Review Article

# DESERT LOCUST [*SCHISTOCERCA GREGARIA* (FORSKAL)] (ORTHOPTERA: ACRIDIDAE) INVASION AND STRATEGIES FOR ITS MANAGEMENT IN NEPAL

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## ABSTRACT

Desert locust is recognized globally as the most devastating of migratory insect pests. It has been recorded throughout the pre-historic as well as modern historical periods. Infestation by a swarm of desert locusts has the ability to create havoc and cause a chain reaction with far reaching effects of famine and starvation. As per the available records, the first invasion of desert locust dates back to 1906. The first authentically identified specimens of desert locust were collected in 1962 in Nepal and preserved at National Entomology Research Center, Nepal Agriculture Research Council (NARC). The Ministry of Agriculture and Livestock Development (MoALD) formed a Desert Locust Technical Taskforce Committee on May 26, 2020 to study the possibility of desert locust migration in Nepal from India and also to suggest available mitigation options. Nepal's National Plant Protection Organization (NPPO) confirmed the first desert locust swarms entering from June 27, 2020 from Bara, Parsa, Sarlahi and Rupandehi which are bordering districts with India. Then number of other swarms entered from these districts including Kapilvastu and Dang and move towards hilly areas of Nepal and reached its distribution to 55 districts by the second week of July 2020. A Locust Information Center was established at NPPO, which provided relevant information on locusts to concerned stakeholders. This paper is focused on the recent desert locust invasion into Nepal with some strategies to mitigate the problem. Management of desert locust through coordinated efforts of all stakeholders at local, provincial, and federal/central levels remains the major challenge to curb the damage by this pest.

***Key words:*** *Desert locust, swarms, task force, stakeholders, strategies, management.*

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## INTRODUCTION

Biological invasions have become more rampant in the twenty-first century. COVID-19 is the latest pandemic that is wreaking havoc all over the world. There are many remarkable incidences of biological invasion on all continents, affecting human health, food production, ecology, and economies (Simberloff, 2013). Nepal is not an exception. In the last few decades, Nepal has recorded invasions of serious agricultural pests and human pathogens (NHRC, 2018), as well as invasive alien plant and animal species (Budha, 2014), disturbing natural ecosystems. Incursions of *Tuta absoluta* in 2016 (Bajracharya *et al.*, 2016) and fall armyworm in 2019 (Bajracharya *et al.*, 2019) have been particularly detrimental to tomato and maize crops, respectively. Recent invasion of the desert locust also poses a great concern among agriculture and agriculture-dependent sectors (NPPO, 2020). The desert locust [*Schistocerca gregaria* (Forskål)] is popularly known as "Salaha" in Nepal (NPPO, 2020), and is one of the oldest and most devastating migratory insect pests to pose a major threat to global agriculture. This insect pest is a species of short-horned grasshopper (Orthoptera: Acridoidae) and some species in this family are known to change their behavior and form swarms of adults or bands of hoppers (Buhl *et al.*, 2010; Cressman, 2016). These changes in behavior and physiology transform these solitary individuals into a cohesive swarm of insects that can cross continents and seas, quickly devour crops and other vegetation, and damage the livelihoods of people. This paper presents historical perspectives, ecology and behavior, extent of damage, and current status of the recent desert locust invasion into Nepal with some strategies to mitigate the problem.

## MATERIALS AND METHODS

The paper is based primarily on the review of the available information and literatures. It is mostly linked with the initiatives taken by the Governmental and non-governmental organizations on management of desert locust after its invasion in Nepal.

## RESULTS AND DISCUSSION

### Historical perspectives and current global status

According to Cressman (2012), the history of desert locust plague dates back to the prehistoric period of the Pharaonic era and is mentioned in both the Bible and the Koran. There are also references to locusts in early Sanskrit literature as great calamities. The desert locust has been documented frequently throughout history (Stower *et al*., 1960; Carlisle *et al*., 1965; Zhang *et al*., 2019). For example, during the first sixty years of the 20th century, there were five major plagues of desert locust that lasted up to 14 years (Magor *et al*., 2008). Since 1963, however, a dramatic decline has been seen in the frequency and duration of plagues, and now locust plagues occur perhaps only once every 10 to 15 years and rarely last more than three years (FAO, 2015). Swarms of desert locust create havoc by ravaging wide areas and a range of vegetation. On their path, forests, pastures, and wild and

cultivated plants are affected, resulting in heavy crop loss. Sharma (2014) mentioned that the infestation of desert locust is setting in motion a chain reaction with far reaching effects such as famine, disruption of trade, abandonment of cultivation, diversion of labor, heavy expenditure on control measures, and so on.

