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Locust Outbreak and Its Management in Thar Desert, Rajasthan

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Abstract

Under normal conditions, solitarious locusts are found in low numbers scattered throughout the deserts of North Africa, the Middle East, and Southwest Asia, trying to survive in isolation by seeking shelter on sparse annual vegetation and laying eggs in moist sandy soil after intermittent rains. Under optimal conditions, locusts increase some times every 3 months after a new generation of breeding. 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. This process is known as gregarization and the inter-mediate phase between solitarious and gregarious, that is, when locusts are grouping is referred to as transiens. 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 this is known as the invasion area. It is international pest affecting about 60 countries, mainly India, Pakistan, Afghanistan, Arabia, Persia, Iraq and Africa. The pest breeds during the spring season in the costal and other areas of West African countries like Parsia where the winter rains bring about the required degree of soil moisture and vegetation. The adults emerging from this breeding stage migrate eastward to Pakistan and India by about the beginning of the monsoon. In breeding regions there are regular showers of rainfall in both the rainfall belts, which brings about the required degree of soil moisture and vegetation. However, the strong winds do not scatter the swarms. Locusts are voracious feeders, each adult, consuming its own weight of vegetation daily. It is estimated that 1 sq. mile settled swarm contains about 300 tons of locusts. Recent locust attacks that hit Rajasthan, Madhya Pradesh, Uttar Pradesh and parts of Haryana and Gujarat may have occurred due to excess rain in March, April and the first half of May 2020. Locusts are also breeding 400 times more than usual, according to a report by the Food and Agricultural Organization (FAO). The current locust attack was categorized into three regions across the world by the FAO: The eastern region, including India, Pakistan, Iran and Afghanistan, the central region including countries in the Horn of Africa and the western region including West African countries. Highest records of locust movement in country wasin the year 2019- 20020. Around 38,308 hectares in 22 of 33 districts in Rajasthan are under locust attack, according to the state government. Locusts have reached as far as Madhya Pradesh and Uttar Pradesh from Pakistan in April. Biggest 300 Sq.miles swarm is on record. Similarly, hoppers eat 6-8 times more than their own weight. It has been assessed that in India during 1926-31 plague, the damage caused to crops, fodder etc., was about 10 crores of rupees and consequential loss due to premature death of cattle and other livestock was incalculable.

Key Words: Locust outbreak, Thar desert, economic lost, controlled practices

Introduction:

Historically, the desert locust has always been a major threat to man's well-being. The desert locust is mentioned as curse to mankind in ancient writings viz. locust problem in southwest Asia has a long history and probably began when crops were first cultivated. Several species of locust occur in the region but the desert locust (*Schistocercagregaria*) is by far the most important. Locusts are mentioned in Sanskrit literature in particular in the epic poem Mahabharata where Karna includes locusts in a "poetically beautiful" speech when he encounters his rival Arjuna on the battle field. The earliest known Sanskrit text dates to about 400BCE but the poem is thought to have existed as early as 750BCE. Equally ancient mention is made in the Iranian Zoroastrian vendi3dad where the locust is one of the evil creations of angramainya. the magnitude of the damage and loss caused by the locust is very gigantic 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,25 camel or 2500 people. locust do cause damage by devouring the leaves, flowers, fruits, seeds, bark and growing points and also by breaking down trees because of their weight when they settle down in masses. It has been estimated that in India damage to crops caused by locust was about rupees 10 crore during 1926-31 plague cycle. During 1940-46 and 1949-55 locust plague cycles, the damage was estimated at Rs.2.00 crore each and it was Rs. 50.00 lakhs during the last locust plague cycle (1959-62). Although no locust plague cycles have been observed after 1962, however, during 1978 and 1993, large scale upsurge were reported.Since the early 20th century, desert locust plagues occurred from 1926–1934, 1940–1948, 1949–1963, 1967–1969, 1987–1989, 2003-2005, and 2019-2020. In March–October 1915, a plague of locusts stripped Ottoman Palestine of almost all vegetation. Locust is the most dangerous pests. Locust is profoundly and qualitatively different from other pests. Their population can quickly grow to catastrophic level and some species from very dense bands and swarms that can cause a great deal of damage in a very short time (Zhang long, *et.al* 2019). Locust is a collection of certain species of short-horned grasshopper in the family *acridiates* that have a swarming phase. These insects are usually solitary, but under certain circumstances they become more abundant and change their behavior and habits, becoming gregarious. Their swarms and migrate hundreds of kilometers per day and invade areas covering millions of square kilometers, resulting in major economic, social, and environmental impacts on an international scale. Locust and grasshopper have been among the most devastating threats to agriculture this group of insect contains hundreds of pest species and affects the live hood of one is every ten people worldwide. Their swarms can migrate hundreds of kilometers per day and areas covering millions of square kilometers. There are more than 500 species of acridiates that can cause damage to crops and about 50 are considered major pests. Locusts and grasshoppers (Orthoptera: Acridoidea) are among the most dangerous agricultural pests. Their control is critical to food security worldwide and often requires governmental or international involvement. Although locust and grasshopper outbreaks are 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 and grasshopper control systems are still curative, the recognition of the damage these pests can cause and the socioeconomic consequences of locust and grasshopper outbreaks have led to an increasing paradigm shift from crop protection to preventive management. We are far now from a system of all-chemical control. Effective preventive management strategy nowadays relies on an improved knowledge of the pest biology and ecology and more efficient monitoring and control techniques (Michel lecoq*et. al*. 2019).

