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Locust Outbreaks in India and the impact of Climate Change

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Abstract
Locusts differ from ordinary grasshoppers in their ability to swarm over long distances and are among the oldest migratory pests. The ecology and life history of locusts make them among the most devastating pests worldwide. Here, we review the locust outbreaks in recent years in the light of climate change. The outbreaks heavily affect the agricultural sectors, which is the foundation of national economies and social stability, and have had profound socio-economic impacts on rural communities in India. Global warming is likely the main cause of locust plague outbreak in recent decades. More recent outbreaks, such as those in 2019-2020, have highlighted the continued vulnerability of Indian agriculture to locust infestations. Despite advances in locust control technology and coordination mechanisms, challenges remain in effectively managing locust outbreaks in India. Climate change, land-use practices, and socio-economic factors are likely to influence the frequency and intensity of future locust outbreaks, necessitating adaptive strategies and resilience-building measures.

Keywords: Locust, migratory pest, climate change, India

1. Introduction

Locust are grasshoppers that belong to the family Acrididae of order Orthoptera. Locusts can be defined as the species of grasshoppers that congregate in large numbers as nymphs and at some point, swarm to fly long distance as adults destroying vegetation on their way. Grasshoppers, on the other hand, are those that do not have this ability. Under certain conditions, such as increased rainfall and abundant vegetation, locusts can undergo a behavioral transformation known as gregarization, where they aggregate into swarms and exhibit migratory behavior. They form highly mobile gregarious congregation of nymphs or swarms of adults [1]. The phase change from one behavioural state to another is usually accompanied by changes in body shape and colour, fertility, survival and migratory behaviour [2]. These changes are so profound in many species that the swarming and non-swarming forms were once considered to be different species [3]. Swarms can travel long distances, aided by prevailing winds, and can cover hundreds of kilometers in a single day. Locust swarm may contain thousands of millions of individual behaving as a unit [4].

2. Locust species affecting India

Locusts are found worldwide, with several species known to exhibit swarming behaviour. All locusts are grasshoppers found in the world but only 9 are recognised as locusts of which 3 belongs to the Indian

subcontinent [3]. These are as viz. Desert locust (*Schistocera gregaria* Forsk.), Migratory locust (*Locusta migratoria*), and Bombay locust (*Patanga succinate*); of which the first two are the main pests. Among these the most important and globally wide spread locust species is the desert locust *S. gregaria*. The Desert Locust is one of the most destructive locust species and is known for its ability to form large swarms that can travel over long distances. It is found in desert regions of Africa, the Middle East, and South Asia, including India [5]. Desert Locust swarms pose a significant threat to agriculture in India, particularly during periods of favourable breeding conditions. The Migratory Locust is another species known for its swarming behaviour and ability to migrate over vast distances. It is found in temperate and tropical regions worldwide, including India. Migratory Locusts can cause damage to a wide range of crops, including cereals, vegetables, and grasslands [3]. These locust species have been responsible for several outbreaks in India, leading to significant agricultural losses and economic impacts. Effective control and management strategies are essential to mitigate the impact of locust infestations on agriculture and food security in the country.

3. Historical and recent Locust outbreaks in India

Locust outbreaks have been documented in India for centuries, with historical records offering glimpses into the cyclical nature and varying magnitudes of these events. In ancient and medieval period, references to locust plagues can be found in ancient Indian texts, such as the Vedas and the Mahabharata, dating back to several millennia. Historians from the medieval period also documented locust swarms and their devastating effects on agriculture and society. During the colonial period, detailed records of locust outbreaks and their impact on colonial agriculture were maintained by British administrators in India. They implemented various measures to control locust swarms, including the establishment of entomological research stations and promoting locust destruction [6].

