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Modelling the effects of decreasing the inter–competition coefficients on biodiversity loss

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Abstract— *The notion of a biodiversity loss has been identified as a major devastating biological phenomenon which needs to be mitigated against. In the short term, we have utilised a Matlab numerical scheme to quantify the effects of decreasing and increasing the inter – competition coefficients on biodiversity loss and biodiversity gain. On the simplifying assumption of a fixed initial condition*$(4, 10)$*, two enhancing factors of intrinsic growth rates, two inhibiting growth rates of intra – competition coefficients and two inhibiting growth rates of inter – competition coefficients. The novel results that we have obtained; which we have not seen elsewhere complement our recent contribution to knowledge in the context of applying a numerical scheme to predict both biodiversity loss and biodiversity gain.*

Keywords— Competition coefficients, biodiversity loss, biodiversity gain, numerical scheme, initial condition, intrinsic growth rate.

I. INTRODUCTION

Following the recent application of a numerical simulation to model biodiversity (Atsu and Ekaka-a 2017), we have come to observe that the mathematical technique of a numerical simulation which is rarely been applied to interpret the extent of biodiversity loss and biodiversity gain is an important short term and long term quantitative scientific process. We will expect the application of a numerical simulation to model biodiversity to contribute to other previous research outputs.

II. MATERIALS AND METHODS

The core method of ODE 45 numerical scheme has been coded to analyze a Lotka – Volterra mathematical structure dynamical system of non – linear first order differential equation with the following parameter values: The intrinsic growth rate of the first species is estimated to be 0.1; the intrinsic growth rate of the second yeast species is estimated to be 0.08; the intra – competition coefficients due to the self-interaction between the first yeast species and itself is estimated to be 0.0014; the intra – competition coefficients due to the self-interaction between the second yeast species and itself is estimated to be 0.001; the intra – competition coefficients which is another set of inhibiting factors are estimated to be 0.0012 and 0.0009 respectively. The aim of this present analysis is to vary the inter – competition coefficient together and quantify the effect of this variation on biodiversity loss and biodiversity gain in which the initial condition is specified by $(4, 10)$ for a shorter length of growing season of twenty (20) days

III. RESULTS

The results of these numerical simulation analyses are presented in Table 1, Table 2, and Table 3

IV. DISCUSSION OF RESULTS

The results are presented and discussed as follows.

Table.1: Evaluating the effect of $r_1 = 0.00012$ *and* $r_2 = 0.00009$ *together on* $x(t)$ *and* $y(t)$ *using ODE 45 numerical scheme*

Example	$x(t)$	$x_m(t)$	$BL(\%)$	$y(t)$	$y_m(t)$	$BL(\%)$
1	4.0000	4.0000	0	10.0000	10.0000	0
2	4.4497	4.4003	1.1113	10.7618	10.7253	0.3398
3	4.9514	4.8381	2.2864	11.5776	11.4950	0.7130
4	5.5111	5.3167	3.5262	12.4505	12.3107	1.1229
5	6.1356	5.8391	4.8318	13.3844	13.1739	1.5728
6	6.8325	6.4086	6.2034	14.3829	14.0857	2.0663
7	7.6102	7.0287	7.6410	15.4502	15.0473	2.6074
8	8.4778	7.7026	9.1439	16.5906	16.0597	3.2001

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Example	$x(t)$	$x_m(t)$	$BL(\%)$	$y(t)$	$y_m(t)$	$BL(\%)$
9	9.4456	8.4339	10.7107	17.8090	17.1235	3.8490
10	10.5247	9.2260	12.3396	19.1103	18.2391	4.5587
11	11.7273	10.0822	14.0278	20.5002	19.4067	5.3340
12	13.0666	11.0058	15.7718	21.9847	20.6261	6.1799
13	14.5569	11.9997	17.5674	23.5705	21.8966	7.1015
14	16.2134	13.0664	19.4097	25.2650	23.2175	8.1041
15	18.0522	14.2084	21.2929	27.0765	24.5875	9.1927
16	20.0902	15.4272	23.2106	29.0141	26.0047	10.3721
17	22.3450	16.7240	25.1557	31.0880	27.4672	11.6469
18	24.8344	18.0991	27.1208	33.3096	28.9723	13.0212
19	27.5763	19.5521	29.0981	35.6920	30.5173	14.4981
20	30.5884	21.0817	31.0794	38.2492	32.0987	16.0800

Table.2: Evaluating the effect of $r_1 = 0.00018$ *and* $r_2 = 0.000135$ *together on* $x(t)$ *and* $y(t)$ *using ODE 45 numerical scheme*