Table.1: Locust species in the world

S. No.	English Name	Scientific Name
1.	The Desert locust*	*Schistocerca gregaria*
2.	The Bombay locust*	*Nomadacrissuccincta*
3.	The Migratory locust*	*Locusts migratoriamanilensis ; locust migratoriamigratoria-oides*
4.	The Italian locust	*Calliptamusitalicus*
5.	The Moroccan locust	*Dociostaurusmorocannus*
6.	The Red locust	*Nomadacrisseptemfaciata*
7.	The brown locust	*Locustanapardalina*
8.	The South American locust	*Schistocerca paranensis*
9.	The Australian locust	*Chortoicetes termenifera*
10.	The tree locust*	*Anacridium spp.*

* Species found in India

Study Area:

The Thar desert also known as the great Indian desert, is a large arid region in the northwestern part of the Indian subcontinent that covers an area of 200,000 km^2 (77,000sq mi) and forms a natural boundary between India and Pakistan.The Thar Desert covers an area of about 0.32 million sq. km., which is nearly 12% of thetotal geographical area of India. It spreads over the four states of Rajasthan (62%), Gujarat (20%), Haryana and Punjab (9%), and in the west merges with the fertile plains of the Indus, in Pakistan. The Thar Desert of Rajasthan comprises 13 districts stretching from Ganganagar district in NorthtoSirohi in South and Jaisalmer in its West. The Thar Desert is essentially a sand Desert, most of whose area consists of dry undulating plains of hardened sand. The remaining region is largely a mass of loose sand, forming shifting sand dunes. The Desert environment is inhospitable for plants, wild animals and human populations. Yet, the Thar Desert is the most populated Desert in the world. Population density here is 84 persons per sq. km. In spite of such a precarious situation the people of Thar have learnt to live with droughts by involving such mechanism like collection, conservation and judicious use of rain water; crop lands converted for furthering ground cover to augment fodder production as '*Gauchars*' and lands with rich biodiversity dedicated to local deities and hero's as '*Orans*' and '*Agores*' to conserve germ-plasma for posterity. This is evidenced by species richness, genetic variation and biological diversity, which exist in Thar. There are over 900 species of plants found in Thar most of which are endemic to this Desert, while a few exotic species like *Prosopis julifloras* predominant in different habitats. The common plant species are Khejari (*Prosopis cineraria*), Ker (*Capparis decidua*), Kumbhat (*Acacia senegal*) and Thor (*Euphorbia granulate*), besides a variety of grasses. The*gaucher-oran-agor*trios are repositories of biological diversity. The Indira Gandhi Nahar originates from Harike Barrage from where the fish species from Punjab have intruded in to the Desert and thus majority of the fishes of the canal are of Sub-Himalayan

