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A General Review of Desert Locust – *Schistocera gregaria*

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ABSTRACT

Locusts (*Orthoptera Acridoidea*) are the most dangerous agricultural pests. Their control is critical to food security worldwide and often requires governmental or international involvement. Although locust outbreak is now better controlled and often shorter in duration and reduced in extent, large outbreaks, often promoted by climate change continue to occur in many parts of the world. While some Locust control system are still curative, the recognition of the damage these pests can cause and the socio-economic consequences of Locust outbreaks have led to an increased paradigm shift from crop protection to preventive management.

Key words: *Schistocerca Gregaria, Locust swarms, Life cycle-locust, Attack - desert locust, Control techniques, Battues, Strategies.*

Introduction

Locusts are long range migratory insects. At high population density, immature animals from marching hopper bands while adults take off and form huge swarms of millions of animals. At low population densities animals are solitarious but likewise migrate, mostly during the night. Numerous studies aimed at predicting locust infestation showed that migrations both as hopper bands and as adults are largely downwind following seasonal shifts of tropical convergence zones taking the animals to areas of rainfall. Only a few studies provided evidence on the active orientation mechanisms, including the involvement of a sun compass. This scarcity of evidence stands in contrast to recent Neurobiological data showing some neuronal adaptations suited for sky compass navigation. Laboratory experiments moreover demonstrated polarotaxis in flying animals. It remains to be shown how locust use their internal sky compass during mass migrations and the role it plays in solitarious locust in their natural habitat.

Connections between locust and people date back millennia and locust remains a major good security challenge today throughout the world. Locust biology is often linked to abiotic conditions like temperature, precipitation, fueling the perception that aside from active control, humans are not key players with the interaction locusts have with their environment (Axelsen, 2009). The impressive capacity of locust swarms to rapidly move long distances and

descend on communities unexpectedly has shrouded their source in mystery. Perhaps for this reason, locusts have often been viewed as a divine punishment or curse both for the Bible and the Qur'an describe locusts as one of the devastating plaques of Egypt. Thus, in the this review we synthesize published research and review on the three most important and major types of locusts (i.e.) Desert locust. Migratory locust and, Red Locust and their Major impact to the environment (Anstey *et al.*, 2009).

Fig. 1. Desert Locust S*chistocerca gregaria*

Locusts have probably been an enemy of man ever since he began to grow crops. Carved images of locusts have been found on the sixth dynasty (2420-2270 BC) tombs at *Saqqara* in Egypt. Locusts are still a great enemy of farmers and in some countries, they are the determining factor between sufficient food for the people and starvation. (Cressman, 1998) Damage is sometimes diffuse and not very obvious but it can be very severe in many more restricted areas. This depends on whether the swarms are moving about quickly or whether they stay for several days in one area (Bennett, 1975). Locusts do damage by eating the leaves, flowers, fruit and seeds, bark and growing points, and also by breaking down trees because of their weight when they settle in masses, and sometimes even spoiling plants with their excrete. They do not as far as we know carry any disease but some laboratory workers have developed an allergy to them (Bullen, 1969).

History and Migration

During last decade, locusts have been in many parts of the world, been so much in the limelight that they hardly stand in need of introduction. During the years 1829 and 1930 especially, there were not many days on which mention was not made of them in the Indian Dailies, either in regard to their flights or the damage done by them to the crops. Nor are locusts to be counted as one of the recent upheavals of the modern age. Their history apparently dates back to hoary antiquity. They are mentioned in the Bible and formed one of the plaques of ancient Egypt. In early Sanskrit literature, references are made to them as one of the recognized calamities of the people (Axelsen, 2009).

Historically, it has been one of the most serious threats to food production of China with Numerous plaques during the last 1000 years originating from the food plains of Yangtze and yellow rivers in East china. Subsequent to the 1950's management of these wetland areas to reduce the breeding grounds as well as intensive use of insecticides to prevent swarms from forming, has largely proved successful at keeping locust population in check. However later, locust migratoria had become a recent threat and there had been outbreak further to the north china around the Bohai gulf region (Balçana, 1997).

