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Locusts: Current Problem in India – A Critical Analysis

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Abstract

Locusts are the short horned grasshoppers (Orthoptera: Acrididae) distinguished by expression of a remarkable and potentially devastating form of phenotypic plasticity, known as density-dependent phase polyphenism with voracious feeding behavior. They are capable of forming swarms (adult's congregation) and hopper bands (nymphal congregation). They cause great devastation to natural and cultivated vegetation. They are indeed the sleeping giants that can flare up anytime to inflict heavy damage to the crops leading to national emergency of food and fodder. Of the more than 12,000 described grasshopper species, 19 are considered locusts, out of which 10 are most important. This paper discusses the current locust problem in India, their ecology, countries affected due to locusts, their migratory behavior, life cycle, physiology of locusts, maternal effects on offspring development, shift in population and management strategies.

Introduction

Locusts are the short horned grasshoppers (Orthoptera: Acrididae) distinguished by expression of a remarkable and potentially devastating form of phenotypic plasticity, known as density-dependent phase polyphenism. Changes in local population density cause the development of strikingly different phenotypic forms, or 'phases'. Low population densities produce the shy, well-camouflaged 'solitarious' phase, whereas crowded conditions produce the aggregating, migratory 'gregarious' phase. Solitarious phase locusts avoid one another, but gregarious locusts can form huge groups and embark on spectacular mass migrations. They travel as marching bands of flightless juveniles and vast flying swarms of winged adults. Though scientists cannot be certain why locusts developed the trait over time, many believe it is because they typically live in temperamental and harsh environments where needed resources are very unpredictable (Tanaka and Maeno, 2010). These are the areas usually without heavy rain fall for years but suddenly slammed by powerful downfalls. Such crazy, unpredictable dynamics can select evolutionarily for this ability to go through these dramatic changes. As a response they capitalize on a rare opportunity andalso develop capacity to migrate.

Of the more than 12,000 described grasshopper species, 19 are considered locusts, out of which 10 important species are listed here (Table 1). Swarming locusts have evolved independently a number of times in a variety of different grasshopper lineages throughout the world.

In India, four species *viz.,* desert locust, migratory locust, Bombay locust and tree locust (*Anacridium* sp.) were observed. Among these, Desert locust, *Schistocerca gregaria* is the most

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important one and started damage in India at present.

Table 1: Ten important species of locusts in the world

S. No	English Name	*Scientific Name*
1	The Desert Locust	*Schistocerca gregaria*
2	The Bombay Locust	*Nomadacris succincta*
3	The Migratory Locust	*Locusta migratoria*
4	The Italian Locust	*Calliptamus italicus*
5	The Moroccan Locust	*Dociostaurus morocannus*
6	The Red Locust	*Nomadacris septemfaciata*
7	The Brown Locust	*Locustana pardalina*
8	The South American Locust	*Schistocerca paranensis*
9	The Australian Locust	*Chortoicetes termenifera*
10	The Tree Locust	*Anacridium sps.*

Solitarious (Figure 1) and gregarious phase (Figure 2) locusts differ in a variety of other traits. The photos below illustrate how they look like and differ in morphology. Apart from that these also differ in nutritional physiology, reproductive physiology etc.

Figure 1: Solitary phase of locust

Figure 2: Gregarious phase of locust

A single locust swarm can contain billions of insects and travel hundreds of kilometers each day (Figure 3). Desert locust threatens over 60 countries covering approximately one-fifth of Earth's land area and one-tenth of the global population. On occasions they can even cross oceans, as happened most recently in 1988 when Desert locust swarms from West Africa flew across the Atlantic Ocean and reached Americas. It is estimated that a swarm covering one square kilometer can eat as much food in a day as 35,000 humans.

Figure 3: Locust swarm

Present Problem of Locusts

The problem of desert locust threat to India during 2020 had its origin in Africa. During May 2018, there was Cyclone Mekunu passed over a vast, unpopulated desert on the Southern Arabian Peninsula known as the Rub' al Khali. The cyclone filled the space between sand dunes with ephemeral lakes which allowed locusts to breed undetected. This was further amplified in October 2018 by another Cyclone Luban, which spawned in the central Arabian Sea, marched westward, and rained out over the same region near the border of Yemen and Oman. These unusually heavy rains were tied to fluctuations in the Indian Ocean Dipole, which in turn is affected by climate change.

