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Desert locust invasions and what are they looking for? – A review

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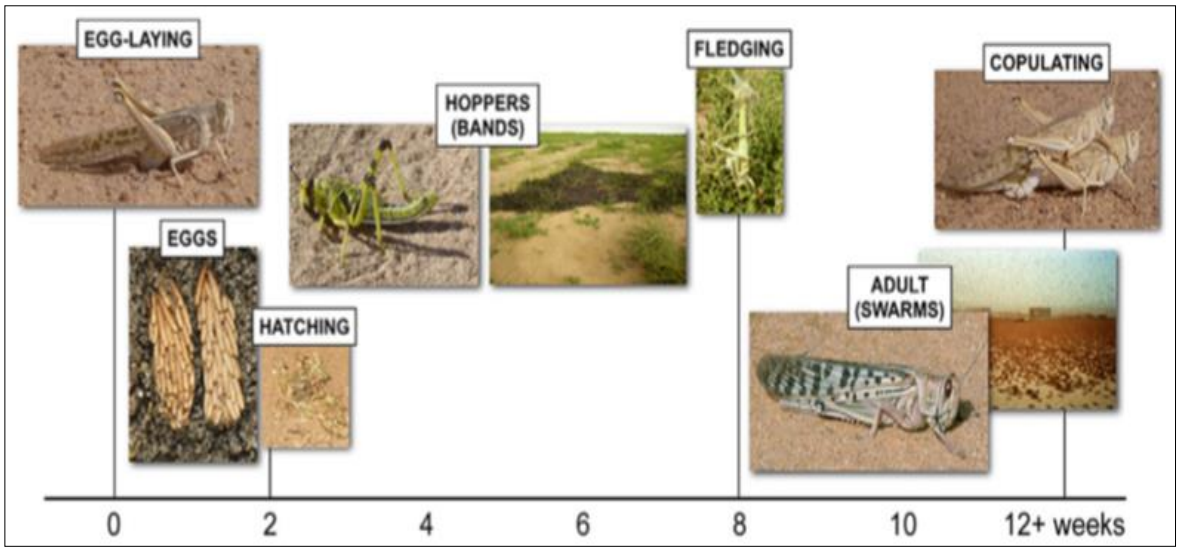
Abstract
Insects have reined the world earlier than mankind and are present everywhere right from below the earth to hill top. Insects are very much associated with man's life. While some are beneficial, others are highly harmful to mankind, one of which is Desert locust, the most harmful insect in the world. They are scourge of mankind since time immemorial. Desert locusts have highly migratory habit, marked polymorphism and voracious behavior of feeding. They are proficient of forming swarms (adult's congregation) and hopper bands (nymphal congregation), causing great devastation to natural and cultivated vegetation. They are the sleeping giants that can outburst any time to inflict heavy damage to the crops leading to national emergency of food and fodder. The invasion area of desert locust covers about 30 million square kilometers which includes whole or parts of nearly 64 countries. This includes countries like North West and East African countries, Arabian Peninsula, the Southern Republic of USSR, Iran, Afghanistan and the Indian sub-continent etc. When locust occurs in low densities, during recession periods, it inhabits a broad belt of arid and semi-arid land which stretches from the Atlantic Ocean to North West India. Thus, it covers over 16 million square kilometers in around 30 countries. The migratory behavior of the Desert Locust is an adaptation to survive in arid environments. In reality, it is neither hunger nor fleeing their cannibalistic peers that push these insects to migrate. This migratory behavior is the result of a long evolution which allowed this species to adapt perfectly to its desert environment. In these areas, favourable rains for breeding and food plant production occur episodically, and are randomly scattered over large areas. Under these unpredictable conditions, migrating thus, is necessary for Desert Locust survival.