An analysis of 2000 records of desert locust shows that, 8% of the damage is done by the hoppers, 69% by immature and maturing swarms ,23% by mature swarms. The figure of hoppers is low because the breeding areas are mostly outside the main crop areas. (Guichard,1955) Early plaque years are 1926-1934, 1940-1948, 1949-1963, 1967-1969 and 1986-1989. Between plaques, the desert locust occupies a smaller area known as the recession area where it lives in small scattered populations. However, with suitable weather conditions which include sufficient rainfall, these scattered populations are concentrated where they can breed successfully leading to a vast increase in number of insects. A locust swarm consists of streams of locust. There will be other streams in the same Swarm facing in many other directions (Karrar, 1974).

India's Locusts -Migration

Few people are unfamiliar with grasshoppers which may be found jumping about on the surface of lawns and fields. Locusts differ very little from them either in their general form, structure or habitat except for the fact that they often occur in large communities, which move about from place to place in gregarious swarms**.** (Anstey *et al.*, 2009).

There are several different species of locusts in the world, each of which has its own more or less restricted area of distribution. Not taking into ac-

count half a dozen species of Indian grasshoppers, which are known to increase in numbers periodically and cause immense damage to crops, there are only three species of true locusts in India of which one, *Locusta migratoria*, through occurring widespread over length and breadth of this country in its solitary phase, has for some unaccountable reason been very rarely recorded in its swarming condition. The other two names, *Patanga succincla* the Bombay locust and the *Schistocerca gregaria*, Forsk - the desert locust - have in the past appeared in enormous swarms over large areas of India and caused a great deal of destruction to agricultural crops.

Of the two, the Bombay locusts affects mostly the peninsular region of India. Presidency, whose flights may spread in years of heavy multiplication far and wide, as far as Guzerat to the north, as far as Central India and Hyderabad, and even Bihar and Orissa in some years to the east as far as Madras Deccan to the south ,and up to Ratnagiri and Goa to the west. On the other hand, the desert Locusta is par excellence, the Locust of North-west India. During years of outbreak, it infests chiefly Baluchistan, Sind, Punjab, the North-west frontier, Rajputana, United provinces and parts of central India, but in years of extraordinary activity its flights may reach as far as east Assam and as far as south Madras Deccan (Axelsen, 2009).

The desert locust is by far the more important of the two, for, the range of its spread is much wider, the periods of its outbreak are more frequent and prolonged, and the extent and degree of damage of crops is on the whole much greater. The scheme of Locust Research is carried on under the Imperial council of agricultural research is concerned at present only with desert locust. (Agroatlas, 2008).

Life cycle of Desert Locust

The life cycle comprises three stages: egg, hopper, adult. The time spent in each stage varies considerably depending on the weather (Steedman, 1990).

Mature adults

The mature adult is yellow, the males being a brighter yellow than the females. The ovaries of the female locusts contain eggs which can easily be seen if the abdomen is pulled away from the thorax. At this stage large swarms break up into smaller ones, as those locusts that mature first settle on the

Fig. 3. Mating- Desert Locust Schistocerca gregaria

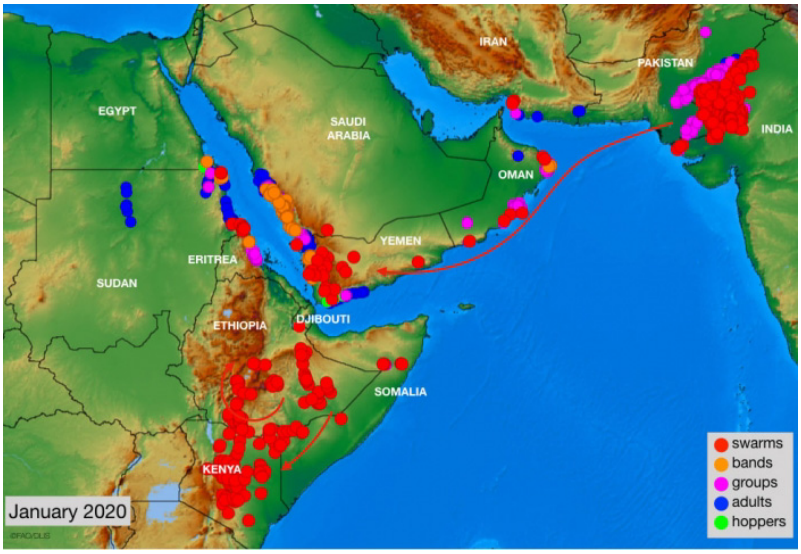

Fig. 2. Migration of Desert Locust from East Africa to India

ground for breeding, while those not yet quite mature fly on (Steedman, 1990).

