Tropical and Subtropical Agroecosystems

NOTA CORTA [SHORT NOTE]

A DAIRY GOAT MODEL TO STUDY THE IMPACTS ON HERD DYNAMICS

[MODELO DE CABRAS LECHERAS PARA EVALUAR EL IMPACTO DE LAS ESTRATEGIAS DE MANEJO EN LA DINÁMICA DEL REBAÑO]

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SUMMARY

The understanding of a dairy goat production system is crucial to establish a more competitive activity. Therefore, a simulation model was built to evaluate the dynamics of dairy goat herd under different scenarios of production. A System Dynamics approach was used to identify management policies that affect the behavior of the herd. All parameters considered in this model assumed average values reported in production systems in the Southeast region of Brazil. To simulate a herd in dynamic equilibrium, the culling and retention rates were used. Thereafter, simulations were performed based on changes in reproductive and mortality rates. All the simulations were planned to take the variation in herd development based on simple management strategies over 10 years of simulation. The dynamic equilibrium of 50 lactating does was obtained when fixed culling and retention rates of 20 and 70%, respectively, were assigned to the does after 36 months of simulation. A sensitivity analysis was made and indicated that an increase of 20% in the reproduction rates increased the number of animals in the herd in 56%. A decrease in the reproduction rate of 20% reduced the number of animals in 43%. A third simulation indicated that increasing mortality rate from 4 to 10% of the female kids decreased the number of lactating does by 36%. These results indicated that small changes in reproduction and mortality rates can considerably affect the dynamics of the herd, even though the herd may not be immediately affected because of the intrinsic delays in the system. This result is extremely important to justify the need of activity planning to consider the gap between a measurement taken and the consequences, preparing the producers to potential delays in the system. The use of mathematical models is important to understand the relationships between variables and the dynamic of the system and to assist in applying best management strategies to enhance productivity of dairy goats.

Key Words: dairy goats, models, breeding, production

INTRODUCTION

Although the goats were the first to be domesticated for production purposes, specifically for milk, thousands of years ago (Wani and Hubert, 2002) they didn't get a huge economic importance in most of the countries. Some efforts have been given to increase milk and meat productions from goats mainly due to their easy adaptability on lands not suitable for other agricultural activities (Santos et al., 2005).

Even though the considerable scientific research conducted with goats and their historical importance, goat production has an uncertain future in some parts of the world, e.g. in Europe, (de Rancourt et al., 2006). One of the reasons might be the large number of other animal industries that are more profitable. On the other hand, the dairy goat activity has importance in the market of cheese industry and milk consumption for people with cow's milk intolerance (Fisberg et al., 1999).

The understanding that components in a production system are interrelated in a complex way is important to begin a discussion about a dairy goat farm. To understand this situation a simulation model can be used to analyze changes and behavior in a dairy goat farm that could be costly and would take too long to verify changes in the behavior of the system along the years (Roberts et al., 1983). The System Dynamics model was built to simulate the dynamics of a dairy goat herd. System Dynamics is a tool that allows the understanding of the dynamic behavior of a herd in different scenarios, helping managers to understand the relationships between decisions, actions and results (Costanza, 1998).

The aim of this study was identify some management strategies that could affect the dynamics of a herd in a dairy goat farm using a System Dynamics simulation model.

MATERIAL AND METHOD

This research was carried out using the simulation environment of Vensim® version 5.0 (Ventana Systems Inc., Boston, MA). The simulation time unit was “month” and a long-term horizon of 120 months (10 years) was considered. A time step of 0.03125 and the Euler integration method were used in this study
The goat model was developed to simulate a free-stall facility assuming 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 animals pass through of categorized groups whenever they became pregnant or not. If the animal got pregnant they were retained for 5 months, which correspond to the average gestation period, and then after kidding they were transferred to the 1st parturition group (*1P*), after each kidding, animals changed categories sequentially to 2nd parturition (*2P*), 3rd parturition (*3P*), 4th parturition (*4P*) and 5th parturition (*5P*), following the same physiological condition as pregnant or non-pregnant (Guimarães et al., 2009).
The culling rate was used as a control tool of the number of animals in the herd (Jalvingh et al., 1992); otherwise the herd could rise exponentially. This rate was calculated by the model to stabilize the herd in a goal seeking formulation.
Gestation period, lactation length, fertility rate, litter size, female and male kids born, growing animals, does mortality rates, average production by categories, nursing time, and time to achieve the adult phase were considered as a biological production parameters. Initial values for the simulations are listed in Table 1.