Keywords: adaptation, desert locust, invasion, migratory behaviour, recession period, swarms

Introduction
In history, the locust has always been a major threat to well-being of human-kind. The Desert Locust is cited as curse to mankind in ancient writings *viz*. The Holy Koran and Bible. The extent of the damage and loss caused by the locusts is very massive beyond imagination as they have caused the starvation due to its being polyphagous feeder, and on an average small locust swarm eats as much food in one day as about 10 elephants or 2500 people. They devour the plant leaves, flowers, fruits, seeds, bark and growing points and also by breaking down trees because of their weight when they settle down in masses [1]. The desert locust (*Schistocerca gregaria* (Forskål 1775)) is considered to be the most hazardous pest due to its ability to reproduce rapidly, migrate long distances, and devastate crops. Responding to the environmental conditions, desert locust has the capability to transform its behavior and physiology, and transmute itself from a harmless solitarious individual to part of a collective mass of insects that form a cohesive swarm, which can cross continents and seas, and quickly devour a farmer's field and his entire livelihood in a single morning. Thus, the desert locust is often mentioned as the most important and dangerous of all migratory pests in the world.

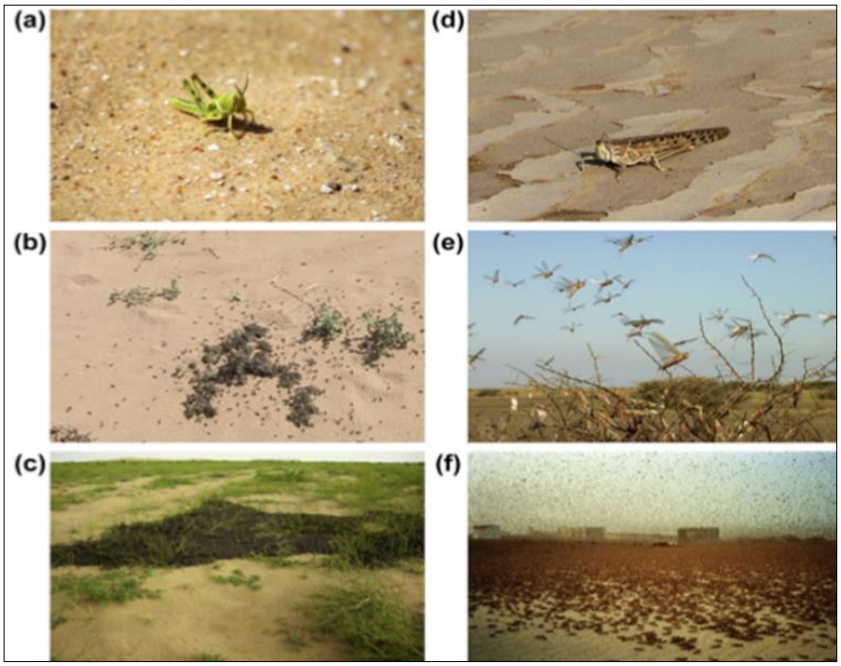
Desert locust: life phases and invasions

Solitarious locusts are generally found in low numbers dispersed throughout the deserts of North Africa, the Middle East, and Southwest Asia, under normal conditions, trying to survive in isolation by seeking shelter on sparse annual vegetation and laying eggs in moist sandy soil after intermittent rains. Such arid areas are some 16 million square kilometers in size, nearly twice as big as the United States of America, and includes about 30 countries. It is referred to as the recession area and the calm period without widespread and heavy infestations, is called a recession. When unusually heavy rains fall somewhere in the recession area, locusts take advantage of these rare events and multiple rapidly to increase in number. Under optimal conditions, locusts increase some 16-20 times every 3 months after a new generation of breeding (Pic 1). Once the desert habitat starts to dry out, large numbers of locusts are forced into the remaining patches of green vegetation, concentrate, come into physical contact with one another and start to behave as a single cohesive mass. They become increasingly more gregarious, initially forming small groups of hoppers (wingless nymphs) and adults that eventually fuse and form dense bands of hoppers and swarms of adults known as gregarization and the intermediate phase between solitarious and gregarious, i.e., when locusts are grouping is known to as transiens (Pic 2). Schematically, we speak of a solitarious form for populations of low density and a gregarious form for those of high density. Fixed gregarization areas do not exist within the vast recession area due to the sporadic nature of rainfall in the desert. Gregarization process happens only in those parts of the recession area, where two generations of breeding can occur in rapid succession [2].