Copulation

This is the mating act. The male jumps on the back of the female and holds on to her with the front pair of legs as shown in the Figure 3. The tips of their abdomens come into contact and the male sex cells (spermatozoa) are passed into the body of the female where they fertilize the eggs. The time spent in copulation varies from 3 to 14 h. Several females can be fertilized by one male and the spermatozoa can be stored inside the female's body and used to fertilize more than one set of eggs. Sometimes there are many more males than females in a mature swarm and then fighting occurs amongst the males for possession of females. (Steedman, 1990).

Eggs laying

Eggs are usually laid in areas of bare sandy soil and require previous rainfall. Generally, the female will not lay unless the soil is moist at about 5–10 cm below the surface as shown in the Figure 4. In soft sandy soils, females have been known to lay when moisture is found only at depths below 12cm. Before laying, the female will often probe the soil, inserting the tip of her abdomen to determine if there is enough moisture (Symmons and Cressman, 2001).

The female lays eggs in batches called pods. The eggs look like rice grains and are arranged like a miniature hand of bananas. The pods contain fewer than 80 eggs in the gregarious phase and typically between 90 and 160 in the solitarious phase. Swarms often lay egg pods in dense groups, with tens and even hundreds of pods per square metre. Laying occurs in only a small number of the apparently suitable sites. This behaviour, as well as an agent added to the egg pod foam when adult females are crowded, will help induce gregarization of the next generation. (Symmons and Cressman, 2001).

Fig. 4. Eggs laying of Desert Locust Schistocerca gregaria

The number of eggs pods a female lay depends on how long it takes for her to develop a pod and how long she lives. An average of two pods per female is the norm. Because of natural mortality, not all the eggs hatch and, of those that do, not all reach the adult stage. In optimal temperature and habitat conditions, a single female can produce up to 16–20 viable locusts in a single generation (Symmons and Cressman, 2001).

When the eggs are laid, they are yellow in colour but in the soil they turn brown. They absorb water from the soil, about their own weight of water in the first five days if it is available at the time, and this is enough to allow them to develop successfully. Research has shown that 20 mm of water is sufficient. If they do not get this quantity of water they will not hatch. If, however, there is not sufficient water in the soil during the first few days, they can absorb as much as the supply permits and then wait for several days before taking in the remainder, after more rain has fallen. It is not possible for Desert Locust eggs to stay dry in the ground from one rainy season to the next and then hatch when the rain comes. (Steedman, 1990).

Incubation period and Hatching

The period of egg development, between laying and hatching, is called the incubation period. The rate at which eggs develop varies according to the soil temperature. For example, in the summer breeding areas of West Africa, the Red Sea coast and lowland India the incubation period takes 10-14 days but this is extended to 25-30 days in the cooler spring breeding areas of central Arabia, southern Iran and Pakistan while in North Africa it can take as long as 70 days in exceptionally cold weather. More detailed information can be found in the section on seasonal movements and breeding areas (Steedman, 1990).

When they are fully developed in the eggs, the young hoppers burst their way out of the egg shells, wriggle up the froth tube to the surface, and immediately shed a thin white skin. These white skins are easily visible on the surface of the soil and are an indication that hatching has recently taken place. They are, however, soon blown away by the wind. Hatching takes place either shortly before or within 3 h of sunrise, and all the hoppers from one egg pod normally hatch on the same morning. It usually takes three days for the complete hatching of a

whole egg field but longer periods have been recorded. Only a few hoppers hatch on the first of these days, most on the second and a few more on the third (Steedman, 1990).

Hopper

Instars

The hopper stage of the life cycle is thus divided into five instars. (Hoppers are sometimes called nymphs and the hopper instars are then called nymphal instars. The word 'stage' is occasionally used instead of 'instar' in locust reports, e.g. 'fifth-stage hoppers'; it should, however, be restricted to the three main stages of the life cycle, egg, hopper and adult as shown in the Figure 5 (Steedman, 1990).

First Instar

The first instar is whitish in colour when newly hatched but in 1-2 h turns mainly black. As it grows bigger and becomes ready for moulting a pale colour pattern becomes more obvious**.**

Second instar

It is not always easy to distinguish the second instar from the first but with experience one recognises that the pale colour pattern is more obvious and that the head is much larger. It is easily distinguished from the third instar because there is no sign yet of wing growth.

