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Climate change: A threat for beneficial insects

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Abstract
Global warming is a great concern throughout the world. The ill effects of global warming like change in climate, temperature, rainfall, humidity, level of carbon di-oxide has been found to have both positive and negative effects on insects, which in turn reduces the effectiveness of crop protection measures. This creates the need for global warming to be taken as an important criterion in Entomology. Being poikilothermic in nature insects are greatly affected by changing temperature. Insect will experience additional life cycles with rapid growth rate. As a result of changes in the population dynamics including distribution and migration the reliability on current insect pest ETL will be reduced. Increased insect pests outbreak will affect agricultural production. Research on basic biology of insect, population dynamics and behaviour patterns should be focused to ascertain the effect of global warming on insect behaviour.

Keywords: global warming, climate change, insect pests

Introduction

Generally global warming refers to an increase in average global temperatures. Climate change has been recognized globally as the most impending and pressing critical issue affecting mankind survival. The fifth assessment report (AR5) by the `Inter governmental Panel on Climate Change` (IPCC) reported that each of past three decades has been successively warmer at the Earth's surface and the decade of 2000's has been the warmest. The globally averaged combined land and ocean data as calculated by a linear trend, showed a warming of 0.85(0.65-1.06) ºC over the period 1880 to 2012 (IPCC 2013). The major cause of climate change is increase in the concentration of greenhouse gases (GHG) *viz*, carbon dioxide (CO2), methane (CH4) and nitrous oxide (NO2) as a result of human activities from pre-industrial era. These gases keep the earth warm and cause global warming or green house effect. Global warming is caused by natural as well as human activities. There are number of natural factors responsible for climate change. Some of the most prominent are volcanoes, ocean currents, forest fire etc. Among human activities, emissions of green house gases, industrialization, deforestation, fuel burning, *etc* are most important factor contributing towards global warming. It is not new that global warming can affect agriculture through their direct and indirect effects on the crops, soils, livestock and pests. Changed climatic conditions will also change the current crop pest scenario. According to survey of over 1700 species 50% of these wild species are already affected by climate change (Parmeshan *et al;* 2002) and even a mid-range climate warming Scenario predicts that 15% to 37% of the species may become extinct by 2050 (Thomas *et al.*, 2003) [13].

Effect of climate change on butterflies

Butterflies require body temperatures of 30– 35oC for optimal growth and development. Although butterflies have all kinds of methods to raise their temperature to this level (e.g. sun basking, coloration, body movement), climate is one of the major factors determining the distribution of these insects. Therefore climatic warming allows range expansion of many species at the cool margins of their range, both in latitude and in altitude, and an eventual contraction at the warmer margins.

There are several ways in which climate change may affect butterflies:

- **Direct effects on the physiology:** Butterflies and their caterpillars have an optimum temperature range, in which their body processes function best. If the microclimate changes, this will affect their survival and thus have an effect on their numbers and range.
- Effects on the abiotic environment. Apart from the direct effect of sea-level rise on coastal areas, the most direct effect of climate change will be on soil systems in terms of organic matter and especially water content. It could lead to drought-periods as well as heavy showers and flooding.
- Climate change has an impact on the vegetation structure, for example, leading to greater spring/summer grass growth in warm years.
- Larval food plants change their range. Many specialist butterflies depend on one or two species of food plant. If their optimal range doesn't overlap with the new food plant range, this can result in a change in the possible future range of such butterflies. This is demonstrated in the example of Bolo ria titania and its larval food plant Poly gonum bistorta.

Warming transformation

Many butterflies possess an unusually heightened sensitivity to overly warm environs. Minute increases in temperature, imperceptible to humans, are of such significance to butterflies that they have triggered new patterns in the ancient process of metamorphosis and have even driven the creatures out of their native habitats. Each species of butterfly and moth.