origin. Along the canal several water-logged areas were developed in and around the west lands and other CPR's. These are now called as escape reservoirs, which have created new geo-morphological conditions in the Thar Desert. These escape reservoirs are large enough to function as perennial water bodies, and supports substantial biomass of fish and great diversity of the other aquatic fauna. Itis to be remembered that Rajasthan has traditionally been the holders of good livestock population since the rural economy is largely depend on livestock after agriculture. For example, the total livestock population of Rajasthan as per 1997 livestock census, it comes to 5,46,27,756. This includes an estimated population of 1,21,41,402 cattle, 9770490 buffalo, 14584819 sheep,16971078 goats, 669443 camels, 185604 donkeys, 304820 pigs and 24016 horses, which is about seven present of India's total livestock population and the animal husbandry contributes 19% of the State GDP (as per Government of India, Planning Commission Report, 2006). This livestock and variety of wild fauna population is largely sustained on the Common Property Resources. Keeping this in view listing of all plants and animals encountered in the different Common Property Resources of the study sites were attempted, new information's gathered with the earlier records and presence confirmed.The Thar Desert extends between the Aravalli hills in the north-east, the great Rann of Kutch along the coast and the alluvial plains of the Indus River in the west and north-west. Most of the desert area is covered by big shifting sand dunes that receive sediments from the alluvial plains and the coast. The sand is highly mobile due to strong winds occurring before the onset of the monsoon. The Luni River is the only river integrated into the desert. Rainfall is limited to 100-500mm (4-20in) per year, mostly falling from July to September. Saltwater lakes within the Thar desert include the sambhar,kuchaman, didwana, panchpadra and phalodi in rajasthan and kharaghoda in Gujarat. These lakes receive and collect rain water during monsoon and evaporate during the dry season. The salt is derived by the weathering of rocks in the region. Lithic tools belonging to the prehistoric aterian culture of the Maghreb have been discovered in middle Paleolithic deposits in the thar desert. The natural vegetation of this dry area is classed as Northwestern thorn scrub forest occurring in small clumps scattered more or less openly Density and size of patches increase from west to east following the increase in rainfall. The natural vegetation of the Thar Desert is composed of the following tree, shrub and herb species: *Acacia nelotica, Balanitesroxburghii , Ziziphus zizyphus, Ziziphus nummularia, Calotropis procera, Suaedafruticosa, Crotalaria burhia, Aerva javanica, Clerodendrum multiflorum, Leptadeniapyrotechnica, Lyciumbarbarum, Grewia tenax, Commiphoramukul, Euphorbia neriifolia, Cordia sinensis, Maytenusemarginata, Capparis decidua, Mimosa hamata.* Common herbs ad grasses are *Ochthochloacompressa, Dactyloctenіumscindicum, Cenchrus biflorus, Cenchrus setigerus, Lasiurus scindicus, Cynodondactylon, Panicum turgidum, Panicum antidotale, Dichanthiumannulatum, Sporobolus marginatus, Saccharum spontaneum, Cenchrus ciliaris, Desmostachyabipinnata, Eragrostis species, Ergamopagan species, Phragmites species, Tribulus terrestris, Typha species, Sorghum halepense, Citrullus colocynthis.* The endemic floral species include*Calligonumpolygonoides, Prosopis cineraria, Acacia nilotica, Tamarixaphylla, Cenchrus biflorus.*Thar is one of the most heavily populated desert areas in the world with the main occupations of its inhabitants being agriculture and animal husbandry. Agriculture is not a dependable proposition in this area because after the rainy season, at least one third of crops fail. Animal husbandry, trees and grasses, intercropped with vegetables or fruit trees, is the most viable model for arid, drought-prone regions. The region faces frequent droughts. Overgrazing due to high animal populations, wind and water erosion, mining and other industries have resulted in serious land degradation. Agricultural production is mainly from kharif crops, which are grown in the summer season and seeded in June and July. These are then harvested in September and October and include bajra (*pennisetumglaucam*), pulses (*phaseolusvulgaris*) such as guar (*cyamopsistetragonoloba*). All crops of the thar desert, jowar (*Sorghumvulgare*), maize

(*zeamays*), sesame (*sesamumindicum*) and groundnuts (*arachishypogaea*). the development of irrigation features including canals and tube wells have changed the crop pattern with desert districts in Rajasthan now producing rabi crops including wheat(*triticum*), mustard(*brassica*) and cumin seed (*cuminumcyminum*) along with cash crops.Thar region of Rajasthan is a major opium production and consumption area. The Indira Gandhi Canal irrigates northwestern Rajasthan while the Government of India has started a centrally sponsored Desert Development Program based on watershed management with the objective of preventing the spread of desert and improving the living conditions of people in the desert.Forestry has an important part to play in the amelioration of the conditions in semi-arid and arid lands. If properly planned, forestry can make an important contribution to the general welfare of the people living in desert areas. The living standard of the people in the desert is low. They cannot afford other fuels like gas and kerosene. Firewood is their main fuel, of the total consumption of wood about 75 percent is firewood. The forest cover in the desert is low. Rajasthan has a forest area of 31150 km^2. which is about 9% of the geographical area. The forest area is mainly in southern districts of Rajasthan like Udaipur and Chittorgarh. The minimum forest area is in Churu district at only 80 km^2. Thus, the forest is insufficient to fulfill the needs of firewood and grazing in desert districts. This diverts the much-needed cattle dung from the field to the hearth. This in turn results into a decrease in agricultural production. Agroforestry model is best suited to the people of desert.*Techomellaundulate* is one more tree species, locally known as Rohida, which is found in the Thar Desert regions of northwest and western India. It is another important medium-sized tree of great use in agroforestry, that produces quality timber and is the main source of timber amongst the indigenous tree species of desert regions. The trade name of the tree species is Desert teak or Marwar teak. It is mainly used as a source of timber. Its wood is strong, tough and durable. It takes a fine finish. Heartwood contains quinoid. The wood is excellent for firewood and charcoal. Cattle and goats eat leaves of the tree. Camels, goats and sheep consume flowers and pods. plays an important role in the desert ecology. It acts as a soil-binding tree by spreading a network of lateral roots on the top surface of the soil. It also acts as a windbreak and helps in stabilizing shifting sand dunes. It is considered as the home of birds and provides shelter for other desert wildlife. Shade of tree crown is shelter for the cattle, goats and sheep during summer days.Tecomellaundulata has medicinal properties as well. The bark obtained from the stem is used as a remedy for syphilis. It is also used in curing urinary disorders, enlargement of spleen, gonorrhoea, leucoderma and liver diseases. Seeds are used against abscess.

