size, kid mortality rate, number of growing kids and does, average production by categories, retention and culling rates, nursing time, and time to achieve the adult phase were considered as biological production parameters and their initial values are listed in Table 1.

Each category was considered a stock of animals (i.e. state or level variables) that can increase or decrease depending on the inflow and outflow rates. The simulation started with a stock of 100 young does

(nuliparous) entering for the first time in the breeding season until reach the amount of 100 animals in lactation in the herd (stabilized herd).

After each kidding, animals changed categories to 1st parturition (1P), 2nd parturition (2P), 3rd parturition (3P), 4th parturition (4P), and 5th parturition (5P), following the physiological condition as pregnant or non-pregnant and lactating or non-lactating stages. After the 5th pregnancy, goats stayed in the herd until the end of lactation period and were culled.

Two models were developed to simulate the seasonal reproductive characteristic of goats. The first model, 1 breeding season (1BS), considered a herd having only the natural breeding season due to the reproductive behaviour of goats (Holtz, 2005) . Most of the goat breeds for milk production originated from temperate climates and they are mostly seasonal milk producers (Rivera et al., 2003). This seasonal characteristic suggests that depending on the lactation length, there is a period of the year without lactating does. When milk production is the main activity, producers have to maximize milk output per doe in order to amortize costs (such as feed, labour, and maintenance).

Animals breeding out of the season frequently don't have the same performance, meaning that in the natural breeding season the fertility rates are higher than other periods (Delgadillo et al., 1992; Rivera et al., 2003). The fertility rates used for the artificial breeding season were considered to be 20% less than in the natural season (Table 1). On the other hand, the use of the light to stimulate the reproduction cycle increase feed consumption and consequently milk production (Garcia-Hernandez et al., 2007), which can in part compensate the losses in the fertility.

In the simulations were assumed an average milk price between these scenarios (US$0.68/kg of milk) as shown in Table 1.

RESULTS AND DISCUSSION

Efforts to breed does out of the natural breeding season could overcome seasonal fluctuations in the production and prices of both meat and milk, providing a consistent supply of milk (and meat) throughout the year (Zarkawi et al., 1999), which is an agreement with our simulations.

The simulation using the 1BS model indicated that costs would be on average 7.5%/year greater than the 2BS model. Therefore, because of the larger herd size in the 1BS model, the costs associated with feed, energy, maintenance, and medicines were increased.

Other sources to improve the profitability of systems included changes in the fertility rate. Figure 1 shows the results of a 10% increase in the fertility rate for the 1BS and the 2BS models. This small change resulted in an increase of 185% (Figure 1a) and 35%

(Figure 1b) in the profitability for the 1BS and the 2BS models, respectively, over 10 years of simulation. Both results demonstrated the importance of reproduction efficiency in the dynamics and the profitability of herds. Moreover, the sensitivity of the results was greater in the 1BS model than in the 2BS model.

These simulations were performed maintaining a herd size in steady state condition of 100 lactating does (i.e. dynamic equilibrium). In practical situations, producers can take decisions concerning the management of the herd by either selling or buying animals according to the fluctuations of the animal price. However, because of delays in the system, the herd would lose the static balance and could take some time to reach a new equilibrium.

The simulations indicated that the adoption of one breeding season was more likely to have losses every time milk price was lower than US$ 0.62 (break even). This fact is a reflection of the ability of the system to self regulate when an exogenous variable to the model (e.g. milk price) varies. In this case, producers might have to increase the production efficiency with narrower ranges for management errors.

In the 2BS model, the break even was around US$ 0.50, meaning the capacity of this system in keeping its financial health was higher than the 1BS model. Therefore, in the 2BS production scenario, the profitability might be more resilient to fluctuations in the milk price.

The results emphasized the importance of reproduction traits as a major contributor of the system sustainability. The simulations indicated that reproductive efficiency might be the bottleneck to achieve greater profitability as long as nutrition requirements (NRC, 2006) and health (Holtz, 2005) are met.

CONCLUSIONS

Our simulations indicated that small changes in reproduction and milk price can affect considerably the dynamics of the herd as well as the financial health of the production system. The profitability of the 1 or 2 breeding seasons was highly sensitive to changes in the milk price and reproductive performance, mainly the system with 1 breeding season. The comparison of models with 1 or 2 breeding seasons indicated that the 2 breeding season scenario was considerably more profitable and had a higher turnover than the model with 1 breeding season. Our findings indicated the use of a second (artificial) breeding season was an important management strategy in providing flexibility in dairy goat production systems.

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Table 1 – Average values for the production parameters and the input variables of the model[a] of dairy goat farms in the Southeast region of Brazil.

