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Impact of Climate Change on the Development of Insects and Their Population Dynamics

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Abstract:

Insects are the organism which are powerful and rapidly adaptive having high fertility and less life cycle. The ecosystem of the insects got disturbed by the human interruption in agro-ecosystem and variations in global climate. The main causes of the environmental variation are erosion of natural habitats, urbanization, pollution and use of chemicals in agro ecosystem which multiplies the intensity of environmental variations. The insects and their populations dynamics are significantly influenced by the both abiotic (temperature, humidity, light) and biotic (host, vegetative biodiversity, crowding and diets) stresses. The population dynamics and status of the insects of crop could profoundly affected by these weather and climate changes, which may be caused by the indirect effects on the host plants, competitors and natural enemies of the pests. Just because of these factors, the metamorphic stages, survival and rate of multiplications of insects may extend. By taking these points into consideration, this paper discussed about the impact of climate change on insect and their population dynamics.

Keywords: *Insects, Climate change, Population dynamics*

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Introduction

Various anthropogenic and natural environment changes because of the global changes. Due to these climatic changes and weather changes, affects the population dynamics, distribution, abundance, intensity and feeding behaviour along with the status of insect pests. Meteorological sciences observed the direct and indirect effect of the intensity of change on the relationship, immune responses, fertility, rate of development and other physiological functions of prey and host in the climatic ecosystem. It was assumed by the various studies that the factors like anthropogenic, biotic and abiotic are responsible for the distribution of Asian Longhorn Beetle, which was conducted in 2008-2012. The multiplication, diapauses, emergence, flight and the dispersal rate of the insect is prevented by the abiotic factors especially, upper and lower thermal effects. Cool temperature plays a crucial role along with the high temperature threshold in the variation and inherent properties of insect species (Khaliq *et al*., 2014).

Insects are highly dependent on the thermal conditions of surrounding environment because it belongs to an ectothermic groups of animals. Hence climate change conditions are basic factors in the formation of range of insects alongside the food plants (Jaworski and Hilszczański, 2013). Insects living in hot temperature climate have light color as compare to that of facing cooled climate which possess dark color. The physiological, behavioral and morphological adaptations in the insects along with its population fluctuation is equally dependent on both the biotic and abiotic factors. In an agro ecosystem, terrestrial flora plays a vital role in the development of various stages, oviposition and hatching success of the terrestrial insects. Many insects are dependent on plants for their feeding like pollinator and other herbivorous, to which plant shows various responses. Carnivorous insects gets influenced by certain bivore induce plant volatile to attack on the plant eating insect species (Khaliq *et al*., 2014)

A range of natural and anthropogenic environmental changes is held by the term global changes. Global change is defined as the "Change in climate over time, either due to natural variability or as a result of human activity", by Intergovernmental Panel on Climate Change. Over the last 50 years, most of the global warming observed which is due the human activities. It is predicted to be increase in global mean surface by 1.4 to 5.8ºC from 1990 to 2100. There is a chance of negative effects of global warming over the next hundred years, if temperature rise by about 2ºC, which initiate to cover most of the world regions.

The population dynamics and status of the insects of crop could profoundly affected by these weather and climate changes, which may be caused by the indirect effects on the host plants, competitors and natural enemies of the pests along with its direct effects on distribution and abundance of pest populations. The changing conditions exploitations may be caused by some pests which are although present but only in small areas, by spreading more widely and reaching up to damaging population densities (Karuppaiah and Sujayanad, 2012; Sangle *et al*., 2015).

Abiotic factors

As the time being passage, the arthropods are insatiably gets affected by the anthropogenic and natural environmental variations. The status of various pest are being changed by the certain factors like thermal effect which suppresses or enhances the genetic potential, rate of fertility and death also the range of host.

