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MATHEMATICAL MODEL OF INSECTS WITH REFENCES TO HARMS CROPS AND FOODS IN LIMITED RESOURCES

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ABSTRACT

Insects are very small but do not have any reduction in harming the crops and food items. We often do not know how many insects us are around, which keep harming many things in our environment. Insects are the most diverse species of animals living on earth. Insects are the main problem for our environment which destroys crops. Insects are the main problem for our environment under limited resources. For agriculture and food industries the growth of population is very fatal. The population growth of insects like aphids and mazus continuously destroys the growth of crops and damages grains and food products in our daily life. In this paper, a mathematical model for controlling the population of insects which are responsible for destroying crops and food production is discussed. For crops. In this paper, a mathematical model for controlling the population of harmful insects destroying the crops and food production are discussed.

KEYWORDS: Population, Insect. Aphids' Moths, Mortality, Density, Toxic Substances

Insects creates many problems in our environment in the form of destroys crops and food products in our daily life. Insects are very smalls but very harmful species of animals living on earth for agriculture and food production whose population growth rate is very fatal in limited resources as exponential in starting Arnold (2021) as Grasshopper, caterpillar, and locust, which affect maize, vegetables Housefly, which affects the farmer's food. Termite, which affects crops and farm tools. Among all the most conspicuous insect Hemiptera like Aphids and Mazus discharges a type of lethal mucilaginous material that is saliva that spreads over the surface of the leaf preventing the individuals from further sucking so causing deaths due to starvation. The verity Lepidoptera is a very harmful verity of insects which is destroy the crops only by larva in the green houses. Several larvae entangle through silky secretion which turns products into entwined lumps. Some adult larvae are responsible crop for the damage to the crops and food products in several growth stages. Many insect pests are primary, i.e., able to attack intact grains such as the genus Sitophilus, while others are secondary pests, attacking already damaged grains or food products. It is exceptional that some insects are familiars with human beings for example, several insect species are predators or parasitoids on other harmful pests, others are pollinators, decomposers of organic matter or producers of valuable products such as honey or silk. Some can be used to produce pharmacologically active compounds such as venoms or antibodies. There are various types of insect species that are declining across most taxonomic lineages in most regions of world, and at potentially increasing rates as anthropogenic impacts intensify globally (Bell:4)**.** India is a very large biodiversity zone Sudhanshu *et al.*, (2021). According to the Zoological Survey of India (ZSI) in their report in 2020 that a total of 102,718 species of fauna, with 557 new species including 407 newly described species and 150 new country records. India has been home to many kinds of insects, bugs, arthropods, etc. Most of the insects are very small size however they cause major damage to us including our health. These dangerous Indian insects have the ability to kill humans as well as animals due to the high amount of venom in their bodies. Here's a list of some of the deadliest insects that are found in India. The most interesting facts that there are more than 15 dangerous insects in India are Red Ant, Indian Wasp, Cockroaches, Mosquitoes, Scorpion, Termites, The Asian Giant Hornet, Moth, Red Scorpion Beetle Bees, Earthworm and Indian Ticks Interesting. There are some types of insects which destroyed the crops are given below:

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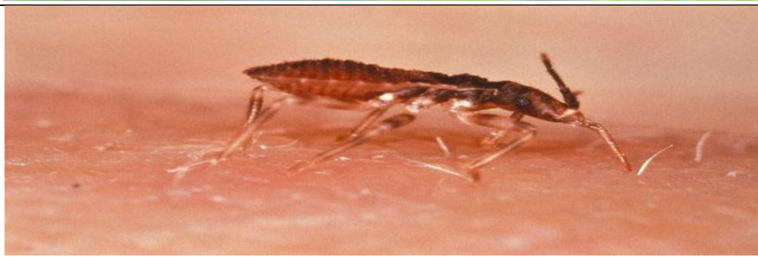
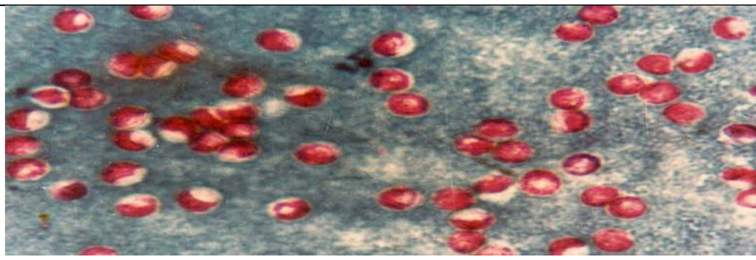
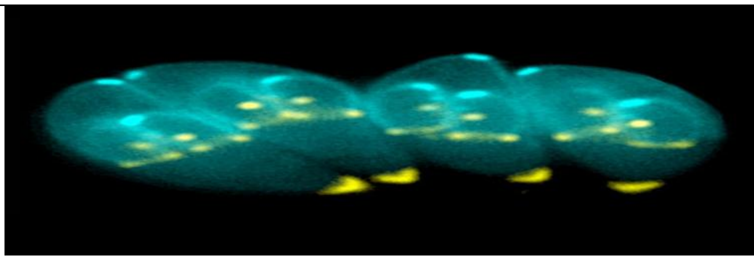
Table 1: Some harmful insects for crops and Food Products

S. No.	Name of insects	Image
1	Desert Locusts	
2	Bean Aphids	
4	Japanese Beetles	
5	Trypanosoma Cruzi	
6	Giant Coreid Bugs	
7	Rice Green Leafhoppers	
8	Pathogenic Nematodes	

In Human being there are many diseases generated by insects which are of pathogens. The insects are responsible for two ways of damage to growing crops. First is direct injury done to the plant by feeding insect, which eats leaves in stems, fruit, or roots. There are more than hundred of pest species of this type, in the form of larvae and adults. There was many attempts have been made to develop the mathematical models by Barlo (1982), Barlow and Dixon (1980), In an experiment it has been observed in the end of a week and after that that total number of individuals in the populations of insects rapidly increased in starting, reaching its maximum and due to mortality there population is decreases.