Observation and Results:

Desert locust

Under normal conditions, solitarious locusts are found in low numbers scattered throughout the deserts of North Africa, the Middle East, and Southwest Asia, trying to survive in isolation by seeking shelter on sparse annual vegetation and laying eggs in moist sandy soil after intermittent rains. This arid and hyperarid area is 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 times every 3 months after a new generation of breeding. 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. This process is known as gregarization and the inter- mediate phase between solitarious and gregarious, that is, when locusts are grouping is referred to as transiens. Due to the sporadic nature of rainfall in the desert, fixed gregarization areas do not exist within the vast recession area. Gregarization takes place only in those parts of the recession area, where two generations of breeding can occur in rapid succession. The marked increase in locust numbers on a local scale due to concentration, multiplication, and gregarization, which unless checked, can lead to the formation of hopper bands and swarms (Roffey et al, 1970). This is called an outbreak. If further rains fall, a very large increase in locust numbers and contemporaneous 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 period of one or more years of widespread and heavy infestations, the majority of which occur as bands or swarms is called a plague. A major plague exists when two or more regions area affected simultaneously. 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. This is known as the invasion area. It is international pest affecting about 60 countries, mainly India, Pakistan, Afghanistan, Arebia, Persia, Iraq and Africa.The pest breeds during the soring season in the costal and other areas of West African countries like Parsia where the winter rains bring about the required degree of soil moisture and vegetation. The adults emerging from this breeding stage migrate eastward to Pakistan and India by about the beginning of the monsoon.In breeding regions there are regular showers of rainfall in both the rainfall belts, which brings about the required degree of soil moisture and vegetation. However, the strong winds do not scatter the swarms. Locusts are voracious feeders, each adult, consuming its own weight of vegetation daily. It is estimated that 1 sq. mile settled swarm contains about 300 tons of locusts.Biggest 300 Sq.miles swarm is on record. Similarly, hoppers eat 6-8 times more than their own weight. It has been assessed that in India during 1926-31 plague, the damage caused to crops, fodder etc., was about 10 crores of rupees and consequential loss due to premature death of cattle and other livestock was incalculable.

The relationship between locust and ecology

When conditions are favorable for reproduction, locust numbers increase and when they are not, numbers decrease either by natural mortality or through migration. For the Desert Locust, favorable conditions for breeding are:

(1) moist sandy or sand/clay soil to depths of 10-15 cm below the surface

(2) some bare areas for egg-laying, and

(3) green vegetation for hopper development. Often favorable conditions may exist in the desert but there are no locusts present. Therefore, the presence of moist soil and green vegetation does not automatically mean that there are locusts around.

Table.2: Natural Predators of locust in the study area

S. No.	Name of species	Scientific name	Remark
1.	Black –winged pratincole	*Glareolanordmanni*	Adult and larva
2.	Rosy starling	*Pastor rseus*	Adult and larva
3.	Domestic guineafowl	*Numida meleagris f. domestica*	Adult and larva
4.	Sandpiper	*Scolopacidae*	Adult and larva
5.	Quail	*Coturnix coturnix*	Adult and larva
6.	Black drongo	*Dicrurus macrocercus*	Adult and larva
7.	Bulbul	*pycnonotidae*	Adult and larva
8.	House Sparrow	*Passer domesticus*	Adult and larva
9.	Cattle egret	*Bubulcus ibis*	Adult and larva
10.	Drongo	*Dicuridae*	Adult and larva
11.	Kite	*Milvus migrans*	Adult and larva
12.	Indian roller	*Coracias benghalensis*	Adult and larva
13.	Indian golden oriole	*Orioluskundoo*	Adult and larva
14.	Flies	*Diptera*	On eggs
15.	Mites	*Tarsonemidae*	On eggs
16.	Nematodes	*Nematoda*	On eggs

