INVESTIGATING THE RELSTIONSHIP BETWEEN ENTOMOLOGICAL INTERACTION, CLIMATE CHANGE AND INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) DATABASE DESIGN

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Abstract
The complex link between the sugarcane borer-parasitoid interaction, climate change and information and communication technology (ICT) database design is one of the current front line scientific research question that demands the application of constructing a sound database design for the purpose of effective monitoring of entomological system that is vulnerable to the ecological and environmental risk of climate. The results of this pioneering study have not been seen elsewhere; these are presented and discussed in this paper.

Introduction
We redefine the net reproductive rate as the difference between the birth rate (birth function) and the death rate (death function). This modification of the net reproductive rate is implied in the original mathematical formulation of the sugarcane borer-parasitoid interaction. On the simplified absorption that the ecological perturbation such as climate change driven by different changes in temperature has the potential of affecting the net reproductive rate severely than any other model parameter value that drives the popularly entomological interaction, we hereby propose an alternative short strategy of assessing the impact of climatic change of the sugarcane borer-parasitoid interaction. We will expect the outcome of this research to provide some insights in entomological decisions with respect to the implication of the ICT component in reaching entomological decision in event of an unexpected entomological risk such as climate change.

Mathematical Formulation
In looking at the two main stages of development of the sugarcane borer *Diatraea sacharalis* – the egg and larval stages. We presume that there exists only an egg parasitoid (*Trichogramma galloi*) in a common environment. The rate at which the infestation is acquired is proportional to the number of encounters between parasitoids and hosts, (Anderson and May, 1981), (Anderson and May, 1991). That is, the net rate of the parasitism transmission is γxz, where x is number of uninfected individuals, z the number of parasitoids and γ the rate of parasitism (Anderson and May, 1981). Considering this assumption for the sugarcane borer–parasitoid interaction (Rafikov, Limeira, 2012), and assuming furthermore logistic growth for the egg population, we have the rate of change of the egg population density x_1 as

$$\frac{dx_1}{dt}=\beta\left(1-\frac{x_1}{K}\right)x_1-m_1x_1-n_1x_1-\gamma x_1 z, \qquad (1)$$

where x_1 is the egg density of the sugarcane borer; z the number of adult parasitoids; β the net reproduction rate; K the carrying capacity of the environment; n_1 the fraction of the eggs from the larvae emerge at time t; and γ the rate of parasitism. In equation (1), the quadratic term $\frac{\beta x_1^2}{k}$ describes the intra-specific competition and m_1 is natural mortality rate of the egg population. The rate of change of the parasitized eggs x_2 is therefore

$$\frac{dx_2}{dt}=\gamma x_1 z-m_2x_2-n_2x_2, \qquad (2)$$

where m_2 is mortality rate of the parasitized egg and n_2 the fraction of the parasitized eggs from which the adult parasitoids emerge at time t. The rate of change of the larvae population density x_3 is

$$\frac{dx_3}{dt}=n_1x_1-m_3x_3-n_3x_3, \qquad (3)$$

where m_3 is mortality rate of the larvae populations and n_3 the fraction of the larvae population which moults into pupal stage at time t.

It is known that the adult parasitoid infects eggs of the sugarcane borer at the beginning of its life (Botelho, Parra, Neto, and Oliveira, 1970). This fact permits us to assume that the parasitism at time t is caused only by new parasitoids emerged at time t, That is,

$$z=\delta n_2x_2, \qquad 4$$

where δ is the number of parasitoids emerged from one parasitized egg (δ = 2 for *Trichogrammagalloi*). Substituting Equation (4) in Equations (1) and (2) and defining $\alpha = \gamma\ \delta n_2$, we have the following mathematical model that describes interactions between the sugarcane borer and its parasitoid:

dx1 dt= β1- x1kx1-m1x1-n1x1-αx1x2,

dx2 dt=γx1z -m2x2-n2x2, (5)

dx3 dt=n1x1-m3x3-n3x3,

Method of Solution

First, the net reproductive rate was varied by twenty percent (20%) given us a new value of the net reproductive rates as 0.026. When this value was implemented in the MATLAB program using the ODE45, our numerical simulation has predicted fourteen (14) instances of biodiversity loss.

Secondly, when the net reproductive rate is varied by one hundred and twenty percent (120%), the new value of the net reproductive rate is 0.156. In this scenario the previous instance of the biodiversity loss bifurcate to a dominant biodiversity gain. The details of this novel contribution are presented and discussed next.

Results and Discussion

The results of this research are presented and discussed in this section.

Table 1: Assessing the impact of Carrying capacity when β = 0.026

Example	β	X_1	X_{1m}	PD(%)	EI
1	0.026	50	50	0	BL
2	0.026	49.30	44.44	9.86	BL
3	0.026	48.67	39.54	18.75	BL
4	0.026	48.08	35.21	26.76	BL
5	0.026	47.53	31.38	33.98	BL
6	0.026	47.02	27.99	40.48	BL
7	0.026	46.54	24.98	46.34	BL

8	0.026	46.10	22.30	51.63	BL
9	0.026	45.67	19.91	56.40	BL
10	0.026	45.27	17.79	60.70	BL
11	0.026	44.89	15.91	64.57	BL
12	0.026	44.53	14.23	68.05	BL
13	0.026	44.18	12.73	71.20	BL
14	0.026	43.84	11.38	74.03	BL
15	0.026	43.52	10.19	76.59	BL

EI Means Entomological implication, PD means Percentage difference, BL means Biodiversity loss

Table 2: Table 1: Assessing the impact of Carrying capacity when β = 0.156

Example	β	X_1	X_{1m}	PD(%)	EI
1	0.156	50	50	0	BG
2	0.156	49.30	50.60	2.63	BG
3	0.156	48.67	51.26	5.32	BG
4	0.156	48.08	51.97	8.09	BG
5	0.156	47.53	52.72	10.93	BG
6	0.156	47.02	53.53	13.84	BG
7	0.156	46.54	54.38	16.83	BG
8	0.156	46.10	55.26	19.89	BG
9	0.156	45.67	56.19	23.03	BG
10	0.156	45.27	57.16	26.25	BG
11	0.156	44.89	58.16	29.56	BG
12	0.156	44.53	59.20	32.95	BG
13	0.156	44.18	60.27	36.43	BG
14	0.156	43.84	61.38	40.00	BG
15	0.156	43.52	62.52	43.66	BG

EI Means Entomological implication, PD means Percentage difference, BL means Biodiversity gain

Conclusion

The key result that we have achieved in this study concerns the fact that a decreased value of the net reproductive rate predicts dominant biodiversity loss whereas an increase value of the net reproductive rate predicts dominant instances of biodiversity gain. On the basis of this observation, we propose that some sort of early mitigation measure should be put in place to control the severe biodiversity loss.

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