There were several locust plagues from the beginning of the twentieth century (1926-1934, 1940-1948, 1949-1963, 1967-1969, 1986-1989, 2003-2005 and 2018-2020 (FAO, 2013, 2020a). In India, serious locust outbreaks occurred in 1812, 1821, 1843-1844, 1863, 1869, 1878, 1889-1892, and 1896-1897 (Sharma, 2014). According to records at FAO, it invaded Nepal in 1906, 1930, 1953, 1962, and 2020 (Personnel communication: Dr. Keith Cressman; Aryal *et al*., 2020; https://www.bbc.com/nepali/news-52935683). As per the available records, the first invasion of desert locust dates back to 1906 but the first authentically identified specimens of desert locust were collected in 1962 in Nepal and preserved at National Entomology Research Center, Nepal Agriculture Research Council (Joshi and Manandhar, 2001).

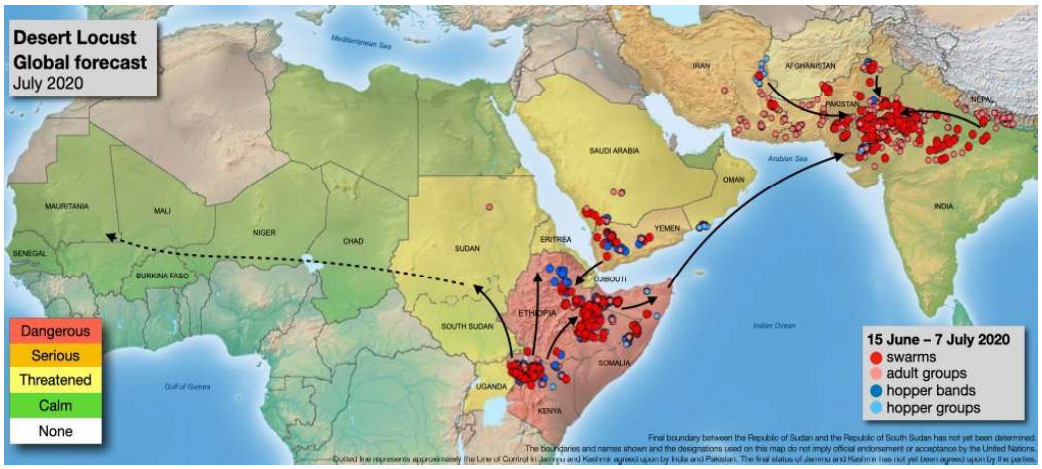



**Fig. 1:** Desert locust global forecast (Source: FAO, 2020)

The 2020 locust upsurge is the continuation of the locust spring-bred generation of 2018, which occurred at Empty Quarter of Southern Arabian Peninsula. Populations of three generations were undetected and not controlled (FAO, 2020b). The FAO (2020), on the global update of desert locust, mentioned that this upsurge still poses threat to food security and livelihoods in the Horn of Africa and the threat is increasing in southwest Asia, even up to Nepal (Fig. 1). In southwest Asia, many of the spring-bred swarms have migrated to the Indo-Pakistan border before the monsoon rains, some swarms continued east to northern states of India, and a few groups have reached Nepal.

The FAO (2020) has further stated that several successive waves of locust invasions can be expected until July 2020 in Rajasthan with eastward surges across northern India as far as

Bihar. After July, there would be westward movements of the swarms, as they will return to Rajasthan on the back of the changing winds associated with the southwest monsoon.

**Ecology, behavior, and damage of desert locust**

Understanding the ecology of desert locusts can be a key to designing control strategies. The life cycle of the desert locust consists of three stages: egg, hopper, and adult, with an average lifespan of 2-6 months (Joshi *et al.,* 2020). Females lay eggs in moist sandy soil in pods at a depth of about 10 to 15 cm by inserting their abdomen inside soil. Egg pods are laid at intervals of 7-10 days and the rate of egg development is dependent upon soil temperature and moisture (Sharma, 2014). There are five instars in gregarious population and 5-6 instars in solitary individuals. The gregarious hoppers have characteristic coloration of black and yellow. The young adult is called a fledgling. Fledglings gradually become hard and gain the ability to fly (Sharma, 2014). Locusts in this condition are called immature adults. Usually the immature adults migrate downwind until they encounter favorable breeding conditions, which may be thousands of kilometers away. Young immature gregarious adults are pink, but older adults may become dark red, brown, or bright yellow. Males mature before females and oviposition usually commences within two days of copulation (Sharma, 2014).