Plate 1: Natural predation by birds on Locust

Economic Loss

Locusts are insects that travel in large swarms with a speed up to 150kms per day which depends on the wind speed as well. The locust swarm attack leads to starvation and famine by causing huge agricultural damage. They feed on crops and devastate them. They quickly eat up the seeds, fruits, leaves, barks, flowers, and growing points of the plant. As they land on the plants or crops in massive numbers, the plant gets destroyed by their sheer weight.As of the earlier attacks, locusts could damage a huge proportion of crops

according to the Union Agriculture Ministry data. During the plague cycle of 1926-1931, the damage caused was worth rupees 10 Crores, and estimated damage of rupees 2 Crores during 1940-1496 and 1949-1955 per cycle. During the last locust plague cycle of 1959-1962, there was a damage of worth rupees 50 lakhs. This year, the nation is serving a favorable condition for the locusts and has facilitated them to travel Rajasthan to several states like Gujarat, Madhya Pradesh, Uttar Pradesh, Maharashtra, Punjab and even in Delhi. These states reported crop damage where the farmers were trying to scare them by making loud noises. The farmers have also tried to smoke them out and spray chemicals to get rid of them.India possesses a specialized Locust Warning Organization and it's headquarter is located in Jodhpur. It is responsible for the timely regulating and planning for locust elimination and providing help to state governments in controlling invasion. The locust swarm also has economic and social impacts. The FAO reports the decadal economic impacts of locust plagues since the 1920s. Although no locust plague cycles have been observed after 1962, large scale upsurges were reported during 1978 and 1993 in India. Estimated damage was Rs. 2 lakh in 1978 and Rs. 7.18 lakh in 1993. In December 2019, the locusts destroyed over 25,000 hectares of crops in Gujarat.In 2020, the locusts have already been reported to have destroyed crops in 18 districts of Rajasthan and 12 districts of Madhya Pradesh while crops in Uttar Pradesh, Punjab, Haryana, and Maharashtra are under threat of an attack. Given that locusts swarm just prior to the monsoon, this adds economic strain to a tenuous system that relies on the annual monsoon for crop success. Locust plagues also pose a threat to livestock grazers by turning grasslands into barren wastelands.

Methods of locust control in practice

The chief aim of locust control is to destroy the locust in all its' stages.

Hopper Control

The mechanical methods included entrapping making hopper bands in 2' x 2' trenches and burrying. The chemical method includes use of poison baits and dusting of insecticides.

Poison baits

5% BHC or pairs green or sodium fluosilicate & 2 Dusting 5 to 10% BHC against hoppers 25 to 30kg/ha has seen found to bring a complete control of the pests. Aldrin 4% dust can also be effectively use.

Control of adults or winged locust swarms

During 5% or 10% BHC or 4% aldrin may be carried out to achieve better control when swarms are resting on the bare ground at night or in early morning can be beaten or swept up and destroyed. If they are resting on bushes or hedges, they can be easily burnt with help of flame throwers. When flying locusts are about to descend in large swarms in cultivated areas, the best way to tackle them is to prevent then alighting by all possible methods, such as waving a white cloth, or creating a cloud of smoke, by burning refuse, etc., spraying with neem kernel suspension as a deterrent to the crop, has also been tried with success. Recently with the introduction of aerial application of insecticide like aldrin, the control of locust swarms has become easier. The advantages associated with aerial spraying are:

1. Vast areas can be treated in relatively short time.
2. The swarm in fight can also be treated.

3. When swarms settle down in a particular area that area can be quickly covered by aerial application.
4. The movements of swarms can be watched with ease.

At present the primary method of controlling Desert Locust swarms and hopper bands is with mainly organophosphate chemicals applied in small concentrated doses (referred to as ultra-low volume (ULV) formulation) by vehicle-mounted and aerial sprayers and to a lesser extent by knapsack and hand-held sprayers. Spraying small targets with ULV spraying can be wasteful. The most appropriate type of sprayer should be used, i.e. handheld sprayers for very small targets. If the patches are still smaller than a swarm width, then a double pass can be made at a short distance upwind of them.

