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Scientists' warning on loss of insect biodiversity and implications for sustainable agriculture

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Abstract

Climate change is a long-term shift in global or regional climate patterns. Climate change is among the biggest environmental challenges, humans face in the 21st century. The most imminent climatic change in recent times is the increase in atmospheric temperatures due to increased levels of greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), ozone (O_3), nitrous oxide (N_2O) and chlorofluorocarbons (CFCs), largely because of industrialization and burning of fossil fuels, etc. The term biodiversity is the short form of 'biological diversity. As per the Convention on Biological Diversity (CBD), biodiversity means the variability among all living organisms from all sources including inter alia terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part. Climate change is among the major environmental challenges for humans with catastrophic effects on faunal (especially insect) biodiversity and agricultural production. Insect biodiversity provides an array of indispensable services in agricultural production including pollination, nutrient recycling and natural control of pests. Special efforts are required for conserving and identifying insects and elucidating their role in ecosystem functioning. Intensive research, constant surveillance, early detection and rapid response are essential to face the emerging pest and disease threats to crop production. Insect Conservation, landscape heterogeneity, biological control and IPM are the keys to environmentally benign and climate-resilient crop protection for sustainable agricultural production in the future.

Key Words: Climate change, biodiversity, insects, pollination, IPM

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The climate is the synthesis of weather conditions in each area, characterized by long-term statistics (mean values, variables, probabilities of extreme values, etc.) for the meteorological elements in that area. Climate change is a long-term shift in global or regional climate patterns. Climate change is among the biggest environmental challenges, humans face in the 21st century. It's generally manifested as variation in the distribution of

weather patterns or change in extreme weather events over extended periods. The Inter-Governmental Panel on Climate Change (IPCC) has defined climate change as 'any change in climate over time whether due to natural variability or as a result of human activity'. The most imminent climatic change in recent times is the increase in atmospheric temperatures due to increased levels of greenhouse gases such as carbon dioxide (CO_2), methane (CH_4), ozone (O_3), nitrous oxide (N_2O) and chlorofluorocarbons (CFCs), largely because of industrialization and burning of fossil fuels, etc. As per recent estimates, the globally averaged combined land and ocean surface temperature data as calculated by a linear trend, show warming of 1.09^0C in 2011-20 over 1850-1900 and estimates reveal projected warming of 1.2-4.5^0C by the end of the 21st century. The amount of CO_2 has jumped from 280 ppm to more than 400 ppm in the last 150 years and is projected to cross 500 ppm around 2050. It is of immense concern that most of the warming (of 0.1^0C/decade) observed over the last fifty years is attributed to human activities (IPPC, 2022).

The term biodiversity is the short form of 'biological diversity. As per the Convention on Biological Diversity (CBD), biodiversity means the variability among all living organisms from all sources including inter alia terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems. The Entomological Society of America (ESA) defines biodiversity as "the comprehensive variety and variability of life on Earth- the full spectrum of species, populations, interactions, behaviors, and gene pools that compose the living world."

A perusal of the voluminous literature available on the subject, suggests that climate change and other anthropogenic activities will have serious consequences for ecosystem services, water availability, crop production and diversity and abundance of arthropods including pollinators, trash burners and decomposers, insect pests and natural enemies and the extent of crop losses due to insect pests (Arora and Dhawan, 2011, Arora, 2013, Sanchez-Bayo and Wyckhuys, 2019). A warning issued by the Union of Concerned Scientists and reissued by the Alliance of World Scientists, and signed by over 15,000 scientists claims that humans are "pushing Earth's ecosystems beyond their capacities to support the web of life" (https://www.scientistswarning.org/the-warning). Climate change is affecting individual organisms, populations, species, communities and ultimately the ecosystems and whole biomes. The loss of agrobiodiversity (flora, fauna especially pollinators), pest and disease outbreaks, and failure of established pest management practices are some of the major consequences of climate change, which will affect both crop production and food security (Arora and

Sharma, 2021, Harvey *et al*., 2022). It has been reported that 3-14% of species are at risk from warming of 1.5^0C, 3-18% at 2^0C, 3-29% at 3^0C and 3- 39% at 4^0C (IPCC, 2022).