Desert locusts are migratory insects exhibiting two different behavioral phases. When there is the rare event of heavy rainfall in the recession area, desert locusts multiply rapidly to increase in number. Under such optimal conditions, desert locusts increase 16-20 times every 3 months. However, once the desert habitat starts to dry out, large numbers of desert locusts are forced into the remaining patches of green vegetation (Despland *et al*., 2000). When solitary locusts come into physical contact with one another, it triggers serotonin, which is responsible for behavioral transformation (Simpson *et al*., 2001; Anstey *et al*., 2009), and spurs locusts 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 intermediate phase between solitary and gregarious when locusts are grouping is referred to as transients (Cressman, 2016).

In their solitary phase, locusts are unassuming insects. Their brown-green bodies are camouflaged to blend into the background and they walk slowly with a low, creeping gait. They generally avoid other locusts unless they are mating or if they are forced together by food shortage. When this happens, the crowding of solitary locusts together induces a change. The insects transform into what is known as their gregarious phase. Gregarious locusts are colorful, move faster, and are attracted to other locusts. It is in this phase that locusts form the oppressive swarms that can blacken the skies and decimate crops. The solitary and gregarious phases differ in their looks, behavior, and life history.

A desert locust adult can consume roughly its own weight in fresh food per day, which is about two grams every day. A one square kilometer size swarm contains about 40 million

locusts, which eat the same amount of food in one day as about 35,000 people. This is based on a person eating an average 2.3 kg of food per day, according to the USDA. According to Smith (2020), FAO estimated that 70,000 hectares of crops in Kenya and around 30,000 hectares in Ethiopia have been infested by locusts, especially attacking coffee and tea crops, which account for approximately 30 percent of Ethiopia's exports (Guo *et al*., 2013).

In 2019, the Indian state of Gujarat experienced damage by locusts on cucumber, mustard, castor, chickpea, wheat, and other crops in 17,000 hectares of land (Joshi *et al*., 2020). One study in April 2020 revealed that 1780 sq. km crop land was damaged, which affected 61,500 families and incurred $50.5 million in control measures. Joffe (1995) stated that the crops and grazing area intermittently subject to swarm invasion of desert locusts as 20 percent (28 million sq. km including over 65 countries in Africa, the Middle East and southwestern Asia where the initial outbreak areas are in remote semi-arid areas in the Sahara, on the Arabian Peninsula, and along the borders of India and Pakistan. According to Zhang *et al*. (2019) the largest recent outbreaks have included two desert locust (*Schistocerca gregaria*) invasions covering a large part of Africa and southwest Asia from 1986 to 1989, where the area treated/protected was 16.8 million hectares (ha) and cost of control involved was US $274 million, and from 2003 to 2005, where the area treated/protected was 13 million hectares (ha) and cost of control was US $500 million.

**Management of invasion of desert locust in Nepal**

Realizing the threat of desert locust invasion in Nepal, MoALD, a Technical Taskforce was formed on May 26, 2020, a month ahead of incursions in Nepal, to prevent possible impact of swarms on the agricultural sector. The Locust technical taskforce team included members from the Plant Quarantine and Pesticide Management Center (PQPMC), National Entomology Research Center (NERC, NARC), Central Agricultural Laboratory under MoALD, and an eminent retired scientist. The main role of this taskforce was to prepare for the possibility of desert locust invasion in Nepal and to suggest available mitigation options, especially since it has caused severe damage in neighboring India. The technical committee has been educating civilians, farmers, and provincial level technical staff on management of the locust, utilizing different digital platforms (television, radio, telephone, webinar) in informing them on the possible management options for locust management. The committee has also produced various Information, Education and Communication (IEC) materials on locust identification and management, which has created awareness among beneficiaries. The Locust Information Center has been established by the taskforce team to provide current information to stakeholders on locust invasion and damage in Nepal. The locust technical taskforce committee members worked closely with the Department of Hydrology and Meteorology, Meteorological Forecasting Division of GoN. Daily prevailing weather data are analyzed. The taskforce team also gathers information along the border between Nepal and India from various sources. Recent updated information includes the current swarm location based on simulation results of Locust Analytics by plant village which is an

open access public resource at Penn State that aims to help smallholder farmers grow more food. Based on this available information, predictions were made, and alerts were issued through the locust information center housed at PQPMC/MoALD.