Table 1 – Average values for the production parameters of dairy goat farm in the Southeast region of Brazil [a].

Parameter	Average Value
Gestation period	5 months
Lactation length	10 months
Nuliparous Fertility rate	41% ± 20
Multiparous ferrtility rate	60% ± 20
Number of kids/Primiparous Does	1 kid/birth
Number of kids/Multiparous Does	1.5 kids/birth
kids mortality rate	6%
Growth mortality rate	4%
Doe Mortality rate	2%
Nursing time	2 months
Time to achieve the adult phase	7 months
Male:Female	1: 30
Time to replace Does	After5th lactation

RESULTS AND DISCUSSION

The simulation was set to have 50 lactating Does. The model changed the culling and retention rates to reach dynamic equilibrium, and on average they were 20 and 70%, respectively.
In attempt to visualize responses of the model by changing the reproduction index were considered two different situations and all those changes were performed after 24 months to evaluate the effects in the herd dynamics.
As showed in Figure 01, increasing the pregnancy rate by 20%, the herd size increased considerably. At the end of 120 months of simulation, the herd had increased by 35% and the Does in lactation increased almost 51% compared to the herd in dynamic equilibrium. In contrast, decreasing the pregnancy rate by 20% compromised the efficiency of the breeding season, causing a drastic reduction of the number of lactating does (Figure 01). The number of animals in the herd and the lactating does decreased by 31% and 44%, respectively, at the end of 120 months of simulation. Even though than changes in reproduction may compromise the growth of the herd (Salama et al., 2005), the impact caused by an increase in the reproduction rates was higher than the impact caused by a decrease of the same magnitude. Considering a *ceteris paribus* condition, improving the pregnancy rate of the herd can increase rapidly the total number of animals, allow better opportunities for genetic improvement and higher production.

Although the changes in the pregnancy rate occurred after 24 months in the simulation, in Figures 01 (a) and 01 (b), the impacts were noticed one year later. This is a common characteristic of dynamic systems due to the interrelationship between variables and the delay between the time some policy was taken and the time the results were noticed in the system (Meadows and Robinson, 1985). This factor is also responsible for a permanent oscillation in a managed system in which managers alternate over- and under-adjustments of variables in an attempt to obtain a faster response or trying to dampen the oscillation.
Mortality rate is also an important parameter that might determine the success of goat production (Amer et al., 1999). To assess the impact of the mortality rate at the nursing phase, the value was increased from 6 to 15%; sanitary problems in the herd could cause this. The rate was changed after 24 months considering a herd in dynamic equilibrium. Figure 02 indicated that the modification of the mortality rate caused a reduction 31% in the number of animals in the herd, respectively, showing the capacity of this rate to influence the behavior of the whole system.

Unfortunately it is not rare to observe producers having problems at the same time in different areas in the production system e.g. reproduction, sanity, production, etc. (Bagnicka et al., 2006) . So, considering the sum of these factors, such as reduction in fertility rates and increase in the mortality rates, the impact in the system would be more drastic. This happen probably because all variables in the model are tightly connected and create a complex behavior in the goat production system (Meadows, 1970), and should be analyzed by the overall to ensure the best understand of the policies and changes. Although the model represents only one part of the whole, it can give insights of physical performance and being an important tool to assess management practices (Aguilar et al., 2006) to plan and equilibrate the herd.

CONCLUSIONS

These trial suggested that mathematical models could be used to understand the herd dynamics and to assist in applying management strategies to enhance planning and productivity of dairy goat's activity. The simulations indicated that changes in reproduction and mortality indexes can impact the dynamics of the herd, reducing the capacity of the system to retrieve from adversities. The changes made in reproduction rate appeared to be more effective in the dynamic of the herd than mortality rate, indicating that reproduction should be view in the system as a key parameter. The culling and retention rates must be carefully used as one of the management practices changing them directing the system to a desired situation.