1. Responses of Insects to High Temperature

Especially temperature, among all the multi climatic factors, can extend or reduce the life cycle of insects. The life cycle stages, growth and some internal metabolic activities of insects are influenced by the high thermal thresh old. For instance, the egg period extended 10.4 days at 25ºC in case of *Helicoverpa armigera*, although it was observed 7.9 days at 28ºC. It was supposed to be increased 1-3 days in generation time of *L. acuta* on raising the temperature up to 3ºC. In coastal environment, the abiotic factors affects the fitness and survival of terrestrial insects, particularly in case of soil salinity. In Korea, there was a study analyze on Rice insect pests under the influence of global warming and meteorological factors in 1992-2008, which is conducted on eight regions and found density variation among them.

A significant linkage is shown by the various physiological process and different environmental temperatures in case of insect pest management population fluctuations. Two flies like medfly (*Ceratitis capitata*) and natal fruit fly (*C. crosa*) shows sensitivity toward the temperature which is used for the sterile insect technique on exposing them to radiation. These mutated species are very helpful in male sterile insect technique because, in the field of experiments they showed greater longevity as compared to others. High risk of microclimatic variation and behavioral optimization is seen more in tropical species of insects than the temperate regions.

2. Insect Responses to Low Temperature

The physiological, mechanical and behavioral of the several insects are disturbed by the cooling and freezing effects. These effects may change the chemical components and may cause dehydration of the cells or it may keep the body fluid in liquid state below the melting point. The physiological behavioral response of insect against abiotic factors are checked by the considerable research in scientific literature. Fluctuating regimes enhances the fertility and survival in several insect species, comprise cycle between both gentle and stressful temperatures. During the warm winter, the pine beetle display and separate with better survival rate as compared to drastically reduced lethal (-16ºC). An increase of 2ºC in temperature may produce 1-5 more generation of Aphids. Even a minute change in temperature may affect the pre- oviposition period, oviposition and survival of insects.

The survival ability of *Nilapavata lugens* (Brown plant hopper) remains unaffected between 25-35ºC, whereas it is reduced at 40ºC. Similarly, the rate of oviposition of female remains higher at 35 and 40ºC but not at 25 and 30ºC. Unlikely to the survival and oviposition, the rate of pre-oviposition decreases with increase in temperature. It is observed that with the change in thermal effect, *N. cincticeps* population fluctuates from 3-4 and both the *N. cincticeps* and *C. suppressalis* are greatly affected by the global warming. Death rate of adult *Nezara viridula* and *Halyomorpha halys* gets decreased by 15% during the winter season along with the increase of 1ºC temperature.

3. Humidity Influences on Insect Fauna

Several insects responds differently to the abiotic factors such as humidity, thermal effects, light, food etc. The physiological mechanism of the insects get disturbed along with their behaviour by these abiotic factors. Host produces immune response in return when stress is given by the variation in abiotic environment such as humidity, diet and heat light to the host. The observation of rate of change other than that of describing direct change in a specific physiological reaction can measure the major factors in physical environment such as temperature, light, humidity etc. Mortality, fertility, generation time, multiplication rate, sex ratio and rather mutation are those factors. For example, the speed of development can be increased with the temperature but also increases the production of abnormalities and larval death. There are certain receptors, like thermo trp's react to a wide range of stimuli and acts as primary integers and also like the source of sensory information (Khaliq *et al*., 2014).

Effects of Climate change on insects:

The good indicators of human drive climatic changes are the insects. They are a good respondent to warming from phonological variations and distribution to the undertaking evolutionary changes. Climate change mostly affects the insects among the groups of organism by causing direct influence on their reproduction, development and survival. Insects responds very quickly to climate change as they have short generation times and high reproductive rates as compare to other long lived organisms like plants and vertebrates.

Impact on Diversity of Arthropods and Their Extinction:

There are nearly 45 to 275 species are being extinct per day and the extinction rates are about 100 to 1000 times greater the earlier at present. It is estimated that every six degree increase of temperature will be resulted in the mass extinction of several species including humans.

Impact on geographical distribution and population dynamics of insects:

Climate change may increase the hibernating of insects due to which larger spring populations produces in the succeeding season. But it will be susceptible to parasitoids and predators if later also hibernate more eagerly. Atmospheric disturbance may also cause increased dispersal of airborne insects. There are many insect species such as *Helicoverpa* sp., which are migratory and hence, moves rapidly into new areas when climate changes to exploit new opportunities (Sangle *et al*., 2015).