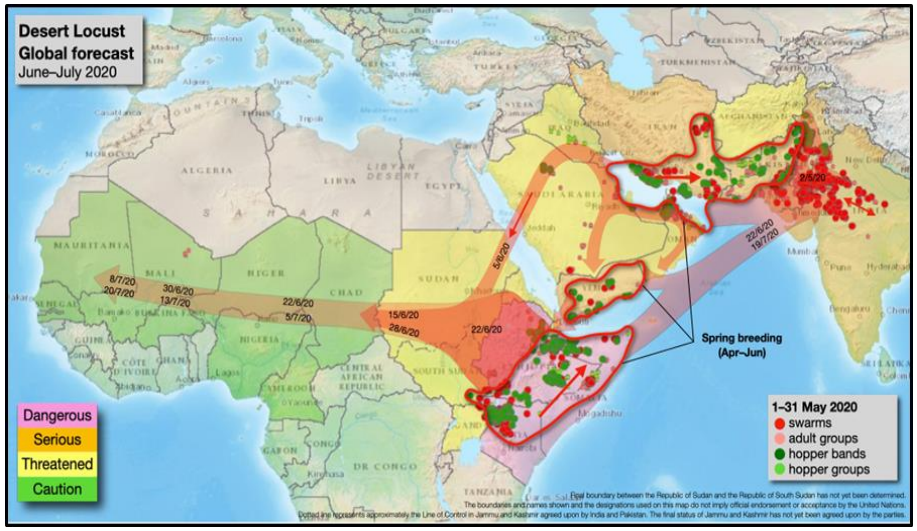


Pic 1: Life phases of Desert Locust (Source: Reference no.1)

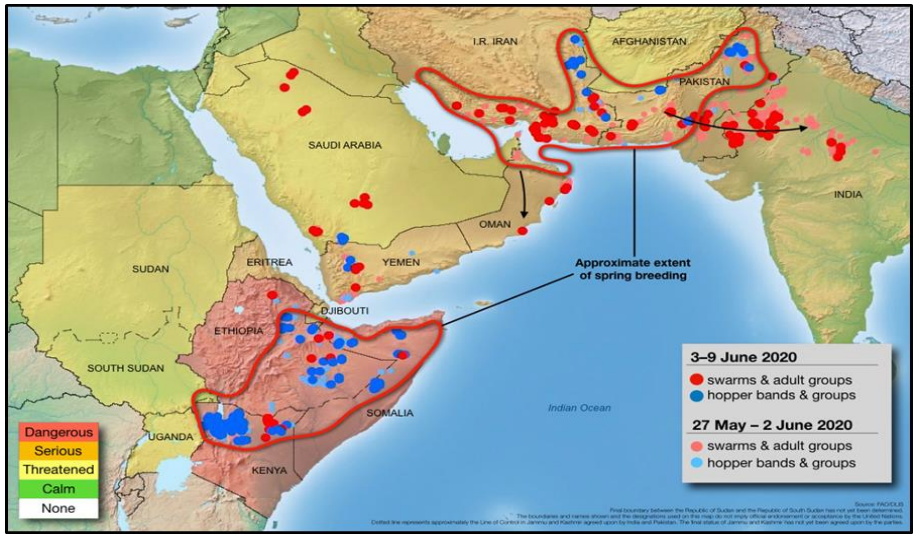
The noticeable upsurge in locust numbers on a local scale owing to multiplication and gregarization, which unless checked, can lead to the formation of hopper bands and swarms which is called as an outbreak. In case of, furthermore rainfall, a very large increase in locust numbers and concurrent outbreaks can occur, followed by the production of two or more successive generations of transient-to-gregarious breeding in complimentary seasonal breeding areas. This is referred to an upsurge. A plague is a period of one or more years of widespread and heavy infestations, the majority of which occur as bands or swarms. During upsurges and plagues, locust swarms tend to migrate beyond the recession area, and invade an area of some 32 million square kilometers in size, equivalent to about 20% of the Earth's land surface, which is known as the invasion area [3]. The Desert Locust constitutes a threat to agriculture from North Africa to the equator, and from the Atlantic to South-West Asia *via* the Near East. The Desert locust has a surprising ability to transform radically when favourable conditions allow their population to reach a density threshold. The solitarious and gregarious forms of the Desert Locust are so dissimilar that they were once considered to be different species. The color, the size, and of course the behavior, changes radically during the passage from one form to the other, which requires a few generations to complete. When density increases, individuals who may have initially been solitarious, seek to stay grouped. At the nymphal stage (without wings), the locusts congregate in bands of thousands of individuals per square meter. Adults, however, can form swarms covering several hundred hectares. Unlike the solitarious locusts who fly at night; the gregarious locusts fly during the day. This insect, both in its solitarious and gregarious phases, is able to remain in flight for a long time and to migrate–carried by the winds–over spectacular distances, known to travel up to 150-200 kms per day and sometimes much more. Due to the sequences of favourable soil and climatic conditions like rain, upsurges and invasions develop.