**Preparatory works for locust management**

The MoALD had formed a Desert Locust Technical Task Force Committee on May 26, 2020 to study the possibility of desert locusts migrating to Nepal. The locust technical taskforce reported the immediate response plan regarding the potential invasion of desert locust and its management on June 7, 2020 and has been working in implementation activities accordingly. The summary of the action plan is given below:

1. Organize a virtual training session in coordination with FAO for obtaining detailed technical information on desert locust. (Date: May 29, 2020 Topic: Topic: Desert Locust Sensitization virtual training facilitated by Dr. Keith Cressman, FAO, Rome, Participation of about 100 participants from different areas).
2. For the early preparedness on the potential arrival of desert locust, MoALD requested FAO for involvement and information on Locust Watch network for prediction and early warning of entry of desert locust in Nepal (Requested).
3. Requested FAO for translation of FAO Desert Locust Standard Operating Procedures in Nepali language.
4. Coordination with Department of Hydrology and Meteorology to acquire meteorological data for analysis of information on the early prediction of potential entry of desert locust and other required weather-related information. Coordination with Department of Hydrology and Meteorology (DHM) has been established.
5. For the early preparedness of locust attack in the country, coordination with stakeholders from research and development and all other related stakeholders. Coordination is being maintained, but there is still room to widen the scope of coordination and collaboration.
6. Demand of registration of Malathion 96% ULV (Ultra Low Volume) (among the recommended chemical pesticides) from private sector for the immediate control of locust swarms to be addressed by PQPMC along with management of supply of other recommended chemical pesticides. Action: Private sector is in regular touch for necessary action.
7. Request to form contingency taskforce at provincial level and request to inform focal point specifying the body leading the task in each province and be ready to mobilize the taskforce immediately if swarms enter. Action: (Requested and formed).
8. Develop capacity of the members of the taskforce and the technical manpower working in the state and local bodies in identification and management of desert locusts. Action: Regular information sharing through Locust Information Center and mass media.
9. Make necessary arrangements for management of power sprayer with rotary nozzle atomizer/hydraulic nozzle or air shear nozzle used for ULV spraying, including at least 5

sets of accessories and personal safety equipment (PPE) when using pesticides in each provincial level. (Action: Requested to Provinces).

10. Management of power sprayer at the rate of at least 10 sets for immediate use and personal safety equipment (PPE) required for use of pesticides in each province. (Action: Requested to Provinces).
11. Requested to keep the fire brigades available in the municipalities in a condition to be used in case of emergency and to do necessary homework for power sprayers and pesticides as much as possible. (Action: Requested).
12. Immediate distribution of factual information, e-copies and hard copies of fact sheets on desert locust to all states, knowledge centers, and municipalities, and disseminate through various media. (Action: Published and distributed).
13. Provide factual information about locusts through FM radio and other electronic media and to disseminate information from provincial level to be ready for possible entry and possible damage management. (Action: Done regularly).
14. Conduct feasibility study on management of locust in Nepal.(Action: Done if severely affected in Nepal)
15. Testing of drones for the survey of the swarm population and also for the spraying of insecticides. (Action: a small 10 liter size drone tested in Chitwan )
16. Analyze the necessity to carry out biological study and other scientific study and research according to present perspective on desert locust.

**Desert locust invasion and its distribution in Nepal**

In 1962, Kathmandu valley experienced the incursion of large swarms of desert locust, causing major damage to crop. After 58 years, the desert locust has again entered Nepal on June 27, 2020 and onwards, with potential to make impacts on the agricultural sector (Aryal *et al*., 2020; NPPO, 2020). As the name desert locust implies, Nepal is not in the regular route of swarms of this pest. Some groups (swarmlets) of desert locust drifted to Nepal from the swarms that reached India (FAO, 2020).

