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Locust Outbreaks: Understanding the Science Behind Desert Locust Invasions

*Rahul Nodal[1], Pavitra Choudhary[2], Tejpal Tetarwal[1] and Ravindra Kumar Meena[1]
[1]Dept. of Entomology, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan
[2]Dept. of Entomology, College of Agriculture, Agricultur University, Jodhpur, Rajasthan
Corresponding Author's email: nodalrahul@gmail.com

Desert locust outbreaks are among the most damaging biological hazards affecting food production across parts of Africa, the Middle East and Southwest Asia. Although swarms can appear suddenly, they are the outcome of a predictable sequence: unusual rainfall enables vegetation growth in arid breeding zones, locust populations increase rapidly, crowding triggers a shift from solitary to gregarious behaviour and wind-assisted migration spreads swarms across large areas. This article outlines the basic science behind desert locust invasions, including the phase change mechanism, the formation of hopper bands and flying swarms and the environmental conditions that allow outbreaks to escalate. It also summarises how modern monitoring combining field surveys, satellite data and weather forecasting supports early warning and targeted control. Understanding these processes is essential for reducing crop losses, improving preparedness and limiting the social and economic impacts of future invasions.

Keywords: Desert locust; Phase polyphenism; Gregarisation; Swarm dynamics; Early warning systems

Introduction

Locust invasions have shaped human history for thousands of years, appearing in early chronicles from North Africa and the Middle East and continuing into the present day. What makes these events especially disruptive is their speed and scale. A swarm can arrive with little warning, consume fields in hours and then move on with the wind, leaving farming communities facing immediate losses of food and income. The desert locust (*Schistocerca gregaria*) is widely considered the most dangerous locust species because it can multiply quickly and migrate over very long distances. The Food and Agriculture Organization (FAO) estimates that swarms may travel up to about 150 km in a day under favourable conditions and that a dense swarm covering just 1 km² can consume roughly the same amount of food in one day as 35,000 people (FAO, 2020; FAO, n.d.). These numbers help explain why even a single swarm can become a national concern. At the same time, the desert locust is not permanently a "plague insect." Most of the time it exists in small, scattered populations in remote desert areas and causes limited damage. The scientific puzzle and the key to effective management is understanding how and why the same species can shift from harmless to highly destructive.

The desert locust and its two phases

A defining feature of locust biology is phase polyphenism: the ability of the same species to express two distinct forms depending on environmental conditions (Pener & Simpson, 2009).

- **Solitary phase:** Locusts occur at low density, avoid one another and tend to be less conspicuous in colour and behaviour.
- **Gregarious phase:** When density increases, locusts become attracted to each other, form cohesive groups and ultimately produce marching bands and flying swarms.

This shift involves more than simple aggregation. It includes changes in behaviour, physiology and external appearance that make mass movement and group living more likely (Simpson *et al*., 1999; Pener and Simpson, 2009). In practical terms, it is the transition to the gregarious phase that marks the beginning of a potentially serious outbreak.

How outbreaks begin: rainfall, vegetation and rapid breeding

Desert locusts live in regions where rainfall is normally scarce. Outbreaks often start when unusually heavy or repeated rains fall in desert breeding areas, producing temporary but extensive growth of vegetation and moist soil suitable for egg-laying (FAO, n.d.; Cressman, 2016).

When conditions are favourable:

1. **Breeding success rises.** Moist soil improves egg survival, and fresh vegetation provides food for hatchlings.
2. **Population density increases.** More locusts survive and concentrate where vegetation is still available.
3. **Crowding intensifies as habitats shrink.** As green patches dry out, insects are forced into closer contact, increasing the chance of phase change.

Large-scale invasions generally require more than one successful breeding cycle, often across different areas, allowing numbers to build over months (FAO, n.d.; Cressman, 2016).