Example	$x(t)$	$x_m(t)$	$BL(\%)$	$y(t)$	$y_m(t)$	$BL(\%)$
1	4.0000	4.0000	0	10.0000	10.0000	0
2	4.4497	4.4030	1.0500	10.7618	10.7273	0.3210
3	4.9514	4.8443	2.1611	11.5776	11.4995	0.6740
4	5.5111	5.3273	3.3346	12.4505	12.3183	1.0619
5	6.1356	5.8551	4.5715	13.3844	13.1852	1.4881
6	6.8325	6.4313	5.8722	14.3829	14.1015	1.9561
7	7.6102	7.0594	7.2370	15.4502	15.0686	2.4698
8	8.4778	7.7432	8.6654	16.5906	16.0874	3.0332
9	9.4456	8.4862	10.1565	17.8090	17.1588	3.6507
10	10.5247	9.2924	11.7085	19.1103	18.2834	4.3269
11	11.7273	10.1653	13.3193	20.5002	19.4616	5.0665
12	13.0666	11.1085	14.9857	21.9847	20.6932	5.8748
13	14.5569	12.1253	16.7041	23.5705	21.9779	6.7566
14	16.2134	13.2188	18.4699	25.2650	23.3152	7.7174
15	18.0522	14.3916	20.2780	27.0765	24.7040	8.7623
16	20.0902	15.6458	22.1224	29.0141	26.1427	9.8963
17	22.3450	16.9830	23.9966	31.0880	27.6297	11.1241
18	24.8344	18.4039	25.8936	33.3096	29.1626	12.4501
19	27.5763	19.9084	27.8060	35.6920	30.7388	13.8776
20	30.5884	21.4956	29.7263	38.2492	32.3552	15.4095

Table.3: Evaluating the effect of $r_1 = 0.001176$ *and* $r_2 = 0.000882$ *together on* $x(t)$ *and* $y(t)$ *using ODE 45 numerical scheme*

Example	$x(t)$	$x_m(t)$	$BL(\%)$	$y(t)$	$y_m(t)$	$BL(\%)$
1	4.0000	4.0000	0	10.0000	10.0000	0
2	4.4497	4.4486	0.0249	10.7618	10.7610	0.0076
3	4.9514	4.9488	0.0516	11.5776	11.5757	0.0161
4	5.5111	5.5066	0.0802	12.4505	12.4473	0.0255
5	6.1356	6.1288	0.1108	13.3844	13.3795	0.0361
6	6.8325	6.8227	0.1436	14.3829	14.3760	0.0479
7	7.6102	7.5966	0.1787	15.4502	15.4407	0.0611
8	8.4778	8.4595	0.2161	16.5906	16.5781	0.0759
9	9.4456	9.4214	0.2560	17.8090	17.7925	0.0924
10	10.5247	10.4933	0.2985	19.1103	19.0891	0.1109

Example	$x(t)$	$x_m(t)$	$BL(\%)$	$y(t)$	$y_m(t)$	$BL(\%)$
11	11.7273	11.6870	0.3437	20.5002	20.4732	0.1316
12	13.0666	13.0155	0.3917	21.9847	21.9507	0.1549
13	14.5569	14.4925	0.4425	23.5705	23.5279	0.1809
14	16.2134	16.1329	0.4964	25.2650	25.2120	0.2101
15	18.0522	17.9523	0.5532	27.0765	27.0108	0.2429
16	20.0902	19.9670	0.6132	29.0141	28.9330	0.2795
17	22.3450	22.1939	0.6763	31.0880	30.9883	0.3206
18	24.8344	24.6499	0.7427	33.3096	33.1875	0.3666
19	27.5763	27.3523	0.8123	35.6920	35.5428	0.4180
20	30.5884	30.3176	0.8852	38.2492	38.0674	0.4753

By using ODE 45 numerical scheme, we have observed that a ten (10) percent variation of the inter–competition coefficient has predicted a monotonically increasing values for the populations ranging from 4.000 to 30.5884 approximately when all the model parameters are fixed. For the same population, due to a variation of the intrinsic growth rates, we have obtained a new population of the first yeast species called $x_1(t)$ ranging from 4.000 to 21.0817. A biodiversity loss has occurred ranging from 0 and increasing monotonically to 31.0794, quantified in percentage terms. In essence, example twenty (20) shows that the first yeast population during a shorter growing season of twenty (20) units of time is more vulnerable to the ecological risk of biodiversity loss. A similar observation is applicable to the second yeast species$y(t)$. In this case, when the model parameter values are fixed, the simulated growth rate data range from 10.0 and increased monotonically to 38.2492 compared to the range from 10.0 to 32.0987 due to a ten (10) percent variation of the intrinsic growth rates. We have also observed that biodiversity loss is quantified to range from 0 to 16.08.