Species interactions

It is inevitable that range changes for plants and animals will lead to new interactions between species. Changes in temperature may result in asynchrony between food sources and breeding, causing starvation of offspring that emerges too early. This will mostly affect specialist species and butterflies with complex interactions with other species. In this respect species of the former genus *Maculinea* (now *Phengaris*), depending not only on food Plants, but also on host-ants, can be vulnerable. Changes and disruptions in the interactions between butterflies and their parasitoids,

Effect on honey bee

Three out of four crops across the globe, which produce fruits or seeds for human consumption, depend on pollinators. As one of the most important pollinators in the world, bees are crucial for food production, human livelihoods and biodiversity. Global warming has direct influence on honey bee behavior and physiology. It can alter the quality and quantity of the floral environment and reduces colony harvesting capacity and development. As global temperatures rise, North American and European honeybee ranges are getting smaller. In their most southern habitats, bees are dying from high heat and in their most northern habitats, they are remaining mostly static, so their range is shrinking. If weather patterns and temperatures shift beyond the norm, plants and bees may become out of sync, resulting in bees emerging long after the plants are ready to be pollinated. Bees are extremely susceptible to certain mites and gut parasites, and these parasites have been steadily increasing due to warming weather conditions. Higher temperatures and more frequent heat waves as a result of climate change, are likely to exacerbate these problems in the future, which could cause Colony Collapse and wipe out entire hives. According to climate change predictions, some regions will become even drier, leading to the disappearance of bee food and their honey bees. (Conte and Navajas, 2008) [3].

Impact of climate change on honey bee behaviour, physiology and distribution

The European honey bee, *Apis mellifera*, has the potential to adapt to hot climates. For instance, *Apis mellifera sahariensis* is found in the oases of the Sahara, where it has adapted to local bloom (such as palm flowers) and extreme heat (Ruttner *et al.*, 1998). In the USA, honey bees can develop in the Arizona Desert. The survival requirement for these bees is a supply of water, which they use in large quantities to raise their larvae and to regulate the brood temperature to between 34°C and 35°C. In an arid environment, desert flowers are unable to provide the bees with enough water and they die. According to climate change predictions, desert regions will become even drier, leading to the disappearance of oases and their honey bees. *Apis mellifera sahariensis* is highly unlikely to migrate naturally to more favourable desert areas because oases are very isolated and not conducive to long-distance migration or swarming. It is therefore vital to envisage conservation measures to transfer this bee to zones favourable to its development, lest we lose this ecotype that is so valuable for world biodiversity. Climate change can influence the honey bee development cycle. It is generally agreed that each race of honey bees develops at its own rate (Louveaux *et al*., 1966) [6]. Any sort of climate change or movement of a race of honey bees from one geographical region to an alien one is therefore bound to have measurable consequences. In cool regions, honey bees spend the winter clustered in a tight ball and use their honey stores to provide them with the energy they need to survive until spring. The honey bee's capacity to accumulate energy reserves and to manage the colony's development exerts significant adaptive pressure. In the spring, when the weather becomes more clement, the queen starts to lay eggs and the colony develops and increases the size of the worker population. A cold snap lasting several weeks may occur during which the honey bees are unable to harvest. The large size of the honey bee population causes such a rapid depletion of stores that the colony can die of starvation. It is something that can easily happen to hybrid bees (crosses of several races by bee breeders), which develop very fast in spring. In contrast, local ecotypes that are better adapted to the environmental conditions are more cautious and develop more slowly in spring until after this cold snap, when they breed very rapidly. In this way they avoid jeopardising the colony's survival. A distinction therefore needs to be made between local ecotypes, which need to adjust their development and stores to the climate, and hybrid bees selected by bee breeders. Hybrids have not been bred to build up food stores, the queen does not adjust her egg-laying and the workers do not adjust their larvae-rearing, with the result that the bees are unable to survive without the assistance of a beekeeper to provide them with unlimited supplies of sugar solution. The variability of the honey bee's life history traits as regards temperature and the environment shows such plasticity and genetic variability that this could give rise to the selection of development cycles suited to new climatic conditions.

Impact of climate change on sericulture

The silkworm *Bombyx mori* (Lepidoptera) is a poikilotherm, highly sensitive to environmental temperature due to artificial domestication and indoor rearing. The most suitable temperature for silkworm development is approximately 24–28 °C. It is predicted that, global warming affects the cultivation area of various crops including mulberry. Mulberry (*Morus alba*) is a C3 plant and it is inefficient in utilizing the atmospheric CO2 leading to less growth of plant ultimately the cocoon production. It has been also reported that, pink mealy bug, *Maconellicoccus hirsutus* has got 346 host plants and in mulberry it causes leaf yield loss of 4500 kgs/ ha/year thus depriving the farmer a brushing of about 450 dfls/ha/year leading decline in cocoon production of 150 kg/ ha/year (Ravi kumar *et al.*, 2010) [10].