Different control measures of locust:
Mechanical methods – digging trenches, beating and burning
Baiting – scattering locust food impregnated with insecticide
Dusting – applying a fine dust impregnated with insecticideSpraying liquid insecticides.
Most locust and grasshopper management programs still rely on chemical pesticides.
While water-
based sprays are sometimes used because such equipment is what is available locally,
vehicle-
Mounted or aerial ultra-low volume (ULV) spraying is now becoming the primary method of application of both chemical and microbial pesticides. ULV spraying has the advantage of allowing more exact control of the droplet spectrum so that there is less waste from very large or very small droplets, and the common application rate of one liter per hectare ensures sufficient droplets are applied for adequate coverage. Suggested products, pros and cons, and doses are available in the report of the FAO Pesticide Referee Group (39).
In addition to overall blanket sprays, some insecticides are considered efficacious as barrier treatments for control of hopper bands of locusts.
Barrier treatments were commonly used against the desert locust, and currently, bands of the Australian plague locust are treated with chemical pesticide applied in barriers 300 to 500 m apart by aircraft flying into the wind: Marching locust bands pass through the treated barriers, picking up a lethal dose (3). In the United States, insect growth regulators are applied to grasshopper infestations by a reduced agent and area treatment (RAAT) in which either all-terrain vehicles or aircraft treat 5- to 30-m-wide swaths alternating with similar untreated swaths (87, 89). In 2010, this technique was used to treat >2 million ha of western US rangelands (101). Both barrier treatments and RAATs aim to provide untreated areas (refugia), contributing to increased survival of nontarget organisms, including parasites and predators. Chemical pesticides have many side effects, and these have been increasingly elucidated, in- cluding their impact on human health, the environment, nontarget organisms, and biodiversity (32, 38, 51, 88, 110, 113, 119, 121, 130, 142). Furthermore, greater margins of safety for environ- mentally sensitive areas are being provided by applying differential GPS guidance and recording by aircraft of exact areas treated.

Table.3: Scheduled desert area of India:

In India the scheduled desert area (SDA) is spread over an area of 2.05 sq km in the state of Rajasthan, Gujarat and Haryana as per the details given below:

State	District	Tehsil, taluka area	Number of villages Effected	Area of Sq. km
Rajasthan	Alwar	Bansure,behror	318	1380.30
	Barmer	Barmer, chohtan, pachpadra, sheo, ramsar, siwana	1636	27,755.64
	Bikaner	Bikaner, lunkaransar ,nokha, srikolayat	673	22,611.13
	Churu	Churu, rajgarh, ratangarh, sardarshahar, sridunargarh, taranagar ,sujangarh	940	16,806.12
	Jaisalmer	Jaisalmer,pokaran	562	43,583.94
	Jalore	Ahore ,bhinmal , jalore, sanchore	612	12,208.56
	Jhunjhunu	Chirawa, jhunjhunu, khetri, Udaipur, shekhawati	692	5,879.82
	Jodhpur	Jodhpur, osian, phalodi,shergarh	624	17,660.10
	Nagaur	Nagour,jayal,didwana, Ladnun,nawa	878	11,132.70
	Sikar	Sikar, lachhmangarh, neem ka thana, fategarh, swaimadhopur	1506	7,765.80
	sriganganagar	Sriganganagar, anupgarh, bhadra, nohar, suratgarh	2308	12,466.56
Total Rajasthan				**1,79,250.67**
Gujarat	amreli	Dwarka taluka	42	711.17
	banaskantha	Deesa,deodar.dhanera, Palanpur (west of main ahmedabad-rly line), radhanpur,tharad (vav,santalpur,sihori,talukas)	1086	9,843.09
	Bhuj	Abdasa,khadif,khauvda ,lakhpat,nakhtrana,wersten-half ,rapar	655	7,013.47
	Halar (Jamnagar)	Drol& parts of jdia, kalyanpur ,khambalia, Jamnagar, lalpura, talukas lying along the gulf of ran of kutch.	221	2,374.50
Total of Gujarat				**23,077.58**
Haryana	Mohindergarh	Mohindergarh, narnaul	378	3,457.20
Total of Haryana				**3,457.20**
Grand total				**2,05,785.45**

Desert Locust Situation for the last five years:

No major activities of Desert locust were reported during 2008, 2009 and 2011; however, adults of solitary phase have been reported at isolated places in District Jaisalmer, Bikaner and Jodhpur in Rajasthan.Similarly, no major activities of Desert Locust were reported during monsoon season in 2010. However, an upsurge of desert locust population was reported from 4th October to 8th November 2010 which was confined to some areas of District Jaisalmer (Rajasthan). Total infested area of about 4700 hectares was treated with 4700 liters of 96% Malathion ULV. This prompt control operation was quite successful and locust swarms were prevented from entering into cultivated areas and as such no crop damage occurred. During current year 2012-13, so far, no major developments of Desert locust were observed, however solitary phase Desert locusts have been reported during survey only at a few places.