Third Instar

The third instar is easily recognized by the two pairs of wing 'buds' which can be seen projecting from underneath the pronotum on each side of the thorax.

Fourth Instar

The colour now is conspicuously black and yellow, more black in cold conditions and less black in hot. The wing buds are larger and more obvious but they are still shorter than the length of the pronotum measured along the middle line.

Fifth Instar

The colour of the fifth instar is bright yellow with a black pattern, again varying with temperature. Wing buds are now longer than the pronotum, but still cannot be used for flight (Steedman, 1990).

Fledgling

The final moult is from the fifth-instar hopper to the adult stage. This change is called fledging and the young adult is called a fledgling as shown in the Figure 5. The thin bent wings hanging down; later they will be pumped full of blood and take up their final shape. The fledgling is pink and the wings, head

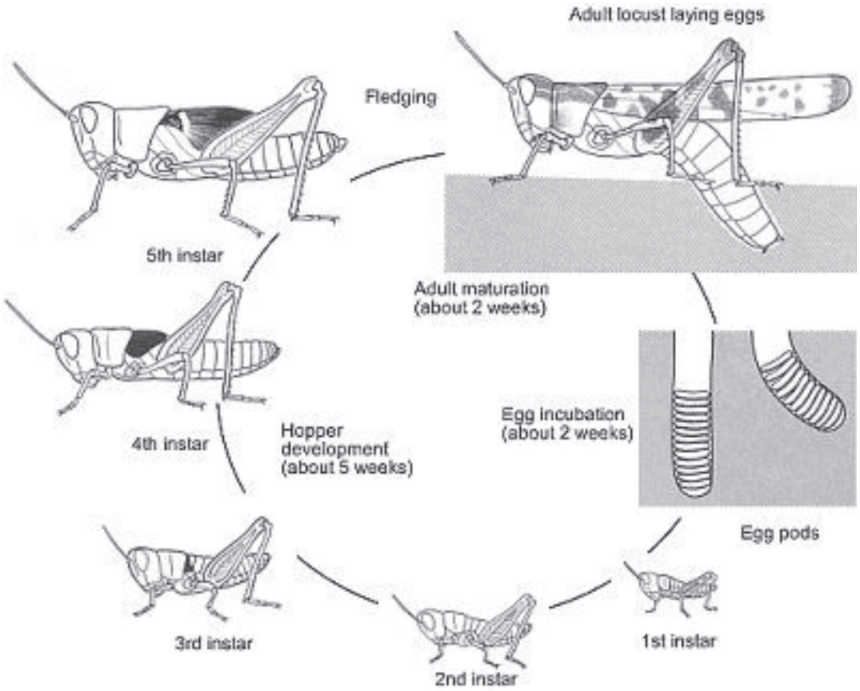

Fig. 5. Life cycle of Desert Locust Schistocerca gregaria

and body are relatively soft. Fledglings gradually become hard and able to fly strongly. Locusts in this condition are called immature adults (Steedman, 1990). Once adult able to fly, solitarious adults migrate at night when the temperature is above 20–22 °C and the wind is less than 7 m/s (13.6 knots). They usually take off about 20 minutes after sunset and can fly for up to 10 hours, usually flying for only a few hours at a time. Individuals have been detected by radar up to heights of 1 800 m (Symmons, and Cressman, 2001).

Colour

An adult in the solitary phase is likely to be pale grey or beige when immature, with the males becoming pale yellow on maturation. In contrast, an adult from the swarming (gregarious) phase will be bright pink when immature and bright yellow when mature (Steedman, 1990).

Locust Control Management

Traditional desert locust control methods: Farmers developed a variety of cultural and physical controls before the availability of chemical ones. Some traditional control methods are sometimes effective. Example: plowing fields infested with pods. Some farmers combine the use of pesticides with fire, burning roaring locusts at night and Battues to control desert locust attack. Chemical methods- The first chemical treatment, used in India from the 1800s through the 1940s, was sodium fluo-silicate and sodium arsenate poisoned bait. BHC (benzene hexachloride) is persistent organic chloride. BHC was first used for desert locust in India in 1949. Spraying of alderin insecticide against desert locust by air was conducted in 1951. In 1960s, Dieldrin and the other persistent pesticides seemed to be major technological advances. Since dieldrin acts as stomach poison that accumulates over time, the insects eventually ingested a lethal dose by eating treated vegetation. DDT was banned in 1972. BHC was banned in 1993. The type of insecticides used in desert locust programs has shifted markedly away from the persistent organochlorine such as dieldrin, BBC, alderin, and lindane to organophosphate.