Variables	Value	Variables	Value
Gestation period	5 months	Prices ($)	
Fertility rate (natural)		Milk·($/liter)	0.68
Nuliparous	41%	Culled does ($/animal)	46
Multiparous	60%	Culled Does for repro ($/animal)	182
Fertility rate (artificial)		Buck ($/animal)	545
Nuliparous	33%	Young Doe ($/animal)	227
Multiparous	48%	Young Buck ($/animal)	272
		Male kid 2 months ($/animal)	37
Litter size		Costs ($)	
Primiparous	1 kid/birth	Labor (salary per month)	227
Multiparous	1.6 kids/birth	Maintenance ($·month^{-1}·animal^{-1})	0.45
		Medicine ($·month^{-1}·animal^{-1})	0.46
Mortality rate		Energy ($·month^{-1}·animal^{-1})	0.68
Kids	6%	Concentrate ($/kg)	0.32
Growing animals	4%	Forage ($/kg)	0.2
Adult does	2%	Milk replacer ($/liter)	0.18
		Mineral supplement	0.18
Milk production per doe			
1ª lactation	1.7 liters/day	Management variables	
2ª lactation	1.9 liters/day	Culling rate	Variable
3ª lactation	2.2 liters/day	Retention rate	Variable
4ª lactation	2.4 liters/day	Nursing time	2 months
5ª lactation	2.1 liters/day	Proportion male to female	1 to 30
		Time to replace sires	5 years
		Time to replace does	5th lactation
		Age of first mating	7-8 months

[a]All costs and prices are in US$, and currency exchange was US$1 = R$2.15 Brazilian Reais.
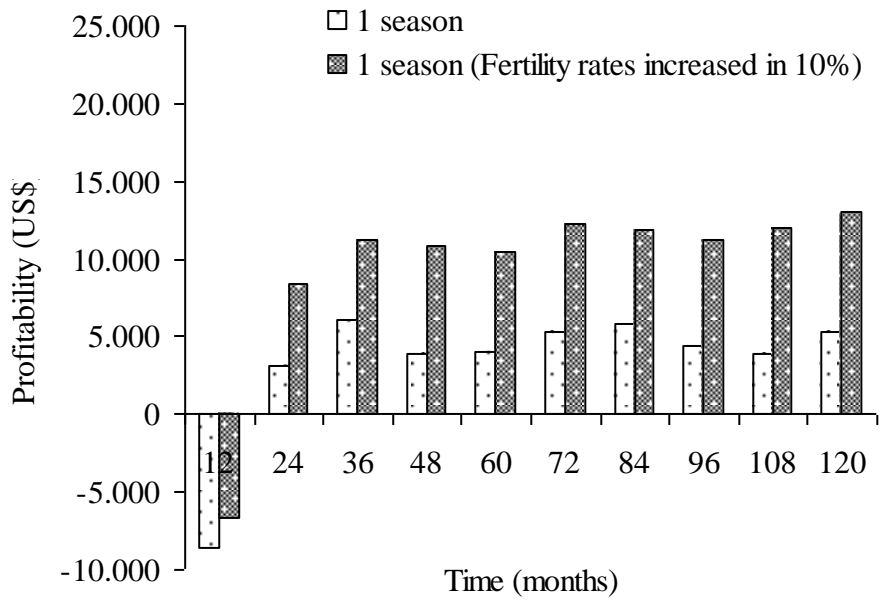
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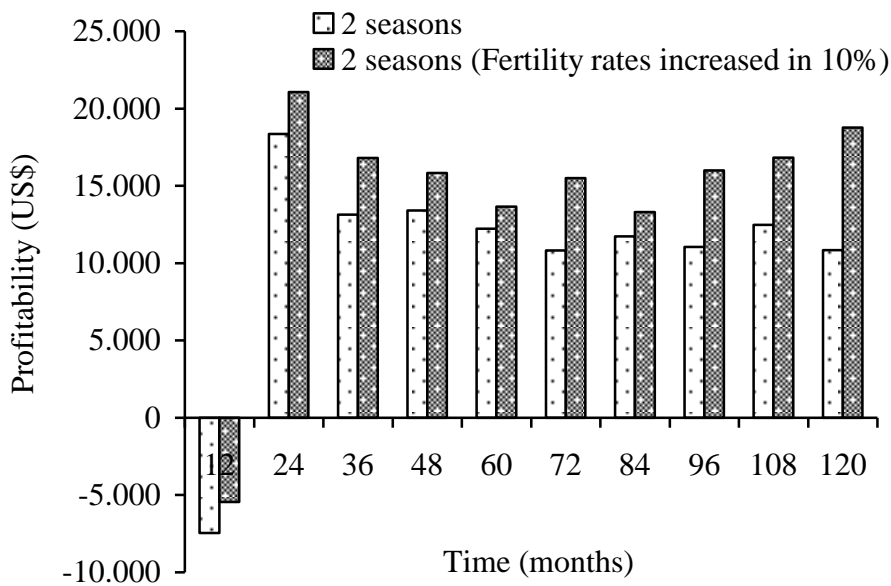
(b)

Figure 1 – Annual profitability for 1 (a) and 2 (b) breeding seasons with normal or a 10% higher fertility rate during 120 months of simulation, using a herd in dynamic equilibrium.