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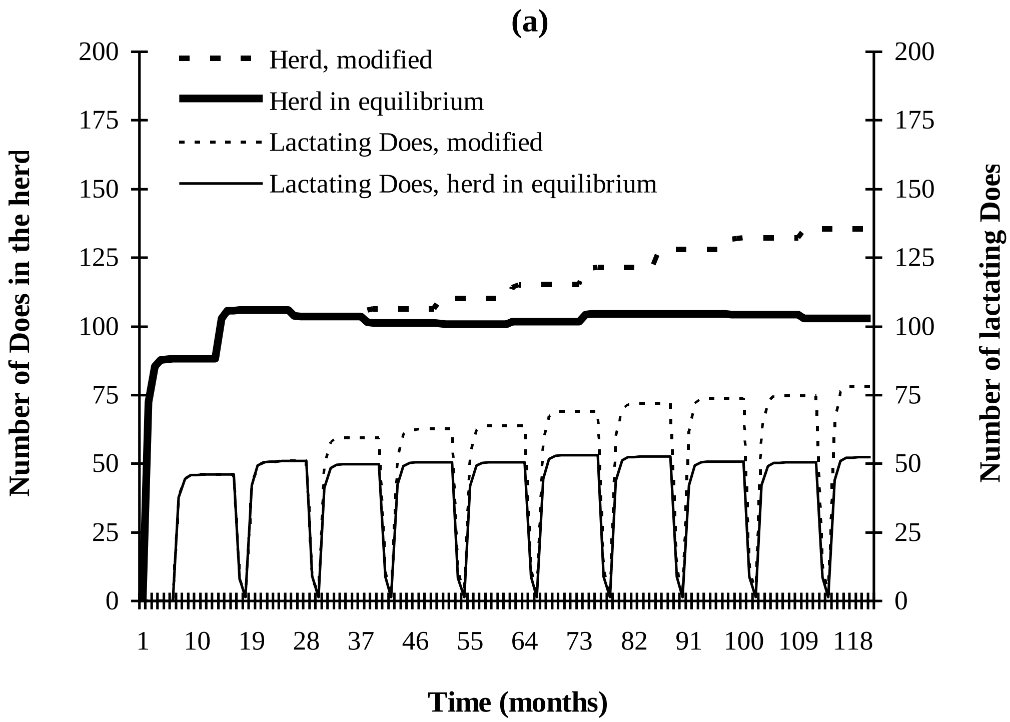