Insect biodiversity globally and in India

With more than a million identified species, insects comprise nearly two-thirds of the animal biodiversity on planet Earth. But many more remain unidentified and the total number of insect species has been estimated to be around 5.5 million. Insects serve to pollinate a majority of the species of flowering plants. Bees (superfamily Apoidea), flies, beetles and butterflies and moths are some of the major groups of insect pollinators of entomophilic plants. Several groups of insects act as natural enemies of many insect pests and weeds. In addition, they provide many other essential ecosystem services in natural as well as in agroecosystems. Springtails, termites, ants, beetles, mole crickets and cicadas serve to improve soil aeration and add organic matter to the soil (Arora and Dhaliwal, 1999, van Huis, 2014). The precipitous and rather unexpected decline in insect populations has been reported over the last two decades but has caught our attention only recently (Wagner *et al*., 2021). It has left us with no option but to take immediate and drastic action for the conservation of insects and other arthropods. Consequently, the Entomological Society of America (ESA) hosted a symposium on 'Insect decline in the Anthropocene' at their annual meeting in St Louis in November 2019. The eleven papers presented there discussed in depth the causes and cures for this decline and the same were published in a special issue (in 2021) of the *Proceedings National Academy Science* USA 118:2). The symposium emphasized that long-term species-level demographic data were meager from the tropics, which embodies much of the biodiversity (Wagner et al. 2021). The major causes of biodiversity losses in insects include habitat destruction and deforestation, urbanization, climate change, intensive agriculture, pesticide and fertilizer use, wetland/river alteration and other anthropogenic activities (Sanchez-Bayo and Wyckhuys, 2019, Harvey *et al*., 2020).

India's Biological Diversity Act, of 2002 was enacted with the aim of conservation of biological diversity, sustainable use of biological diversity, and fair and equitable sharing of the benefits of biological diversity. The act is being revised and the Biological Diversity Amendment Bill, 2021 is pending before Parliament for approval. However, no special provisions are proposed for the conservation of arthropods which are essential for providing ecosystem services. As per the Zoological Survey of India, Kolkata, the insect biodiversity in India is comprised of 63760 identified species from 658 biological families representing 3 classes and 27 orders. Among various states in the country, Sikkim harbored the maximum number (5941) of insect species followed by West Bengal (5818) and Meghalaya (5118). Not surprisingly, Punjab- the food bowl of the country, has only 1116

identified species of insects (Chandra, 2015). But many more insect species remain unidentified and their role in ecosystem functioning remains unacknowledged.

Implications of biodiversity loss for sustainable agriculture

i. The loss of many species of pollinators, natural enemies of pests, trash burners and decomposers of dead plants, animals and other organic matter.

ii. Fragmented food chains and food webs resulting in losses in biodiversity and/or abundance of many species of amphibians, reptiles, fishes and birds.

iii. The emergence of many new economically important pests of crop plants in different regions of the world.

iv. Failure of existing/ recommended control measures against important pests in many crops/ locations.

Insect conservation

The funding for research on arthropods and the conservation of arthropods and other organisms needs to increase dramatically to enable us to protect nature's ecosystem and ultimately ourselves from impending disaster. Professor E.O. Wilson proposed conserving half the lands and seas on the planet to safeguard the bulk of biodiversity and the project came to be known as the 'Half-Earth Project' (Wilson, 2016). With only about 20 percent of an estimated 5.5 million insect species identified, there is an immediate need to identify insects and other arthropod fauna and to illuminate their ecological role in nature as well as in agroecosystems. There is an urgent need to prepare a long-term research agenda in insect taxonomy including molecular taxonomy. There are just a couple of designated insect repositories including the Zoological Survey of India (ZSI), Kolkata and the National Bureau of Agricultural Insect Resources (NBAIR), Bengaluru in the country. New designated repositories and data centres on insects must be established in universities/ other institutions as per the Biodiversity Act of 2002. The number of threatened and extinct insect species is woefully underestimated because so many species are rare or undescribed. Further, inventories of insect fauna must be prepared at the block, district, state and national levels (Chandra, 2015).

The extinction risk and conservation status of an overwhelming majority of identified species also need to be determined. Biological invasions have become increasingly common, posing a great threat to regional biodiversity and ecosystems. The impacts of invasive species are considered to be the second leading threat to worldwide biodiversity after habitat destruction (Harvey *et al*., 2020). Arthropods constitute more than half of the biodiversity on the planet and research and conservation of these organisms must receive proportionate funding.

The development of forecasting models for predicting the effects of climate change on ecologically significant arthropods should be a priority at the regional, national and international levels. Dynamic global vegetation models have emerged as an important technique to study the impact of various climate change scenarios on vegetation, biogeochemical cycles and biodiversity.

With increasing urbanization, there has been a phenomenal increase in lighting especially UV lights and LED lights, which have adversely affected the survival and behaviour of insects. Light pollution interferes with insects that use natural light as orientation cues for navigation. The adverse effects of soil, water and air pollution, by pesticides, fertilizers, and industrial effluents, on insects are well known. Noise pollution by vehicles and industries interferes with acoustic communication by insects. Hence, a reduction in various types of pollution may help in the establishment and growth of insect populations (Owens *et al*., 2020).

Deforestation, urbanization and mining have caused extensive destruction of the habitats of insects and other organisms. Further, modern agriculture based on monocultures and homogeneity cannot support biodiversity. An increase in landscape diversity and a lowering of cropping intensity are expected to support a wider variety and abundance of native flora and fauna including insects.

The massive task of biodiversity conservation and mitigation of the adverse effects of climate change, on pollination and other ecosystem services, is only possible with the participation of all sections of society, with emphasis on students, informed citizens and farmers, mobilized through awareness campaigns and educational programmes for community participation.