In summary, by comparing these two dominant scenarios of biodiversity loss, it is very clear that the first yeast species is almost double more vulnerable to biodiversity loss than the second yeast species. Similar observations are applicable to Table 2 and Table 3. On the basis of this analysis, we have observed that a ninety – eight (98) percent variation of the inter – competition coefficient together has predicted a far lower volume of biodiversity loss as expected which can be tolerated because it is an evidence that this devastating ecological risk will soon be lost at the next level of variation such as hundred and one (101) percentage variation.

V. CONCLUSION

We have successfully utilized the technique of ODE 45 numerical scheme to model the possibility of biodiversity loss. These results have been discussed quantitatively. A small variation of the inter – competition coefficient together is dominantly associated with a higher vulnerability to biodiversity loss whereas the inevitability of biodiversity loss which should be expected can be tolerated for a lower decreasing volume of the intrinsic growth rates together. It is therefore necessary to find some sort of mitigation measures that will recover biodiversity loss and sustain biodiversity gain. This idea will be key subject in our next investigation.

REFERENCES

[1] Atsu, J. U. & Ekaka-a, E. N. (2017). Modeling the policy implications of biodiversity loss: A case study of the Cross River national park, south –south Nigeria. International Journal of Pure and Applied Science, Cambridge Research and Publications. vol 10 No. 1; pp 30-37.

[2] Atsu, J. U. & Ekaka-a, E. N. (2017). Quantifying the impact of changing Intrinsic growth rate on the biodiversity of the forest resource biomass: implications for the Cross River State forest resource at the Cross River National Park, South – South, Nigeria: African Scholar Journal of Pure and Applied Science, 7(1); 117 – 130.

[3] De Mazancourt, C., Isbell, F., Larocque, A., Berendse, F., De Luca, E., Grace, J.B et al. (2013). Predicting ecosystem stability from community composition and biodiversity. Ecology Letters,, DOI: 10.1111/ele.12088.

[4] Ernest, S.K.M. & Brown, J.H. (2001). Homeostasis and compensation: the role of species and resources in ecosystem stability. Ecology, 82, 2118–2132.

[5] Fowler, M.S., Laakso, J., Kaitala, V., Ruokolainen, L. & Ranta, E. (2012).Species dynamics alter community diversity-biomass stability relationships. Ecol. Lett., 15, 1387–1396.

[6] Gonzalez, A. & Descamps-Julien, B. (2004). Population and community variability in randomly fluctuating environments. Oikos, 106, 105–116.

[7] Grman, E., Lau, J.A., Donald, R., Schoolmaster, J. & Gross, K.L. (2010). Mechanisms contributing to

https://dx.doi.org/10.22161/ijaems.4.1.3 *ISSN: 2454-1311*

stability in ecosystem function depend on the environmental context. Ecol. Lett., 13, 1400–1410.

[8] Hector, A., Hautier, Y., Saner, P., Wacker, L., Bagchi, R., Joshi, J. et al. (2010). General stabilizing effects of plant diversity on grassland productivity through population asynchrony and overyielding. Ecology, 91, 2213–2220.

[9] Loreau, M.. & de Mazancourt, C.. (2013). Biodiversity and ecosystem stability: a synthesis of underlying mechanisms. Ecol. Lett., DOI: 10.1111/ele.12073.

[10] MacArthur, R. (1955). Fluctuations of Animal Populations, and a Measure of Community Stability. Ecology, 36, 533–536.

[11] Marquard, E., Weigelt, A., Roscher, C., Gubsch, M., Lipowsky, A. & Schmid, B. (2009). Positive biodiversity-productivity relationship due to increased plant density. J. Ecol., 97, 696–704.

[12] May, R.M. (1973). Stability and complexity in model ecosystems. 2001, Princeton Landmarks in Biology edn. Princeton University Press, Princeton. McCann, K.S. (2000). The diversity-stability debate. Nature, 405, 228–233.

[13] McNaughton, S.J. (1977). Diversity and stability of ecological communities: a comment on the role of empiricism in ecology. Am. Nat., 111, 515–525.

[14] Mutshinda, C.M., O'Hara, R.B. & Woiwod, I.P. (2009). What drives community dynamics? Proc. Biol. Sci., 276, 2923–2929.

[15] Proulx, R., Wirth, C., Voigt, W., Weigelt, A., Roscher, C., Attinger, S. et al.(2010). Diversity Promotes Temporal Stability across Levels of Ecosystem Organization in Experimental Grasslands. PLoS ONE, 5, e13382.