Threat to Locust existence:

Another aspect which has been reported by Sharma .M, 2021 that organochlorine pesticides (OCPs) were found in the drinking water samples and milk samples from Bikaner city of Rajasthan, India, and it was found that mostly all samples have OCPs residues and many of them are statistically significant P< .05 and P< .01. This shows that how these xenobiotics have contaminated our Mother Nature and now faunal diversity is facing danger of existence and locust is not staying away from this potential danger. More scary studies have indicated that we have largely over looked the darker side of these chemicals as OCPs are reported to be carcinogenic (Mathur et al, 2002 &Ingber et al 2013) mutagenic (Ingber et al 2013&Yaduvanshi et al 2012) teratogenic (Yaduvanshi et al 2012 & ATSDR. Atlanta, GA.1994) immunosuppressive (Repetto. R & Baliga. S.S, 1997 &Corsinia et al, 2003) create endocrine dysfunction such as hypothyroidism or high estrogenic activity (Dewailly et al 2000&Rathore et al, 2002) disturb reproductive processes (Pantet al ,2007 &Tiemann.U. 2008) growth depressants (Colborn et al, 1993&Mercier. M, 1981) induces several psychogenic and neurogenic abnormalities in adult stages (Mactutus& Tilson, 1986 & Van Wendel de Jood et al,2001) and are associated with abortions, premature deliveries, still births and infants with low birth weights (Saxena et al, 1981; Saxena et al, 1980; Tyagi et al 2015; Chen.Q et al 2014& Sharma & Bhatnagar, 1996). OCPs have been in use in India nearly for a half century now. Even after having clear cut evidence suggesting that these chemicals have the ability to eliminate entire species from the planet, the annual consumption of pesticides in India is about 85,000 tons of which OCPs comprise the bulk (India Environment Portal Knowledge for change, 30/10/1998.). Therefore, today OCPs are perhaps the most ubiquitous of the potentially harmful chemicals encountered in the environment and are still widely detected in humans despite the considerable decline in environmental concentrations (Dewan et al. 2003). This kind of environmental Contamination with organochlorine pesticides (OCPs) has also been reported by Sharma and her coworkers in 1996 from Jaipur City. She reported contamination of human samples like mothers' blood, cord blood, placenta and mothers' milk with OCPs. Presence of pesticides with OCPs shows that how these xenobiotics have contaminated our Mother Nature and now faunal diversity is facing danger of existence and locustis not staying away from this potential danger. It can be concluded that the magnitude of pollution is quantitatively enough to contaminate the food and environment and reaching out to all faunal diversity. It can be concluded that the magnitude of pollution is quantitatively enough to contaminate the food and environment and the pesticides reach the human body through various sources mainly by absorption form the gastrointestinal tract through contaminated food chain, are circulated in blood, stored milk and secreted during lactation resulting in sufficient neonatal intake. The battle against the harmful insects would be much less costly and more efficient, and the problem of contamination of the environment by toxic materials would be vastly reduced, if insect activities are controlled by natural means. The use of pest-specific predators; parasites or pathogens; sterilization of insects with the help of radiations;

trapping insects using insect attractants like pheromones; use of juvenile hormones or hormone inhibitors may therefore be suggested as alternate ways of pest control (Sharma, 1996; 2021a; 2021b;2021c;2021d), Sharma, M. & Bhatnagar, P, 1996 &2017; Sharma. M and Singh. (2021).

Plate 2: Method of locust control, the local counties

Locust survey and control are primarily responsibility of the "Ministry of Agriculture, Co-operation & Farmers Welfare" in locust affected States and are operations undertaken by Locust Warning organisation (LWO). There are also several Locust Circle Offices (LCO'S) that assist with survey and control operations. During times of outbreaks and plagues, external assistance from the donor community and other international organizations is usually required.

Locust movement in India

Recent locust attacks that hit Rajasthan, Madhya Pradesh, Uttar Pradesh and parts of Haryana and Gujarat may have occurred due to excess rain in March, April and the first half of May 2020. Locusts are also breeding 400 times more than usual, according to a report by the Food and Agricultural Organization (FAO). The current locust attack was categorized into three regions across the world by the FAO: The eastern region, including India, Pakistan, Iran and Afghanistan, the central region including countries in the Horn of Africa and the western region including west African countries. Records of locust movement in country in the year 2019- 20020.

