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Modelling the co-existence and survival scenarios of two competing legumes with a low environmental perturbation

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Abstract— *The occurrence of an environmental perturbation on the outcomes of co-existence and survival for two competing legumes for limited resources is one of the challenging crop science problems that requires a mathematical quantification. We have explored the application of a MATLAB algorithm in this study. We have found that the inclusion of a low random noise intensity value of 0.01 has dominantly predicted more instances of valid co-existence scenarios and fewer instances of degeneracy scenarios providedthe inter-competition coefficients outweigh the intra-competition coefficients. We would expect these present novel results to provide a further insight on the crop science ideas of co-existence and survival.*

Keywords— Environmental perturbation, co-existence, survival, random noise, MATLAB Algorithm, inter-competition, intra-competition.

I. INTRODUCTION

Within an agricultural setting, the competition between two legumes such as cowpea and groundnut for limited resources can play a significant role in terms of their co-existence, survival and food production. However, the effect of a low environmental perturbation such erosion or an un-expected sea level rise has the potential to shift the expected co-existence and survival scenarios under the simplifying assumption of its impact on the intrinsic growth rates provided the inter-competition coefficients outweigh the intra-competition coefficients. The mathematical analysis of other related cowpea-groundnut interactions can be seen in the works of

II. MATERIALS AND METHODS

The model parameters that we have utilized in this pioneering study were derived by Ekaka-a et al (2013) based on the primary growth data by Ekpo and Nkannang (2010) including the several cited articles that supported their full report. For the purpose of this analysis, the intrinsic growth rate parameter values are 0.0225 grams and 0.0446 grams per area of habitat, the intra-competition coefficients are 0.0167 and 0.033, the inter-competition coefficients are 0.02 and 0.035.

Simplifying Assumptions

The deterministic model formulation follows the popular Lotka-Volterra type which is not the central focus of this analysis. A MATLAB algorithm has been implemented to predict the data below under the implicit assumptions that the said environmental perturbation only affects the intrinsic growth rates provided the inter-competition coefficients outweigh the intra-competition coefficients. For the purpose of clarity, the notations represented by the model parameter K stand for the biological carrying capacity which is defined as the ratio of the intrinsic growth rate to the intra-competition coefficient while the notations represented by the model parameter alpha as the ratio of the inter-competition coefficient to the intra-competition coefficient.

III. RESULTS

The results of this analysis are displayed as in Table 1 and Table 2 below:

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Table.1: MATLAB Algorithm Predicted Data of Co-existence and Survival Outcomes with a Low Random Noise Intensity Value of 0.01: Scenario 1

Example	C_b	G_b	α_{12}	$\frac{K_1}{K_2}$	α_{21}	$\frac{K_2}{K_1}$
1	0.71	0.74	1.1976	1.0687	1.0606	0.9357
2	1.22	0.29	1.1976	0.9896	1.0606	1.0105
3	0.65	0.90	1.1976	1.0869	1.0606	0.9200
4	0.24	1.39	1.1976	1.1577	1.0606	0.8638
5	0.77	0.58	1.1976	1.0493	1.0606	0.9530
6	-0.41	1.82	1.1976	1.2785	1.0606	0.7822
7	0.55	0.93	1.1976	1.0990	1.0606	0.9099
8	-0.25	1.77	1.1976	1.2433	1.0606	0.8043
9	1.03	0.46	1.1976	1.0180	1.0606	0.9824
10	0.06	1.45	1.1976	1.1869	1.0606	0.8425

Table.2: MATLAB Algorithm Predicted Data of Co-existence and Survival Outcomeswith a Low Random Noise Intensity Value of 0.01: Scenario 2

Example	C_b	G_b	α_{12}	$\frac{K_1}{K_2}$	α_{21}	$\frac{K_2}{K_1}$
1	0.44	0.94	1.1976	1.1135	1.0606	0.8981
2	0.06	1.37	1.1976	1.1868	1.0606	0.8426
3	1.92	-0.46	1.1976	0.8694	1.0606	1.1502
4	1.06	0.36	1.1976	1.0048	1.0606	0.9952
5	-0.04	1.50	1.1976	1.2046	1.0606	0.8302
6	-0.10	1.58	1.1976	1.2156	1.0606	0.8227
7	0.44	1.10	1.1976	1.1225	1.0606	0.8909
8	0.05	1.30	1.1976	1.1876	1.0606	0.8420
9	0.84	0.59	1.1976	1.0441	1.0606	0.9577
10	0.67	0.70	1.1976	1.0694	1.0606	0.9351

IV. DISCUSSION OF RESULTS

On the basis of our proposed method of analysis and its simplifying assumptions, we have made these valid observations: two instances of degeneracy on the cowpea legume and one instance of degeneracy on the groundnut legume (Table 1 and Table 2). In Table1 and Table 2, the cowpea legume is about 20 percent more vulnerable to degeneracy whereas the groundnut legume is about 10 percent more vulnerable in the context of two competing legumes. Apart from the degeneracy scenarios, the inclusion of a low random noise intensity value of 0.01 has predicted a dominant instance of co-existing legumes which do not survive together.

V. CONCLUSION

A low environmental perturbation has dominantly predicted the feasibility for the co-existence of two interacting legumes which may not necessarily survive together provided the inter-competition coefficients outweigh the intra-competition coefficients and that the low environmental perturbation or a low random noise intensity value of 0.01 only affects the intrinsic growth rates. The effects of these assumptions on other model parameter values which we did not consider in this present study will be the subject of a future investigation.

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