Climate-resilient plant health management

The wide-ranging and in many cases uncertain effects of climate change on crops, insect pests and natural enemies require intensive research, constant surveillance, early detection and rapid response (Arora, 2013, Arora and Sharma, 2021, Rao *et al*., 2022). Strict quarantine measures must be adopted to prevent the spread of pests and pathogens to new areas. Invasive species are a huge threat to modern agriculture and must be contained as soon as detected.

The period of activity and rate of multiplication of insects may keep changing with changing environmental conditions. The temperature may also affect the number of days required to reach different crop phenological stages. Therefore, the population dynamics of the pests as well as their natural enemies on the popular cultivars of important crops must be studied periodically at multiple locations in each agro-climatic zone.

Pesticides are known to kill many species of non-target insect/ non-insect populations in the agroecosystem as well as in soil and water. Further, pesticide production, transport, storage, application and breakdown all contribute to climate change. Therefore, pesticide use must be replaced with biological control and other ecological measures (IPM) through policy interventions (subsidies, taxation) to induce innovation and adoption of insect-friendly technologies. Most countries have already enforced pesticide residue limits while importing agricultural commodities.

There is a need to prioritize the import of agricultural produce from healthy, species-rich ecosystems using holistic crop production and protection technologies. This will help to bring investment in eco-friendly technologies.

Pest management is a dynamic process, especially in a changing climate regime. It is therefore essential that all the cultural, mechanical biological and chemical control measures must be periodically (at least after every 5 years) reevaluated and suitably modified to maintain their efficiency.

Conclusions

Climate change is among the major environmental challenges for humans with catastrophic effects on faunal (especially insect) biodiversity and agricultural production. Insect biodiversity provides an array of indispensable services in agricultural production including pollination, nutrient recycling and natural control of pests. Special efforts are required for conserving and identifying insects and elucidating their role in ecosystem functioning (Harvey *et al*., 2020). Intensive research, constant surveillance, early detection and rapid response are essential to face the emerging pest and disease threats to crop production. Insect Conservation, landscape heterogeneity, biological control and IPM are the keys to environmentally benign and climate-resilient crop protection for sustainable agricultural production in the future.

References

Arora, R. 2013, Impact of climate change on insect pest scenario and management. In: *Proceedings of Brainstorming Workshop on Climate Change and Sustainability of Agriculture*. February 6, 2013, DST, PSCST and Punjab Agricultural University, Ludhiana, pp. 32-46.

Arora, R. and Dhaliwal, G. S. 1999, *The Insects- Diversity, Habits and Management*. Kalyani Pubs., New Delhi.

Arora, R. and Dhawan, A. K. 2011, Climate change and insect pest management. In: Dhawan, A.K., Singh, B., Arora, R. and Bhullar, M.B. eds., *Recent Trends in Integrated Pest Management*. Indian Society for the Advancement of Insect Science, Punjab Agricultural University, Ludhiana, pp. 77-88.

Arora, R. and Sharma, S. 2021, *An Introduction to Integrated Pest and Disease Management.* Kalyani Pubs., New Delhi.

Chandra, K. 2015, A century of ZSI research on insect biodiversity. Lead Paper presented at the 4th Congress on Insect Science, April 17, 2015, Indian Society for the Advancement of Insect Science, Punjab Agricultural University, Ludhiana.

Harvey, J. A. and Heinen, R. 2020, International scientists formulate a roadmap for insect conservation and recovery. *Nature Ecology & Evolution.* Available online at http//doi.org/10.1038/s41559-019-1079-8.

Harvey, J. A. and Tougeron, K. 2022. Scientists' warning on climate change and insects. *Ecological Monographs* 2022, DOI: 10.1002/ecm.1553.

IPPC. 2022, *Climate Change 2022: Impact, Adaptation and Vulnerability*. Working Group II Contribution to the IPPC Sixth Assessment Report. Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge.

Owens, A. C. S. and Cochard, P. 2020. Light pollution is a driver of insect declines. *Biol. Conserv*. **241**: 108259.

Rao, S. M. and Prasad, T. V. 2022, *Adaptation Strategies for Pest Management in Climate Change Scenarios*. ICAR-CRIDA and MANAGE, Hyderabad.

Sanchez-Bayo, F. and Wyckhuys, K.A.G. 2019. Worldwide decline of the entomofauna: A review of its drivers. *Biol. Conserv.* **232**, 8-27.

Van Huis, A. 2014. The global impact of insects. Farewell address upon retiring, Wageningen University, Wageningen.

Wagner, D. L. and Grames, E. M. 2021. Insect declines in the Anthropocene: Deaths by a thousand cuts. *Proceedings National Academy of Sciences*, USA, 118(2), e20233989118.

Wilson, E. O. 2016. *Half-Earth: Our Planet's Fight for Life*. E.O. Wilson Biodiversity Foundation, Liveright Publ. Corp., NY.

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