Insecticides like organophosphate chemicals is sprayed in the air. Spraying should take place under specific meteorological conditions to ensure maximal effects on locust populations.

Best time: between 8 am and 11 am and after 4 pm. If the wind is strong, spraying May be possible before 8 am. If it's either cloudy & relatively cool (less than 30°C). Effective spray may be possible between 11 am and 4 pm. Wind should be there when spraying. It is needed to spread. It should be done at right angle to the right direction.

A technique using much smaller volumes of spray liquid, called ultra-low volume (ULV) spraying initially developed in 1980s for use against the desert locust and is now mostly efficient and commonly used method. It is defined as applying between 0.5-5 litres of spray liquid per hectare. In order to spray such small volumes over the locust, the liquid must be broken up into small droplets light enough to be carried easily by the wind. ULV formulation is based on oil. These small droplets do not deposit very easily (Pesticide referee group, FAO, 2001).

Impacts of chemicals on the environment and other critical ecosystems key to food security- such as bees and other insects which not only pollinate 70 percent of food but also may have an impact on human health. Wind fields and weather conditions are highly turbulent to disperse populations. Research is still under way to find a safer biopesticides like pathogenic fungi, plants extracts and insect growth regulators. While people and birds do eat locusts, that is not enough to control locust population.

Modern weapon: Satellite Surveillance is the major and modern weapon. Food and agriculture organization of united nations monitors and provides information on general locust situation and to give timingly warning and forecasts to those countries in danger of invasion. (Ceccato *et al.,* 2014).

Use of new technologies in desert locust early warning

In 2000, a prototype data logger was developed for field officer, consisting of a custom database that was linked to a navigation mapping programme. The software could connect to a handheld GPS and was powered by a vehicle's cigarette lighter socket. This system, called e locust. During the 2004-05 regional plague in West Africa additionally emerging funds were available for addressing the issue of data transmission. FAO, in collaboration with French space agency and its commercial branch Novacom, developed all in one handheld system that allow field staff to record 2nd transmission geo- referenced locust survey and control data in real time to national decision makers.

The system, called Elocust 2. E locust 2 equip-

ment transmits the field data to the national headquarter from the field. systems, and (e) resolution of NDVI imagery. Usage gradually becoming incorporated into the national survey and control programmes of all locust affected countries. Since its introduction in early 2006, more than 400 units have been distributed to field teams. In early 1990s as personal computers became more prevalent, geographic information systems were into to address an increasing interested in maps and mapping.

By 1996 SWARMS (Schistocerca warning and management system) were being used at FAO DLIS in Rome. In late 1990s, it became apparent that national locust countries in affected countries were having difficulty in managing the increases volume of field data in actively and accurate manner. A simpler and smaller GIS, RAMSES (Reconnaissance and management system of the environment of the environment of Schistocerca) was developed for countries, which was introduced in 2000 (Cherlet and Di Gregorio, 1993).

Organization Created to Control Desert Locust

Many countries established national locust control organization to combat this menace once its life cycle was deciphered and actively helped each other by providing research data, pesticides and man power under the aegis of FAO since 1951. CIRAD's PRIFAS organized in 1975 after requested by French ministry by French ministry of cooperation and African countries to control locus and its population from attacking crops.

Following the desert locust plague of 1926- 1931 the imperial council of agricultural research sponsored a scheme of research on the desert locust in 1931. After the termination of locust warning organization with nucleus staff under supervision of the imperial entomologist to government of India. (Van Huis *et al.*, 2001). The desert control management throughout the world was influenced by Uvaror' s preventive control strategy of treating bands and swarms as soon as they formed in outbreak areas. (Uvarov and CMG, 1966). India adopted this idea to avoid crop damage in agricultural areas. This strategy was first used for controlling the locusts in 1955-1956 and got good results. Encouraged with new technological advancement in the form of t lethal pesticides means of transport, better understanding of the life cycle of the desert locust and put an end to plague cycle of 1950 to 1962. Ever since then India is free from any desert locust infestation of the dimension of a plague population.