Pic 2: The gregarization process in desert locust occurs consisting of: (a) solitarious hopper, (b) a small group of transiens hoppers, (c) a fully gregarious hopper band, (d) solitarious adult, (e) a group of transiens adults, and (f) a fully gregarious adult swarm (Source: Reference no.1)



Pic 3:



Pic 4.

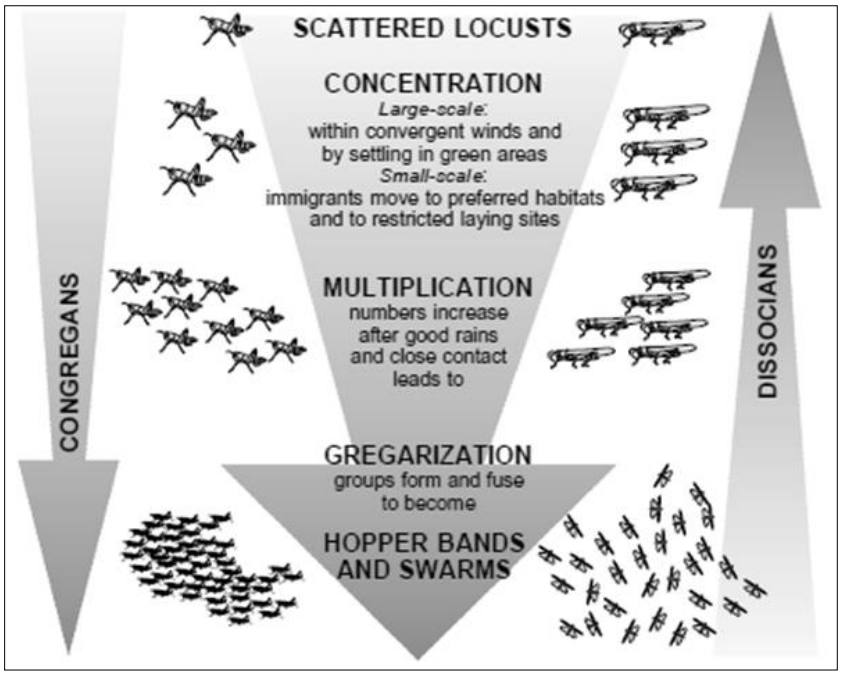
Pic 3 & 4: Distribution, spring breeding centres, invasion and global forecast of Desert locust (Source: www.fao.org)

Breeding season

There are three main locusts breeding seasons:

1. Winter breeding <November to December>
2. Spring breeding <January to June>
3. Summer breeding <July to October>

India has only one i.e. "Summer breeding" locust breeding season. However, the neighbouring country like Pakistan has both seasons of spring and summer breeding. In India, Locust Control and Research scheme is responsible for Desert Locust control and is being implemented through an organisation referred as "Locust Warning Organisation (LWO)", which was established in 1939 and later incorporated with the "Directorate of Plant Protection Quarantine and Storage" in 1946. The latter organisation is accountable for managing and controlling the locust situation in scheduled desert areas mainly in the States of Rajasthan and Gujarat, while partly in the States of Punjab and Haryana by way of inclusive survey, surveillance and control operations, where and when required [3].