Development and Reproduction:

Although, the goals of development are not exceeded but, there might be the chance of positive direct responses of insects towards the enhanced reproductive potential to increase temperature conditions which can be expected. Some polyvoltine species for instance, economically important bark beetle like *Ipstypographus*, have increased developmental rates which allows the earlier life cycle competitions and also complete additional generations within that particular season. The rate of growth and fertility decreases when temperature remains above the specific optimum range but the rate of mortality for a multitude of species increases. The reproductive capacity and changes in distribution of various pest species are enhanced by the milder winters and decreased frequencies of temperature. For example, the winter moth *Operophthera brumata* and the autumnal moth, *Epirrita autumnata* and the gypsy moth, *Lymantria dispar* in North America or the European pine sawfly, *Neodiprion sertifer* are

predicted for having increased survival of activity and a certain accumulated effective temperature overwintering eggs in peripheral areas of occurrence. The decrease in hibernating survival of species which hibernates under the protection of snow is resulted by the increase in temperature, reduced snowfall and hence earlier snow melt (Karuppaiah and Sujayanad, 2012).

Review of Literature

Ju, Wang, and Li (2011) on the development of insect temperature has a main influence as C. ciliate is not considered in an exception. In the stage of development the effect of temperature on insects may vary from species to species. The rate of development of insects is decreases during lower temperature and it is increases during the spent of time in each stage. It is concluded that with the increase of temperature the development time of different stages of C. ciliate is decreases. With the decrease in temperature adult longevity, pre-oviposition, and oviposition periods were extended. C. ciliate was sensitive to extreme temperature but both limited high and low temperature are essential for the reproduction and growth.

Regniere, *et al.* (2012) to understand the ecology of insects it is important to understand the development response with temperature. The temperature dependent impact is determined by temperature-dependent phenology in which the impacts like geographical distributions, management of insects and population dynamics is consider. The result obtained for the approach are directly applicable to the model based on individuality of development, reproduction and survival with respect to the temperature. For analyzing eruptive insect population performance and reaction to changing the condition of climates this approach is useful and it makes possible for the development of process based phenology model. The model is based on the carefully use of available information and in the development of powerful tools.

Piyaphongkul, Pritchard and Bale (2012) on the reproduction and development of brown plant hopper this study was conducted to investigate the effect of sub lethal high temperature. The mean development time for adult was increased from 15.260.3 and 18.260.3 days when first instar nymphs were exposed. In the treated insects the mean fecundity was decreased from 403.8613.7 to 128.0616.6 eggs per female when both male and female instar nymphs were exposed at ULT50 of 41.8uC. The time is significantly increased for the insect progeny to complete development of egg by the exposure of nymphs and adults at their respective ULT50 temperature, by which all meetings are combined as compare to the control. Nymphal development, fertility and egg development time delays and inhibited by the sub lethal heat stress.

Kiritani, (2013) discussed about the change in climate directly affects the population dynamics of insects. In hot summer different insects respond differently which result in sometime increase or decrease in density. The effect may be delayed for 1-2 years or occurs immediately at time. The affected population of insects recover their affects when the regime remains unchanged. Between the temperature 28 and 32 ˚C it is susceptible that most of the insects stresses heat. The effect of global warming on insects is more insightful on the population dynamics or biodiversity of insects. The biotic interaction may change during time and the composition of genetic and phenotypic may change with time and space. The rate of environment changes is unprecedented and changes are convoyed by a time or regime shift.

Scharf, *et al.* (2015) studied on the development of insects two most influential environmental conditions are temperature and diet. Under both offspring growth temperature the temperature which is higher adult temperature managed to be more strong reproduction. In the experiment of temperature it is concluded that in the warmer adult temperature, when it match to the offspring grow condition then it only contribute to larval mass. In the two different growth conditions the effect of temperature also differs the yeast rich diet had a simple effect, with adult temperature interacting with parental growth temperature, which further leads to a combined effect on the success rate of reproduction.