Historically, the Persian Gulf has very few cyclones. But the past decade has brought a significant increase because of the Indian Ocean dipole. This phenomenon resulted in flooding in the western Indian Ocean and consequent dry weather in the east. Locusts grew exponentially in this kind of climate. Ultimately, these two 2018 cyclones enabled three generations of wildly successful locust breeding in just nine months, increasing the number of insects buzzing over the Arabian desert by roughly 8,000-fold.

Countries Affected by Locust Menace

From January 2019 onwards, the outbreak spread to the African countries of Ethiopia, Kenya, Eritrea, Djibouti, Somalia, Uganda, and South Sudan. Among the countries in Arabian Peninsula, Yemen, Saudi Arabia were also affected (Torto *et al.,* 1994). Finally by June 2019 the swarms reached to South and South-West Asia countries of Iran and Pakistan and spread there until December, 2019. In India the swarms came from Iran and Pakistan, but the situation has been brought under control and there was no major loss. A number of timely measures and a change in wind direction have prevented a spread and large-scale damage to the rapeseed and cumin seed crops. The main affected states were Gujarat and Rajasthan.

In Gujarat, locusts attacked in December 2019 damaged crops, mainly rapeseed and cumin seed, planted on about 17,000 hectares. Parts of western Rajasthan crops spread over at least 3,50,000 hectares of land have been destroyed. The districts adversely affected by the large scale attacks by locusts include Sri Ganganagar, Jaisalmer, Barmer, Bikaner, Jodhpur, Churu and Nagaur (Figure 4). Three villages in Gujarat's Banaskantha district, which shares a border with Pakistan's desert areas, came under fresh locust attacks in January 2020.

Figure 4: Locust damage in Rajasthan

In May 2020, Rajasthan and Madhya Pradesh were severely affected by locust swarms measuring a kilometer wide, the worst locust attack in 27 years. On 27th June 2020, millions of locusts swarmed on a massive scale in Gurgaon, Delhi-NCR region, made look like a sand storm in the sky.

The Ecology of Locust Swarms

Locusts are actually special kinds of grasshoppers known for their gregariousness. In gregarious phase, their bodies actually change the color and grow bigger muscles as they gather into massive clouds, rolling across landscapes and devastating crops.

It might have something to do with the dry environments in which these species exist. Desert locusts only lay eggs in moist soil, to keep them from drying out. When heavy rains come in to saturate the desert, locusts breed profusely and fill the soil with their eggs, perhaps 1,000 per square meter of soil (Figure 5 and 6). When those eggs hatch, they will have plenty of vegetation to eat, until things dry up once again. As soon as they start increasing they migrate in search of more food.

Figure 5: Egg laying in the moist soil

Figure 6: Adult locust with Eggs

An individual locust might travel over 90 miles in a day, consuming its own weight in plant matter. A single swarm can cover up to 1200 square kilometers and can contain between 40 and 80 million locusts per square kilometer (a total of around 50 to 100 billion locusts per swarm, representing 1,00,000 to 2,00,000 tons, considering an average mass of 2 grams per locust). The locust can live between three and six months, and there is a ten to 16-fold increase in locust numbers from one generation to the next.

How and Why Do Swarms Form and Migrate?

Weather plays a critical role in locust population growth and swarm formation. It promotes growth of host plants and provides soil moisture for egg development. Juveniles in pre-outbreak populations feed on a variety of plants that contain secondary compounds toxic to vertebrates. They become even more willing to do so as they become gregarious. When this happens, their conspicuous gregarious phase colour patterns serve as a warning colouration to vertebrate predators (Torto *et al.,* 1994). That signals as though the locusts are toxic prey by virtue of feeding on noxious plants.

Locust swarms often fly with prevailing winds that take them to regions of rainfall, and potentially generate suitable habitat. Further, bands form as an anti-predator strategy in which individuals in gregarious phase are much less likely to be killed by predators than insects that are on their own. However, band members suffer from increased intraspecific competition for nutritional resources as well as an increased risk of cannibalism by other hungry band members (Seidelmann and Ferenz, 2002).

Life Cycle of *Schistocerca gregaria*

In Life cycle of *Schistocerca gregaria*, eggs are laid in soil. Egg period is 10-65 days, non-flying nymphal period is 24-95 days, flying adult lives for 2.5-5 months. Fledging stage 40-50 days, adult maturation is 3 weeks to 9 months. Total life span is 2 to 6 months (Figure 7-10).

Figure 7: Eggs

Figure 8: Hopper

Figure 9: Adult

Figure 10: Fledging

Physiology of Locusts

The desert locust is potentially the most dangerous of the locust pests because of the ability of swarms to fly rapidly across great distances. It has two to five generations per year.