The phase change trigger: why crowding changes behaviour

Research over several decades has shown that crowding is the critical trigger for gregarious behaviour. Repeated tactile stimulation particularly contact around the hind legs contributes to the behavioural shift, accompanied by changes in neurochemistry (Simpson *et al*., 2001; Rogers *et al*., 2003). A widely cited finding is that changes in neurotransmitters, including serotonin, are associated with the rapid onset of gregarious behaviour in desert locusts (Rogers *et al*., 2003). In effect, crowding helps "switch on" traits that favour group formation and collective movement. Over time and across generations in dense conditions, morphological and physiological traits also shift, reinforcing gregariousness (Pener and Simpson, 2009).

From hopper bands to swarms

Locust damage escalates because the insects become both numerous and mobile.

- **Hopper bands:** After hatching, young locusts ("hoppers") cannot fly. In gregarious conditions they form dense marching bands that move across the ground and strip vegetation.
- **Flying swarms:** After several moults, hoppers become winged adults. Gregarious adults can form swarms that travel with the wind, sometimes crossing multiple countries.

This progression matters for control. Hopper bands are typically more concentrated and easier to target than dispersed flying adults, making early detection essential (FAO, n.d.).

Why swarms cause severe agricultural losses

Desert locusts are generalist feeders. They can consume cereals, legumes, vegetables, tree seedlings, and pasture grasses, threatening both crop farming and livestock production. The damage is driven by two reinforcing factors:

1. **Consumption at scale:** Locusts eat daily and swarms contain enormous numbers of insects (FAO, 2020).
2. **Rapid movement:** Swarms can arrive quickly, feed intensively and move on, leaving little time for local response (FAO, n.d.).

These impacts are often greatest in regions where agriculture is rain-fed and household food security is already vulnerable. Major outbreaks therefore become not only an agricultural issue, but also a humanitarian concern (World Bank, 2020).

Weather, climate variability and recent large outbreaks

Locust outbreaks have always been linked to rainfall and wind patterns, but recent events have increased attention on climate variability and extreme weather. For example, the 2019–2021

upsurge in East Africa was associated with unusual rainfall patterns and storm activity that created favourable breeding conditions in typically arid areas (FAO, 2020; WMO, 2020). While no single factor explains every outbreak, successive seasons of good rainfall can allow multiple generations to breed, multiplying populations rapidly before control measures can catch up (FAO, n.d.; Cressman, 2016). It is important to distinguish the general point from overstatement: climate change is not the only driver of locust events, but changes in the frequency and intensity of rainfall extremes can increase the likelihood of the environmental conditions that permit rapid population growth (IPCC, 2021; WMO, 2020).

Monitoring and control: how science reduces risk

Modern locust management prioritises early warning and early intervention.
Surveillance and forecasting commonly involve:

- field surveys in known breeding areas
- satellite-based observation of vegetation greenness and soil moisture
- weather and wind forecasting to estimate breeding potential and swarm movement (FAO, n.d.)

Control methods include:

- **Targeted chemical control** (most effective when locusts are concentrated in hopper bands or roosting groups)
- **Biopesticides** such as fungal agents developed for locusts/grasshoppers, used to reduce broader ecological harm in appropriate contexts (Lomer *et al*., 2001)
- improved coordination and information-sharing across borders (FAO, n.d.)

The central operational lesson supported by decades of experience is that preventing or interrupting gregarisation early is far more effective than attempting to stop mature swarms after they have spread.

Conclusion

Desert locust invasions are not random mysteries. They are the predictable outcome of a chain reaction linking rainfall, vegetation growth, rapid reproduction, crowding-driven phase change and wind-assisted migration. Because swarms can develop quickly and travel widely, effective management depends on continuous monitoring of remote breeding areas, reliable forecasting and fast, well-coordinated response. As climate variability influences rainfall and storm patterns in key regions, strengthening early warning systems and preparedness will remain essential for limiting the agricultural and economic impacts of future outbreaks.

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