During twentieth century several significant locust outbreaks occurred in different parts of India, particularly in the western and northwestern regions. Significant outbreaks occurred in the 1920s, 1940s, and 1970s, leading to widespread crop damage and economic losses. In response, Locust Warning Organization (LWO) was established in 1939 to assist locust control efforts in India [7]. At global level, massive locust outbreaks still threaten the terrestrial environments and crop production in around 100 countries of which Ethiopia, Somalia and Kenya are the most affected. Six large locust outbreaks were reported for the period from 1912 to 1989 all being closely related to long-term droughts and warm winters coupled with occurrence of high precipitation in spring and summer [8]. In recent decades, India has experienced sporadic locust outbreaks, often linked to favourable breeding conditions triggered by climatic factors such as rainfall and vegetation growth. The 1993-1997 outbreak, for example, affected several states in western and northern India, causing significant damage to crops and pastures [9]. More recent outbreaks, such as those in 2019-2020, have highlighted the continued vulnerability of Indian agriculture to locust infestations.

The most notable recent locust outbreak occurred in 2019-2020, affecting several states in western and northern India. This outbreak was linked to favourable breeding conditions in the Horn of Africa and the Arabian Peninsula, resulting from heavy rainfall and cyclonic activity. According to the Food and Agriculture Organization (FAO) of the United Nations, this outbreak was the worst in 70 years probably triggered by climate change, hurricanes and heavy rain and has affected a total of 70,000 ha in Somalia and Ethiopia [9]. The outbreaks in East Africa, India and Pakistan were the most pronounced with locusts migrating more than 150 km/day during which the locusts consumed food equivalent to their own body

weight on a daily basis [8]. These swarms of Desert Locusts invaded India, devouring crops and vegetation in their path. States such as Rajasthan, Gujarat, Maharashtra, Madhya Pradesh, and Uttar Pradesh were among the worst affected by the 2019-2020 locust outbreak. It caused extensive damage to crops, including wheat, rice, pulses, and vegetables. Farmers in these regions suffered significant losses as locust swarms decimated standing crops, leading to reduced yields and income [10].

4. The impact of climate change on Locust outbreaks

The relationship between locust outbreaks and climate change is a growing concern, as shifts in climate patterns can influence locust behavior, distribution, and outbreak frequency [11]. The outbreak of 2019-2020, affecting several states in western and northern India, was directly linked to favourable breeding conditions in the Horn of Africa and the Arabian Peninsula, resulting from heavy rainfall and cyclonic activity [9]. Climate change is altering environmental conditions in ways that could impact locust populations and their propensity to swarm [12]. Understanding this relationship is crucial for predicting and mitigating the risks associated with locust outbreaks.

Changes in temperature patterns can affect locust development, reproduction, and migration. Warmer temperatures may accelerate the locust life cycle, leading to more frequent breeding and swarming [13]. Variations in rainfall patterns can influence vegetation growth, which is essential for locust survival and reproduction. Increased rainfall can create favourable breeding conditions, while drought can trigger migrations in search of food. Extreme Weather Events like, cyclones, floods, and other extreme weather events associated with climate change can disrupt locust habitats and trigger mass movements of locust swarms [14]. Changes in temperature and precipitation patterns could create suitable conditions for locusts in regions where they were previously uncommon, potentially increasing the frequency and intensity of outbreaks. Climate change may alter the geographic distribution of locust populations, expanding their range into new areas or causing shifts in their traditional habitats [15]. Higher temperatures and altered precipitation patterns could lead to longer breeding seasons and larger populations of locusts, thereby increasing the likelihood of swarming events. Thus, climate change may contribute to more frequent and severe locust outbreaks by creating conducive conditions for locust breeding and swarming. Climate change interacts with other environmental factors, such as land use change, habitat loss, and pesticide use, which can further influence locust populations and dynamics. Deforestation, agricultural expansion, and urbanization may alter locust habitats and migration routes, affecting their behaviour and distribution [16].