The solitary and gregarious phases display striking differences in morphology *i.e.* brain size, body size, and color; and physiology *i.e.* neuroendocrinological status along with their behavior (tendency to migrate with their crowd and timing of response to moving objects). The phase change involves 532 genes and 90 of them are differentially methylated in the solitary versus gregarious forms. What both forms have in common is their ability to transmit their phase to the progeny and revert to the alternative phase under appropriate conditions.

Crowding and the smell of conspecific individuals in phase transition imply their perception in the locust brain. This is followed by alterations in neurons, especially in synaptic morphology, as well as types and amounts of neurotransmitters and neuropeptides secreted in the nervous system. Experimental injection of the neurotransmitter serotonin alone or its analogs induces transition of solitary locusts to the gregarious phase.

Maternal Effects on Offspring Development

Schistocerca gregaria females reared in isolation laid more eggs than those reared under crowded conditions, due to the larger number of ovarioles. Further, thesizes of the eggs laid by individuals reared under isolation are also smaller than the ones reared under gregarious conditions. Egg development is influenced greatly by ovarian ecdysteroids. Ecdysteroid contents of ovaries of females reared under crowded conditions were up to four times higher than those in the ovaries of females reared in isolation. These studies, thus, raise the possibility that endocrine differences in the mothers, resulting from their exposure to crowding during their development, are carried over to their offspring. This may explain some aspects of the transgenerational nature of this phase transition. Pheromones and semiochemicals transferred to eggs may also direct embryonic development. These compounds, when deposited on the eggs or egg pod material attract other gravid females to the area resulting in clustered oviposition. But they may also lead to an increase in the propensity of the hatchlings to express gregarious characteristics.

Shift in Population State of Desert Locusts

Population density often exhibits threshold levels at which a population undergoes a rapid transition to a new state, such as irruption or extinction. Small populations or solitary phase of the desert locust, *Schistocerca gregaria*, are characterized by scattered nymphs and adults feeding and moving independently. When the environmental conditions favor high rates of reproduction, crowding also increases the levels of serotonin in their thoracic ganglia. This causes nymphs to undergo changes in color and form gregarious phase and aggregate into small groups. Additional changes in gene expression accompany this phase shift.

Then, smaller groups can coalesce into marching bands of hundreds to millions that cover up to several square kilometers. Various pheromones appear to cause individuals and groups to remain near each other rather than disperse. Major outbreaks occur only when small groups remain cohesive and move into neighboring habitat. Finally, those merge with other groups to form a coordinated band. If such cohesive movement fails to occur, the nymphs disband and return to the solitary phase.

Locust Warning Organization in India

Locust warning organization (LWO) in India operates a centralized forewarning system for the desert locust to keep the state authorities informed on the current desert locust situation. This is done on a regular and timely basis as reported through the surveys conducted in the scheduled desert area (SDA) by LWO staff. Survey data and field reports received from different circle offices of LWO are analyzed at LWO field headquarters, Jodhpur, together with data on ecological conditions and weather etc. These are compared with the historical data of analogous situations in order to provide meaningful forewarning. The outcome of these surveys is sent to central headquarters, Directorate of Plant Protection, Quarantine and Storage, Faridabad. Here the data are compiled and collated, and Locust Situation Bulletins are issued every two weeks throughout the year. These bulletins are circulated among all national and international

agencies related to the locust control work to appraise them of the latest developments in Indian Thar Desert. The state authorities are alerted/ warned immediately when any significant development of locusts is noticed.

Management Strategies for Locusts

Most recent finding from International Centre for Insect Physiology and Ecology (ICIPE) reveals that a specific locust pheromone Phenyl acetonitrile, or PAN for short, can be used against young locusts with devastating effect. PAN caused the insects to resume solitary behaviour. Confused and disoriented, some locusts lost their appetite altogether, while others turned cannibal and ate one other. Any survivors were easy prey for predators (Tanaka and Maeno, 2010).

Green Muscle® containing spores of the naturally occurring fungus *Metarrhizium anisopliae* var. *acridum* is an effective biological approach. The fungus, germinates on the skin of locusts and penetrate through their exoskeletons. Then it destroys the locust's tissues from inside. The fungus has no effect on other life forms. However, it takes 15-18 days for the fungus to kill locusts.

Insect Growth Regulators are moderately effective for several weeks after application as so-called barrier treatments. Only narrow swathes of the product are applied, perpendicular to the direction of the marching hopper bands. Only 10 percent of the amount used in blanket treatment is needed. Some IGRs available in the literature are-

• ***Diflubenzuron:*** dose rate of 100 g a.i./ha within the barrier, or 1.67 L/ha.