Pic 5: Stages of Congregans and Dissocians (Source: http://ppqs.gov.in/)

How much damage can they cause?

The Desert Locust is the most challenging of all locust species due to the threat it poses to many countries. The extent of its devastation has been not only mentioned since ancient times, but also as in recent years. The Desert Locust is extremely polyphagous (able to consume a wide variety of foods); capable of damaging all types of vegetation and crops. Cereal crops including wheat, barley, millet, maize, sorghum, and rice are particularly vulnerable. But, vines, citrus fruits, palm trees, date palms or vegetable crops are not spared. Pastoral areas are also undergoing major destruction, affecting both the total production of biomass and its palatability for livestock. Crop losses can lead many households to sell animals at low prices to meet their needs, or even to require food aid. In addition, the negative income shock can have a long-term impact on the educational outcomes of children living in rural areas. Invasions can result in abandonment of crops and rural evacuation. In addition, large-scale chemical control programs (essential to control an invasion) can affect bio-diversity, including harming non-target grasshoppers and many other arthropods.

What are they looking for?

The migratory behavior of the Desert Locust is an adaptation to survive in arid environments. This insect, whether in the form of hopper bands, swarms of adults flying during the day, or solitarious individuals flying at night, has a high migratory capacity. In reality, it is neither hunger nor fleeing their cannibalistic peers that push these insects to migrate. This migratory behavior is the result of a long evolution which allowed this species to adapt perfectly to its desert environment. In these areas, favourable rains for breeding and food plant production occur episodically, and are randomly scattered over large areas. Under these unpredictable conditions, migrating is necessary for Desert Locust survival. These migrations are systematic and adults are pushed by the winds that concentrate in the zones of convergence where rain is generated, allowing locusts to find favourable conditions. This migration takes place both in the solitarious phase (at night) and in the gregarious phase (by day). The search can sometimes last for months, but this insect has a great resistance capacity and lays its eggs only when the conditions for reproduction are met. For hoppers, the migratory behavior allows them to exploit the local resources by moving regularly within the vegetation. In either case, migration takes place even if local resources are still available. Staying in the same place for too long would be risky for individuals. Abundant and persistent rains spread over a large area are very favourable to produce upsurges of this insect. To multiply, they need sandy or sandy-clay soils, areas of bare soil for egg laying, and suitable vegetation for the development of nymphs. Weather conditions and the structure of the habitat are, therefore, the two main factors involved in the multiplication of the Desert Locust. Following favourable rains, in desert environments where solitarious individuals live, locusts concentrate on suitable areas and breed. If the rains are sufficient, persist for a fairly long period, and are spread over a wider area than usual, the numbers of locusts

can increase significantly. Here we see the phenomenon of gregarization start, the first hopper bands from and then primitive swarms. This is the beginning of an outbreak that can turn into an upsurge, and then into an invasion, if favourable conditions persist and if no early control operation is taken [4].

Conclusion

Invasions of Desert locusts occurred regularly in the past following abundant rains. Such invasions did not appear overnight, but was the result of favourable conditions that arose many months ago. For instance, at the beginning of 2018, the locust situation was very calm and populations were low. Reports of this insect from the Atlantic to India were almost non-existent. During the second half of April and again in October 2018, unusually strong tropical cyclones formed in the southern Arabian Sea. They caused heavy rains in Yemen, Oman, Djibouti, in northern Somalia, eastern Ethiopia, and in southern Rub al Khali in Saudi Arabia. The favourable conditions for Desert Locust breeding have been maintained for at least nine consecutive months i.e. from June 2018 to March 2019, allowing the development of three generations. Thus the development of this invasion resulted from particularly favourable rainfall conditions for the Desert Locust. Such invasions have occurred regularly in the past following abundant rains in outbreak and key breeding areas. If climate change leads to increased precipitation in these outbreak areas, this would undoubtedly increase the probability of future invasions.

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