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OPTIMIZING BEEKEEPING PRODUCTION THROUGH SYSTEM DYNAMICS MODELING: A CASE STUDY ON FORECASTING BEE QUEEN REARING CAPACITY

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Abstract – Commercial bee queen rearing is an intensive process in which the main commercial product, bee queens, are produced in a short period of time. The intensity is even more severe in regions where the beekeeping season is shorter, as preparation, rearing initiation and capacity increase during the season consume a lot of time. Bee queens can be divided into different product categories: virgin, mated, mated in isolated station, and instrumentally inseminated queens, and they can be further divided by race, pedigree, and colony characteristics. Each category is with varying time and resource consumption. To optimize bee queen rearing and choose the appropriate rearing strategy, product categories, production capacity dynamics, and other aspects, the authors of this case study developed a system dynamics model with the aim of finding the optimal number of production units, the most appropriate product groups and their volumes, according to changes in income and time consumption. The model clearly shows the system's sensitivity to having too many production units – nuclei and queen rearing colonies. Too many production units led to ineffective use of nuclei, increased bee queen mortality, high bee queen surplus, high human and time resource costs and unnecessary batching of orders. The developed model demonstrated how to predict the optimal production capacity and how inefficiency leads to the inevitable collapse of the bee queen rearing system, from which the bee queen breeder cannot recover during the season. The model allowed to conclude that balancing material and human resources in bee queen rearing is very important for efficient production.

Keywords – Beekeeping; bee queens; production capacity; production optimization; queen rearing, rearing strategies; resource management; system dynamics modeling