• ***Triflumuron:*** dose rate of 75 g a.i./ha within the barriers, or 1.5 L/ha.

• ***Teflubenzuron:*** dose rate of 75 g a.i./ha as ULV.

• ***Flumuron:*** dose rate of 100 g a.i./ha.

• ***Hexaflumuron:*** dose rate of 100 g a.i./ha.

Important recommended insecticides that have been mentioned in literature are given below:

• Alpha-cypermethrin (EC 100 g/L) @ 160-200 mL/ha)

• Beta-cyfluthrin (EC/ULV 25 g/L) @ 200 mL/ha)

• Carbaryl SC (500 g/L) @ 1200-1400 mL/ha)

• Chlorpyrifos (EC 500 g/L) @ 350 mL/ha)

• Cypermethrin (EC 200 g/L) @ 160–200 mL/ha)

• Diazinon(EC 800 g/L) @ 700 mL/ha)

• Fenitrothion(EC/ULV 1000 g/L) @ 270–400 mL/ha)

• Fipronil (SC 200 g/L) @ 6.25 mL/ha)

• Gamma cyhalothrin (EC 150 g/L) @ 20-30 mL/ha)

• Lamda-cyhalothrin CS 250 g/L @ 24-36 mL/ha)

However, insecticides have to be used after observing all required precautions.

On Receiving the Message of Locust Swarm Invasion, Farmers May Take the Following Preventive Measures:

• Farmers should go to their cropped fields and make loud sounds (100-125 decible) by beating empty tins/ metal plates, drum or radio or through other electronic sound system to prevent locust swarm landing in the crop.

• Spray mixture of neem based formulation (0.15% EC) @ 45 ml + DDVP 76 EC @ 10 ml/ 15 lit of water on standing crop as feeding deterrent and for quick knock down of the hoppers/ adults. (Caution: Do not harvest the crop till 10 days after the spray) OR,

• Dust the crop with quinolphos 1.5% DP or chlorpyriphos 1.5% DP @ 25 kg/ha on standing crop. (Caution: Do not harvest the crop till 15 days after the spray).

• If oviposition holes are found in the uncultivated fields, first dust any insecticide quinolphos 1.5% DP or chlorpyriphos 1.5% DP @ 25 kg/ha) and then plough the fields to kill the eggs and emerging nymphs.

• If hatching of eggs started and nymphs observed, spray bio-pesticide Metarrhiziumanisopliae var. acridum @ 75 g/ 15 lit of water or dust any insecticide quinolphos 1.5% DP or chlorpyriphos 1.5% DP or methyl parathion 2% DP @ 25 kg/ ha to kill the emerging nymphs.

• If hopper band is formed and observed marching, burn dry grass or any trash in front of the marching hopper band to kill the nymphs. OR,

• Dig a trench two feet deep and two feet wide in front of marching hopper band and then apply quinolphos 1.5% DP or chlorpyriphos 1.5% DP or methyl parathion 2% DP dust in the trench or if water is available, pour water in the trench.

• If hopper band is roosting, either go for quinolphos 1.5% DP or chlorpyriphos 1.5% DP or methyl parathion 2% DP @ 25 kg/ha or spray malathion 96% ULV @ 1.0 lit/ha or fenitrothion 96% ULV @ 0.5 lit/ha with the help of ULV sprayer directly on the hopper band.

• If the adult locust swarm has settled on the ground in uncultivated fields, either go for quinolphos 1.5% DP or chlorpyriphos 1.5% DP or methyl parathion 2% DP @ 25 kg/ ha or spray malathion 96% ULV @ 1.0 lit/ha or fenitrothion 96% ULV @ 0.5 lit/ha with the help of ULV sprayer directly on the hopper band provided it is in small area.

Conclusion

Locusts are the short horned grasshoppers distinguished by expression of a remarkable and potentially devastating form of phenotypic plasticity. Desert locust threatens over 60 countries including India, covering approximately one-fifth of Earth's land area and one-tenth of the global

population. An individual locust might travel over 90 miles in a day, consuming its own weight in plant matter. A single swarm can cover up to 1200 square kilometers and can contain between 40 and 80 million locusts per square kilometer. Green Muscle® containing spores of the naturally occurring fungus *Metarrhizium anisopliae* var. *acridum* is an effective biological approach. Insect Growth Regulators are moderately effective for several weeks after application. On receiving the locust swarm message, farmers can dust the crop with quinolphos 1.5% DP or chlorpyriphos 1.5% DP @ 25 kg/ha as preventive measure.

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