5. Control and Management Strategies

Countries effected by the desert locust generally adopt a preventive control strategy for the management of desert locust, in order to reduce the frequently, duration, duration, and intensity of plagues. The most common solution adopted is simply spraying them with pesticides and insecticides either on the ground or in the air with the help of helicopter. The problem with the solution is that sprayed pesticides has a negative impact in general on the environment. Another solution could be the use of eco-friendly pesticides. However, it is observed that these pesticides are slow acting and do not kill them effectively. Another method is using loud noise but it is not a long term or scalable solution. A unique and interesting solution is capturing locusts for chicken feed. Physical control is generally simple, effective, and low-cost method. The traditional method is to dig ditches, trap them, and then kill or burn them. However, this method is only effective for low-density locusts. Pheromones have also been used. Biogenic pesticides as essential part of biological control has been more effects on locusts, such as anti-feeding, repelling,

regulating growth, and sterilization. Azadiractin, Pathogenic fungus, Bacillus thuringiensis, protease inhibitors are some of the biocontrol measures. Many natural enemies have also been used at various scenarios [17,18].

Effective locust control requires coordinated efforts and collaboration among various stakeholders, including government agencies, NGOs, and international organizations. Each plays a crucial role in different aspects of locust monitoring, management, and mitigation. Efforts to reduce greenhouse gas emissions, such as transitioning to renewable energy sources, improving energy efficiency, and promoting sustainable land-use practices, can help mitigate climate change impacts on locust habitats and populations. Use of climate-smart and diversified agriculture can help in control. Climate data integration, remote sensing and monitoring improves detection and tracking of environmental conditions conducive to climate-driven locust outbreaks, locust breeding and swarming [19].

6. Conclusion

Climate change poses significant challenges for locust management, with potential implications for agriculture, food security, and livelihoods. Addressing these challenges requires concerted efforts at local, national, and global levels to mitigate climate change impacts and build resilience in vulnerable communities. Recent locust outbreaks in India have highlighted the vulnerability of agriculture to pest infestations and the importance of proactive measures to mitigate their impact [20]. Building resilience against future locust outbreaks requires a multi-pronged approach, encompassing early detection, rapid response, sustainable pest management practices, and community engagement. Investments in research and innovation, including the development of alternative control methods and resilient crop varieties, are essential for long-term locust management. Building resilience against climate change impacts on locusts requires a multifaceted approach, like, setting up Early Warning Systems by enhancing surveillance and monitoring networks to detect locust outbreaks and assess climate-related risks; implementing sustainable pest control strategies that minimize reliance on chemical pesticides and promote natural enemies of locusts [21]. Community engagement should be encouraged by involving local communities in locust monitoring and control efforts, while providing support for livelihood diversification and adaptation. Investing in research should be a priority to better understand the interactions between climate change and locust dynamics, and developing innovative solutions for locust management [22].

Locust outbreaks have had profound socio-economic impacts on rural communities in India, particularly small-scale farmers and pastoralists. Crop losses, food insecurity, and loss of livelihoods are among the primary consequences of locust infestations, exacerbating poverty and vulnerability in affected areas. Over the years, India has developed comprehensive strategies for locust control and management, including early warning systems, surveillance networks, and control operations. Collaborative efforts with neighboring countries and international organizations have also been instrumental in addressing transboundary locust threats. By learning from past experiences and adopting holistic strategies, India can better safeguard its agricultural sector and ensure food security for its population in the face of future locust threats. The government, in collaboration with state authorities and international agencies, should mounted a concerted effort to control the locust infestation.

7. Conflict of Interest

This review was not sponsored, or any other way influenced by anybody/any organization - not fully neutral. The authors declare that there is no conflict of interest with anybody/any organization.