Impact of climate change on bumble bee

Bumblebees (*Bombus* spp.) are important pollinators (Michener *et al.*, 2000) [7] of many native plant species and agricultural crops, particularly in temperate and high-elevation regions, and are associated with vegetation abundance and diversity (Over the past century however, several bumblebee species declined in range and abundance (Arbetman *et al.*, 2017) [1]. Threats include habitat loss and fragmentation, pesticides, parasites, pathogen spillover, and climate change (Goulson *et al.*, 2000) [5].

Some pollinator species have shifted higher in latitude or elevation in response to periods of rapid climate change (Cameron *et al.*, 2011) [2]. However, the majority of bumblebee species have failed to disperse beyond their northern range limits, while suffering losses at their southern range limits. Local extinctions at bumblebees' southern range limit may be linked to their vulnerability to frequent extreme temperature events under recent climate change. Bumblebee decline observed at their historical southern limit, and their failure to track climate change at their northern limit, indicate the potential for increased risks of local extinction under climate change.

Effect on natural enemies

Natural enemies of insects are likely to undergo diverse effects due to changes in atmospheric CO2levels, increase in temperatures and shifts in precipitation. Plants respond to elevated levels of CO2 with higher biomass. As a result there would be a dilution effect on nitrogen levels and those chemical constituents that require nitrogen. Lower nutritional value of plants adversely impacts insects that feed on them directly and also their parasitoids and predators indirectly. Increased temperatures can alter both plant and herbivore phenology with likely impact on synchronization between the two again indirectly influencing the activity of natural enemies and the effectiveness of their natural control. Hymenopteran wasp parasitoids which are relatively host-specific are likely to be influenced more than tachnid flies which generally survive by feeding on a variety of insects. Higher minimum temperatures in temperate regions can lead to expansion of geographical range of insect pests which are currently intolerant to low temperatures. This may result in pest outbreaks in the newer areas if natural enemies fail to track and follow their hosts. Variability in rainfall reportedly has an adverse influence on parasitism levels of several caterpillar pests. Sucking pests like cereal aphids are less susceptible to climate change effects. In case of mealybugs, parasitism is reduced under conditions of water stress associated with drought conditions apparently due to improved immune response. The effects of climate change on natural enemies mediated byCO2, temperature and moisture effects on plants could be complex and unlikely to be predicted easily due to interactions between these effects. Adaptation and mitigation practices to combat climate change such as conservation agriculture practices are likely to have a positive effect on parasitoid and predator abundance with resultant benefits on natural pest control. Much of the climate change research has been conducted in the temperate countries. While referring to these available results, an attempt has been made in this review to illustrate examples of natural regulation of insect pests in India in the context of climate change and variability.

a. Effects of increased atmospheric Co2 levels

Yin *et al*. (2009) [14] conducted an experiment under 750ppm CO2 concentration involving Helicoverpa armigera Hubner larvae reared on milky grains of wheat and its larval parasitoid Microplitis mediator, widely used in its biocontrol. No significant change in parasitisation rate of M. mediator was found. The development of the parasitoid wasp, Glypta pantelesliparidis, of gypsy moth, Lymantria dispar, feeding on three different tree species fumigated with 540+20 ppmCO2 was not adversely affected by changes in food quality when compared to ambient CO2 (Schafellner and Schopf, 2008) [12].

b. (b)Effects of increased temperature

Temperature greatly influences the survival, development and abundance of insects and the effect is direct. Each insect species and even each population might have different optimum temperatures for survival and reproduction. Insects inhabiting the colder climates with marked seasons have better tolerance to thermal extremes. They are currently exposed to cooler temperatures than their optima (Deutsch *et al*., 2008) [4] and therefore might benefit from global warming. An increase of 30C in mean daily temperature would cause the carrot fly, Deliaradicum (L.) to become active a month earlier than at present (Collier *et al*., 1991). An increase of 20C will reduce the generation turnover of the aphid, Rhopalosiphum padi (L.) (Morgan, 1996) [8].

Conclusion

Global warming is the international problem. Agricultural business is likely to suffer losses in long run due to climate change and new emerging pest scenario. Hence pest management tactics are to be improved according to the prevailing condition. Productive insects and natural enemies are affected to a greater extent. So, resistant strains are to be developed. IPM principles will be required to be followed more strictly in the future scenario of global warming. Reduction in use of pesticides will also help in reducing carbon emissions. Historical data should be taken into consideration while formulating the experiments and standardization of protocols. Further research has to be carried out to manipulate the effects with a focus to improve the effectiveness of crop protection practises.

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