

Bayesian Modeling of Lactation Curves in Italian Mediterranean Buffalo Using the MilkBot Equation

Trapanese Lucia^{*[1]}, Liu Enhong^[2], Salzano Angela^[1], Hostens Miel^[2]

[1] Department of Veterinary Medicine and Animal Production, University of Naples Federico II, Naples, Italy, [2] Department of Animal Science, College of Agriculture and Life Sciences, Cornell University, United States

Italian Mediterranean buffalo dairy farming is a key component of the agricultural economy of Southern Italy. Although several quantitative approaches have been applied to describe buffalo lactation dynamics, the adoption of biologically interpretable models remains limited. The MilkBot model offers a mechanistic representation of lactation development, but its application to Italian Mediterranean buffalo has been hindered by the lack of species and parity-specific priors. The aim of this study was to derive and validate parity-specific Bayesian priors for the MilkBot model in Italian Mediterranean buffalo using a large-scale field dataset.

Test-day milk yield records collected between 2018 and 2023 from routine milk recording schemes were analyzed, comprising 403191 observations from 92427 animals across 328 herds. Data were stratified into two parity groups: primiparous and pluriparous. The observations were split into 80% training and 20% testing sets using a herd-level partitioning strategy, ensuring that no herd was represented in both subsets and thereby preventing data leakage. A Bayesian framework was implemented to estimate the parameters of the Milkbot lactation model. Informative priors derived from Irish dairy cows were specified for each model parameter and updated using the train data using a Hamiltonian Monte Carlo algorithm. Four parallel chains were run for each parity group and convergence diagnostics indicated adequate mixing and stable posterior distributions. Posterior distributions were used to obtain the most probable values, which were subsequently applied to predict mean lactation curves and evaluate predictive performance on the independent testing set. The fitted curves closely captured milk yield dynamics throughout lactation across all parity groups, with discrepancies observed during the descending phase of lactation in multiparous animals. Model performance metrics indicated high predictive accuracy for both parity groups, with R^2 values ranging from 0.95 to 0.96, RMSE from 2.57 to 3.23 and MSE from 6.63 to 10.47.

These findings demonstrate that, when supported by appropriately informed priors, the MilkBot equation represents a reliable and biologically meaningful tool for modelling lactation curves in Italian Mediterranean buffalo.