Agent-based simulation model to evaluate the technical performance of reproductive programs in beef cattle

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INTRODUCTION

The intensification of reproductive programs through the use of timed artificial insemination (TAI), is a way to improve the herd results. Nonetheless, the trade-offs of its implementation need a particular analysis. Beef cattle systems are complex, simulation models are presented as a valuable tool that allows modeling a herd in order to understand the system and to evaluate several strategies. The objective of this study was to create and describe a stochastic, agent-based simulation model that allows the comparison of the technical performance of strategies that use natural mating (NM), TAI, or combinations of TAI+NM.

METHODOLOGY

The model simulated a Nelore cattle herd in Brazil. The parameterization was based on the historical database of the IZ and from the scientific literature. The herd was set to contain up to 400 females and 0, 7, or 15 bulls, depending on the scenario used. AnyLogic® simulation tool was used and the experiments were conducted on the University of Florida's HiPerGator supercomputer. An average of 96 hours was required to run the simulations for each scenario, using a CPU with 16 cores and 32 GB of memory. Ten scenarios were analyzed: a scenario using only NM (ONM); a scenario using one TAI plus NM (1TAI+NM); three scenarios using two TAI plus NM, with an interval between TAI of 24 (2TAI/24+NM), 32 (2TAI/32+NM), and 40 days (2TAI/40+NM); three scenarios using three TAI without NM, with an interval between TAI of 24 (3TAI/24), 32 (3TAI/32), and 40 days (3TAI/40); and two scenarios with three TAI plus NM, with an interval between TAI of 24 (3TAI/24+NM) and 32 days (3TAI/32+NM). Each scenario was replicated 32 times, with data collection represented by 1-day time intervals by 5,000 days.

Data was analyzed using ANOVA and post hoc Tukey HSD tests using the R programming language version 3.6.1. Values of $P < 0.05$ were considered statistically significant.

RESULTS

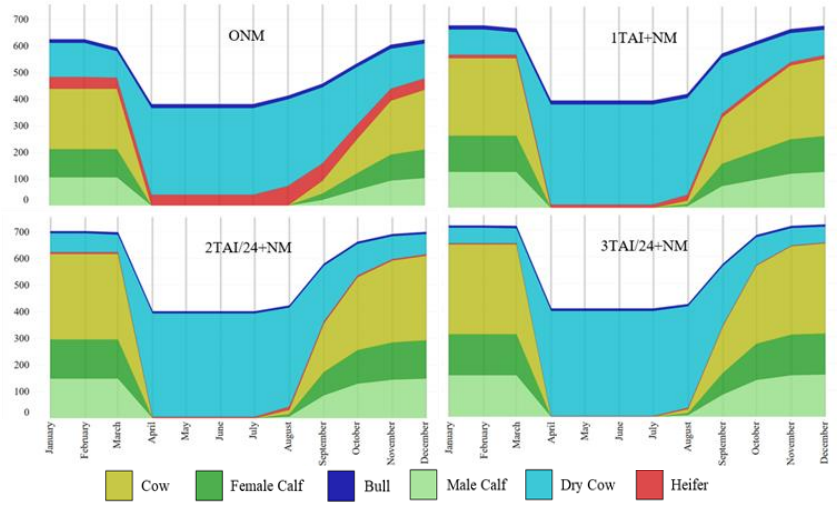

Figure 1. Herd structure through the 6th year of simulation for the proposed scenarios. Due to space restriction only the ONM, 1TAI+NM, 2TAI/24+NM, and 3TAI/24+NM scenarios are presented.

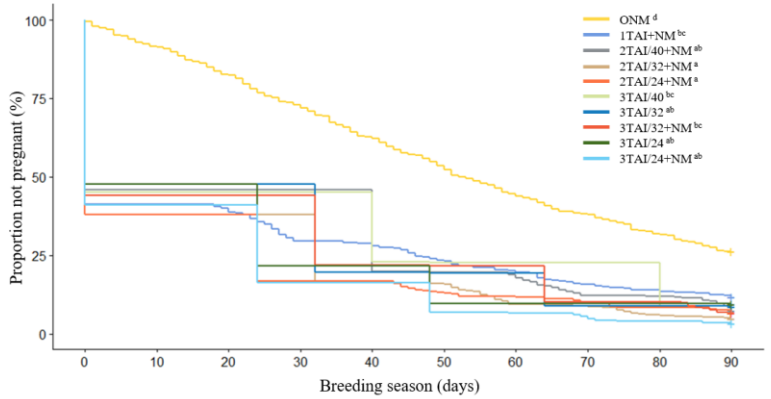

Figure 2. Survival curves for the proportion of nonpregnant cows by days of the breeding season for the proposed scenarios.

RESULTS (Cont.)

Regarding the structure of the herd (Fig 1), in February, it is notable how the relationship between cows and the total number of breeding adult females was different among scenarios. The time to pregnancy was affected ($P < 0.05$) by scenario (Fig. 2). The median time to pregnancy (median days to reach 50% of pregnancy) was 52.5 days shorter ($P < 0.05$) in cows belonging to the scenarios that included TAI. Regarding the total weaning weights and total number of weaned animals, the scenarios with the shortest interval between inseminations obtained the best results (Fig 3).

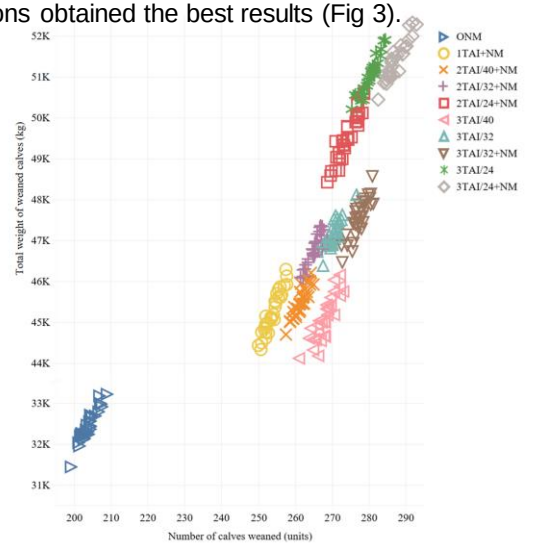

Figure 3. Total weaning weight of calves and total number of calves weaned per year for the proposed scenarios.

CONCLUSION

The present study demonstrates the utility of agent-based simulation models within the scope of cow-calf production systems. The 3TAI/24+NM scenario presented better reproductive performance and produced more and heavier calves.