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9. References

1. Spinage C.A., Spinage C.A., "Locusts the forgotten plague Part I: locusts and their ecology", African Ecology: Benchmarks and Historical Perspectives, 2012, 481-532.
2. Lecoq M., "*Locusta migratoria* (Migratory locust)", Crop Protection Compendium. Wallingford, UK: CAB International. https://doi. org/10.1079/cabicompendium, 2023, 31151.
3. Kamil Usmani M., Usmani S., "Locusts. Pests and Their Management", 2018, 825-869.
4. Georgiou F., Buhl J., Green J.E.F., Lamichhane B., Thamwattana N., "Modelling locust foraging: How and why food affects group formation", PLOS Computational Biology, 2021, 17(7), e1008353.
5. Cressman K., "Desert locust. Biological and environmental hazards, risks, and disasters", 2016, 87-105.
6. Rai A.N., Sharma A., "Historical Overview of Locusts Attack in India: A Review Article", International Journal of Agriculture System, 2020, 8(2), 140-148.
7. Sharma, A., "Locust control management: moving from traditional to new technologies–an empirical analysis", Entomol. Ornithol. Herpetol, 2014, 4(141), 2161-0983.
8. Peng W., Ma N.L., Zhang D., Zhou Q., Yue X., Khoo S.C., Yang H., Guan R., Chen H., Zhang X. Wang Y., "A review of historical and recent locust outbreaks: Links to global warming, food security and mitigation strategies", Environmental research, 2020, 191, 110046.
9. Sultana R., Kumar S., Samejo A.A., Soomro S., Lecoq M., "The 2019–2020 upsurge of the desert locust and its impact in Pakistan", Journal of Orthoptera Research, 2021, 30(2), 145-154.
10. Ahmad R., Hussain B., "Locust Outbreaks in India and in the Cold Arid Region of Ladakh and Their Management", In Locust Outbreaks, Apple Academic Press, 2024, 173-190.
11. Hassan A., Aslam M., "Locust Outbreaks, Climate Change, Sustainable Agriculture, and Environmental Effects", In Locust Outbreaks, Apple Academic Press, 2024, 155-171
12. Cease A.J., "How Nutrients Mediate the Impacts of Global Change on Locust Outbreaks", Annual Review of Entomology, 2024, 69, 527-550.
13. Cressman K., "Climate change and locusts in the WANA Region", Climate change and food security in West Asia and North Africa, 2013, 131-143.
14. Meynard C.N., Lecoq M., Chapuis M.P., Piou C., "On the relative role of climate change and management in the current desert locust outbreak in East Africa", Global Change Biology, 2020, 26(7), 3753-3755.
15. Chen C., Qian J., Chen X., Hu Z., Sun J., Wei S., Xu K., "Geographic distribution of desert locusts in Africa, Asia and Europe using multiple sources of remote-sensing data", Remote Sensing, 2020, 12(21), 3593.
16. Klein I., Oppelt N., Kuenzer C., "Application of remote sensing data for locust research and management—a review", Insects, 2021, 12(3), 233.
17. Showler A.T., "A summary of control strategies for the desert locust, *Schistocerca gregaria* (Forskål)", Agriculture, ecosystems & environment, 2002, 90(1), 97-103.
18. Shuang L.I., Feng S.Q., Ullah H., Tu X.B., Zhang Z.H., "IPM-Biological and integrated management of desert locust", Journal of Integrative Agriculture, 2022, 21(12), 3467-3487.

19. Heeb L., Jenner E., Cock M.J., "Climate-smart pest management: building resilience of farms and landscapes to changing pest threats", Journal of pest science, 2019, 92(3), 951-969.
20. Pandey B.W., Ganesh P., Maurya R., Pathak U.K., Kumar R., Ghosh M., Singh Y., "Spatial distribution of outbreak of locust swarms: a geographical analysis of vulnerability and preventions in India", Sustainability, Agri, Food and Environmental Research, 2021, 9(1), 91-106.
21. Agarwal A., Saxena S., Arora S., "CRISPR/Cas Technology: A Climate Saviour or a Genetic Pandora's Box?", In Gene Editing in Plants: CRISPR-Cas and Its Applications, Singapore: Springer Nature Singapore. 2024, 735-773.
22. Sokame B.M., Agboka K.M., Kimathi E., Mudereri B.T., Abdel-Rahman E.M., Landmann T., Rwaheru M.M., Abdalla O., Mafabi M.M., Lubango L.M., Tonnang H.E., "An integrated assessment approach for socio-economic implications of the desert locust in Eastern Africa", Earth's Future, 2024, 12(4), e2023EF003841.