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Forecasting phenological model for tropical forest species: *Monoon coffeoides*

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Monoon coffeoides is a forest plant growing a tropical intermediate forest and pollinated by a native species of weevils in Sri Lanka. The longtime survival of both *M. coffeoides* and weevils is governed by its flowering and fruiting phenology. Due to a lack of phenological information implementation of proper conservation and management measures are not possible. The main purpose of this study is to analyze phenological parameters, namely, flower buds, open flowers, leaf flushing, leaf dropping, immature fruits and mature fruits of the *Monoon coffeoides*, to identify their correlation and variation patterns. Further, forecasting of these parameters are important in future forest management. Hence, the study has been extended to investigate the ability to forecast the parameters. Unsupervised learning techniques such as K-means clustering under Data mining are applied to identify similar behaviors among 50 trees of *Monoon coffeoides*. Silhouette width test was used to validate the cluster accuracy. Further, the Cross-correlation analysis was used to identify the relationships between series of phenological parameters with following delay periods as lag phases. The analysis resulted, the delay between flower buds and open flowers is 2 weeks, the delay between leaf flushing and mature fruits is 17 weeks, the delay between open flowers and immature fruits and between immature fruits and mature fruits is 5 weeks. Additionally, it was identified that the flowering and fruiting periods are varied from January to May and from March to August respectively. As the next step, phenological parameters and climate factors have been forecasted using univariate time series models. The accuracy was tested using standard tests: R-squared, Root Mean Squared Error (RMSE), Mean Absolute Percentage Error (MAPE) and Mean Absolute error (MAE). The best-fitted models for each of these parameters are; flower buds: ARMA(2,3)-GARCH(1,1), open flowers : ARMA(2,3)-GARCH(1,1), mature fruits : ARIMA(1,1,1)-GARCH(1,1), immature fruits : ARMA(1,4)-GARCH(1,1), leaf dropping : ARMA(1,1), leaf flushing : ARMA(1,1)-GARCH(1,1), average temperature : ARIMA(1,2,1) and rainfall : ARMA(3,1) respectively. All the models were significant to forecast the values and thereby, these models can be used to forecast phenological parameters.

Keywords: Cluster analysis, *Monoon coffeoides*, Phenological data, Time Series Modeling