Ma, *et al.* (2017) temperature is one of the most important abiotic factor which will directly affect the growth and establishment of pest population. Parameters like reproduction, morality, development and others are dependent on the temperature. In the survival and development of insects temperature is a crucial factor with minor variation on the rate of growth of insects of one or more of their stages. By using linear and non- linear reversion equation, temperature dependent development rates is determined for signifying the development range on temperature changes.

Liao, *et al.* (2017) in seven constant temperature the development and growth of M. exigua was studied, which is resulted as at 10˚c M. exigua egg is failed to flap and development of larvae is not complete at 15 and 35˚c. The stages developed under the temperature of 20, 25, 27 and 30 ˚c. The pre-adult development time of M. exigua is decreased with an increase of temperature the time decrease at 61.58 days at 20 ˚c to 28.94 days at 30 ˚c. Except at 30 ˚c the longevities of male adult is generally longer than the female. The highest peak value of mean fecundity, age-stage

specific fecundity and age-specific fecundity all observed at 27 ˚c.

Conclusion

Insects responds to every variation or abnormalities from normal environmental conditions. This may affect the ovulation, rate of fertility, development, survival, multiplication and genetic responses. Multiplications, emergence and migration of the insects are influenced by certain plant characters, nutritional modifications, and variation in flora and insect crowding in biotic stresses. There is a need to maintain a systematic documentation about the metabolic alterations of insects due to climate change of major and minor pests which will be very useful for facing the challenges in future and will help them.

References:

Jaworski, Tomasz, and Jacek Hilszczański. "The Effect of Temperature and Humidity Changes on Insects Development Their Impact on Forest Ecosystems in the Expected Climate Change." *Forest Research Papers*, vol. 74, no. 4, 1 Dec. 2013, pp. 345–355.

Ju, Rui-Ting, *et al*. "Effects of Temperature on the Development and Population Growth of the Sycamore Lace Bug, Corythucha Ciliata." *Journal of Insect Science*, vol. 11, no. 16, 2011, pp. 1–1

Karuppaiah, V., and G. K. Sujayanad. "Impact of Climate Change on Population Dynamics of Insect Pests." *World Journal of Agricultural Sciences*, vol. 8, no. 3, 2012, pp. 240–246.

Khaliq, A., *et al*. "Environmental Effects on Insects and Their Population Dynamics." *Journal of Entomology and Zoology Studies*, vol. 2, no. 2, 2014, pp. 1–7.

Kiritani, Keizi. "Different Effects of Climate Change on the Population Dynamics of Insects." *Applied Entomology and Zoology*, vol. 48, no. 2, 23 Jan. 2013, pp. 97–104.

Liao, Qiu-Ju, *et al*. "Temperature-Dependent Development and Reproduction of Rice Leaffolder, Marasmia Exigua (Lepidoptera: Pyralidae)." *Plos One*, vol. 12, no. 11, 10 Nov. 2017.

Ma, Li, *et al*. "Temperature Effects on Development and Fecundity of Brachmia Macroscopa (Lepidoptera: Gelechiidae)." *Plos One*, vol. 12, no. 3, Feb. 2017.

Piyaphongkul, Jiranan, *et al*. "Heat Stress Impedes Development and Lowers Fecundity of the Brown Planthopper Nilaparvata Lugens (Stål)." *PLoS ONE*, vol. 7, no. 10, 11 Oct. 2012.

Régnière, Jacques, *et al*. "Effects of Temperature on Development, Survival and Reproduction of Insects: Experimental Design, Data Analysis and Modeling." *Journal of Insect Physiology*, vol. 58, no. 5, Jan. 2012, pp. 634–647.

Sangle, P. M., *et al*. "Impact of Climate Change on Insects." *Trends in Biosciences*, vol. 8, no. 14, 2015, pp. 3579–3582.

Scharf, Inon, *et al*. "The Effects of Temperature and Diet during Development, Adulthood, and Mating on Reproduction in the Red Flour Beetle." *Plos One*, vol. 10, no. 9, 8 Sept. 2015.