Routine monitoring surveys are a regular feature in India and the basic data needed for early warning that is collecting, transmitting and analyzing information on locusts' weather and habitat are now displaying in computer based geographical information system. India has got a national organization with survey and control responsibility with operation readiness and further manpower can be mobi-

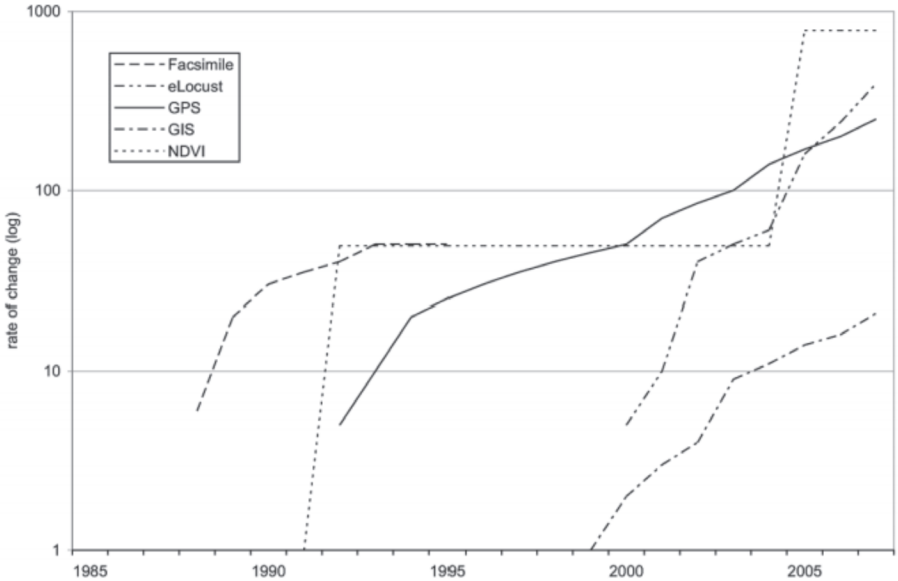

Fig. 6. The Development and growth of selected new technologies in locust affected countries 1985 to 2007:(a) facsimile machines, (b) eLocust2 devices, (c) handheld GPS units, (d) GIS

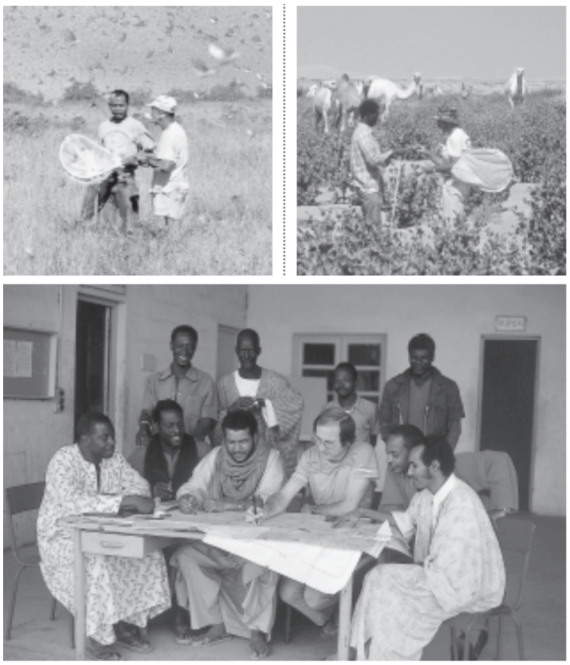

Fig. 7. Studying the locust situation with surveyors from a locust control organization.

lized at a short notice for making the prevention control against desert locust a success. (Latchininsky *et al.*, 2016) During the last 50 years after the end of the plaque cycle of 1959 -1962 to 2012 there were 18 upsurges which were controlled successfully whereas in 32 years the desert locust population did not increase to such level as to warrant any control. This may be due to change of rainfall pattern. It may also be noted that after the upsurge of 1978 the frequency of upsurge is declining and the period when the locust population did not increase to such level as to warrant any control increasing from 1 year to seven years and this is a good sign.

Conclusion

Locust are the species of short-horned grasshoppers, which feed on green vegetation, crops, etc. Even a very small, one-square-kilometer locust swarm can eat the same amount of food in one day as about 35000 peoples. So, in the early prevention strategy has achieved its original objective of preventing damage to major agricultural zones in invasion area. This strategy has also reduced the size of upsurge and time for control this helping to protect the crops of small farmers on one hand and the grazing grounds for the livestock on the other. Recently, locust outbreak in Rajasthan nearly 3.6 lakhs hectares crops land were affected.

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