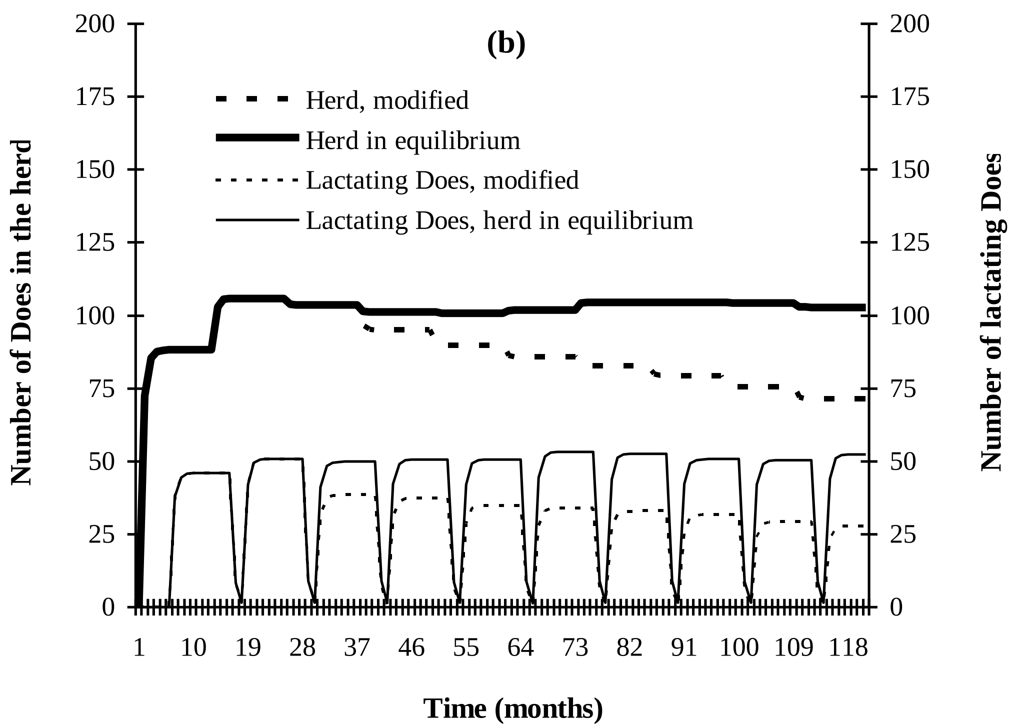

Figure 01 – Effect of an increase of 20% (a) and a decrease of 20% (b) in the fertility rate of the herd after 24 months

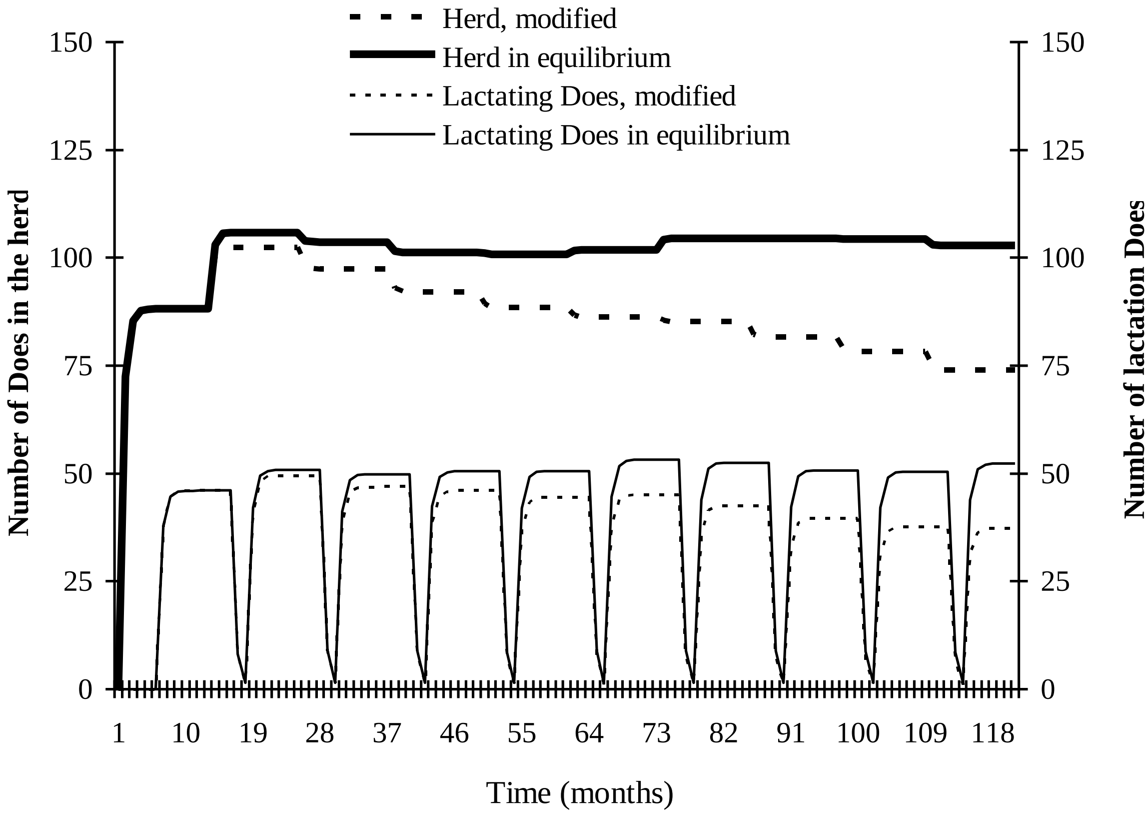

Figure 02 – Effect of mortality rate of 10% for nursing kids after 24 months

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