Table.4: Locust movement in India in the year 2019-2020

S. No.	Date of arrival	Name of place, district, state
1	15 June 2019	Iran
2	10 September 2019	Sikar
3	6 November 2019	Bajju
4	13 November 2019	Barmer
5	25 December 2019	Jaisalmer(ramgarh)
6	18 May 2020	Lunkarnsar
7	19 May 2020	Chtargarh
8	25 May 2020	Jaipur
9	27 May 2020	Dholpur
10	28 May 2020	Shriganganagar
11	2 June 2020	Bikaner
12	10June 2020	Kota
13	15 June 2020	Gujarat
14	15 June 2020	Udaipur
15	27 June 2020	Guru gram

Around 38,308 hectares in 22 of 33 districts in Rajasthan are under locust attack, according to the state government. Locusts have reached as far as Madhya Pradesh and Uttar Pradesh from Pakistan in April.

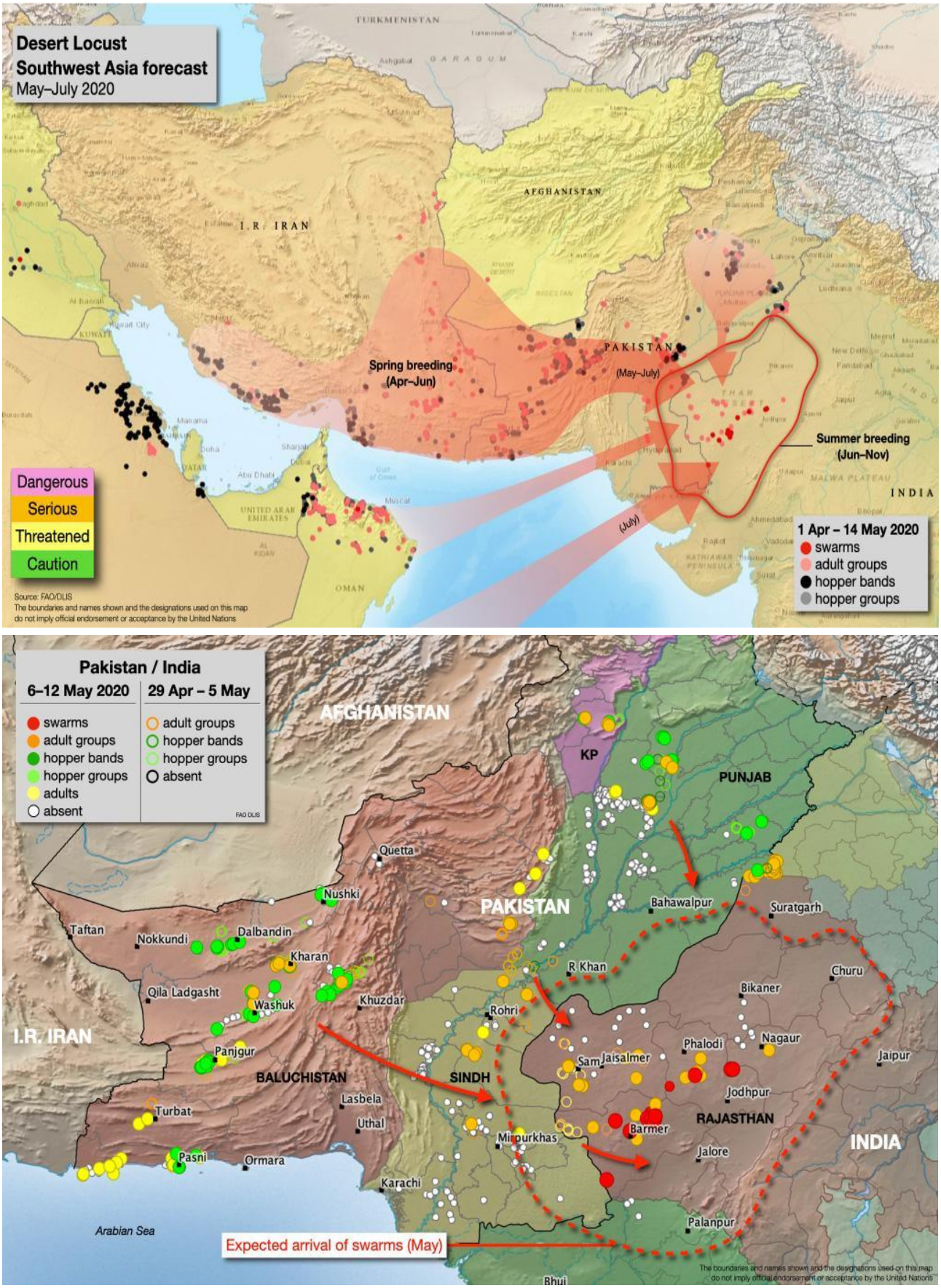

Plate 3: Graphical representation of locust movement and distribution in different parts

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