Moth species associated with grass or herb host plants were more severely affected, as were ground beetle species that were closely associated with xerophytic habitats Didham *et al.*, (2020) The population of insect has a birth rate and death rate. The first and simplest law of population by Malthus (1978)

$$\frac{dN}{dt} = pN$$

Which leads the exponential growth equation is $N(t) = N_0 e^{pt}$

This model is valid only in limited resources

Where $N(t)$ denotes the population at time t and $p > 0$ is the specific growth rate. and N_0 is the population at some arbitrary time.

$t = 0.$ According to Perl (1925) developed another model for limited resources.

$$\frac{dN(t)}{dt} = pN(t) - qN(t) \quad , t>0$$

There are many models for growth by Kapur (1985) assuming different law of by Shehata and Marr (1971). Moths can play as biodiversity indicator of the environmental impacts of human activity Dennis *et al.*, (2019). The insect moths produced toxic substances by bacteria become a limiting factor to their further growth by increasing rapidly the mortality rate of organism because mouths spread saliva on the leaf preventing further sucking and movement on the individuals so causing death by eating toxic substance. Aphid populations show periodic fluctuations, and many causes are attributed to their dynamic Braec *et al.*, (2014). To elucidate this we have developed the following model:

Formulation of the Model and its Solution

Let $N(t)$ is the total number individuals at time $t.$ Ammusing the mortality rate is affected by two factors one is increasing density of insect's population and secondly is affected by increasing concentration of toxic product produced by insect, the insect population growth considered as

$$\frac{dN(t)}{dt} = pN(t)\left(1 - \frac{N(t)}{R}\right) - Rr[N(t)]^2$$

Where R is a positive constant and r denotes the concentration of toxic product.

$$\frac{dN(t)}{dt} = pN(t)\left\{\left(1 - \left(\frac{1}{R} - \frac{R}{p}r\right)N(t)\right)\right\} \quad \ldots (1)$$

Or $$pdt = \frac{1}{N(t)\left\{\left(1 - \left(\frac{1}{R} - \frac{R}{p}r\right)N(t)\right)\right\}} dN(t)$$

Or $$pdt = \frac{dN(t)}{N(t)\left\{1 - \frac{N(t)}{K}\right\}} \text{ where } K = \frac{Rp}{p - R^2 r} > 0$$

Or $$pdt = \frac{1}{N(t)} + \frac{1}{\{K - NN(t)\}},$$

Now integrating both side we have,

Or $$pt = \int_{N_{0(t)}}^{N(t)} \left\{\frac{1}{N(t)} + \frac{1}{\{K - N(t)\}}\right\} dN(t)$$

Or $$pt = [\log N(t) - log\{K - N(t)\}]_{N_0(t)}^{N(t)}$$

Or $$pt = log\left[\frac{N(t)}{\{K - N(t\}}\right] - log\left[\frac{N_0(t)}{K - N_0(t)}\right]$$

Or $$pt = log\frac{N(t)\{K - N_0(t)\}}{N_0(t)\{K - N(t)\}}$$

Or $$e^{pt} = \frac{N(t)\{K - N_0(t)\}}{N_0(t)\{K - N(t\}}$$

Or $$e^{pt} N_0(t)\{K - N(t\} = N(t)\{K - N_0(t)\}$$

Or $$N(t) = \frac{KN_0(t)}{1 + (K - N_0)e^{-pt}} \quad \ldots (2)$$

RESULTS AND DISCUSSION

Equation (2) represent the size of the insect populations i.e., the density of the population at time $t.$ obviously as $t \to \infty, N(t) \to K$

So from equation (1)

$$N''(t) = \frac{p^2}{K^2} N(t)[K - N(t)][K - 2N(t)]$$

If $(K - N(t)) > 0$ i.e., then $N''(t) > 0$

So that the rate of increase of $N'(t)$ increases with time. This shows that there is an accelerated growth of the insect population in the range $0 < N(t) < K/2.$ If $K/2 < N(t) < K$ then

$\{K - 2N(t)\} < 0$, so that $N''(t) < 0$ that is the rate of $N'(t)$ decreases with time thus there is a retarded growth of insect population in the range $\frac{K}{2} < N(t) < K$ where the population in the range $\frac{K}{2} < N(t) < K$

CONCLUSION

In the above Mathematical model, we have seen that the population of insects is not fixed in a jone, it varies in different intervals. These values occurred when a certain population reached a maximum density and we observed that it initially increases first but after that, the insect population decreases and tends to zero which is the population tended to extinction. So, there is to find control its population density is possible which prevented a high growth rate of population growth by which our crops and food items can be protected from harm.

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