Nepal is not necessarily a suitable breeding ground for locusts. On June 27, 2020, the first locust swarm entered Nepal from India at the three locations in the central part of the country- Rupandehi, Bara, Parsa and Sarlahi districts between 7-9 AM, and flew northwards up to the river valley towards Palpa, Dhading, and Sindhuli. The swarm contained about one million individuals. Subsequently, on June 28 and June 29, 2020, two swarms again entered Nepal and the size of each swarm was estimated to be 2.5 million individuals. Most of the desert locust swarms that invaded Nepal were immature (Pink/browns) adults but mature (yellow) adults were also seen in some instances (Fig. 2. A, C and D).

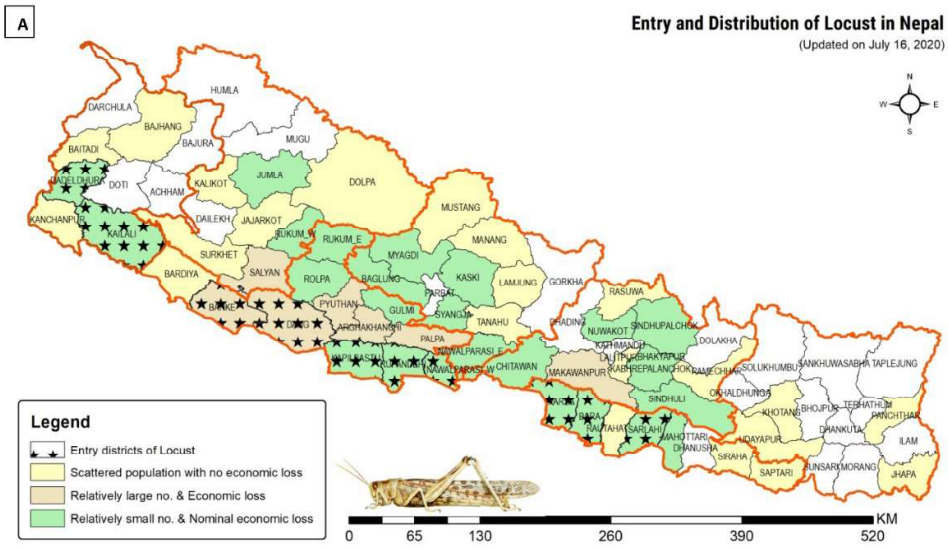

**Fig. 2:** Adult desert locust at Kathmandu (A), Sindhuli (C) and Guthichaur, Jumla (D). Desert locust roosting on bushes and tree at Lete, Mustang (B & E). Photo credit: Corey O'Hara, IDE/Nepal (A): Kishor Yadav, PPO, Mustang (B &D), Dev Raj Adhikari, PMAMP, Sindhuli (C), Ramesh Sah, MARI, Jumla

These large swarms scattered and formed smaller groups, flying with the wind and moving throughout Nepal, especially the mid-hills. Out of 77 districts, 55 districts have observed the presence of locusts in Nepal. As per the initial estimate by the PQPMC, around 7-8 million locusts have entered Nepal, and over 3 million are assumed to be actively flying around the Nepal skies in groups that can potentially damage crops. The remaining locusts have either died off or separated from their large swarms. A few groups were seen in the Kathmandu valley on June 30. Another surge of swarms entered Nepal on July 12 from Dang and Rupandehi districts. The swarm was also seen flying in the sky of Guthichaur, Jumla on July 16 (2700 amsl) at 100 to 200 m above ground level. There was also a report of a swarm settled at Lete, Mustang on July 23, 2020 (Fig. 2B & 2D). Swarms were also reported from 10 km across the Nepal-China border in the north at an altitude of 3,400 masl (PQPMC, 2020). On July 16, swarms again entered through the Banke and Kanchapur districts. The

swarmlets of Desert Locust which entered into Nepal earlier, have moved northwards from the headquarters of Mustang District (Jomsom) on July 24, 2020. Some of those locusts have moved further north towards the China border. As the locust communication center reports, the fraction of swarms arrived in the lower belts of Mustang on 23rd, 2020, many of them died there because of the cold weather, and have not done any economic damage to the crop during that periods.

These swarms have mainly caused low to moderate damage to maize crops in the mid-hills district. Apart from maize crops, there has been report of minor damage to soybean, and some vegetable and fruit crops in Nepal. PQPMC has been tracking the movement of the swarms in the country. A locust swarm that entered into Nepal spread to the Karnali and Far Western province districts of Nepal. The frequent change in the pattern of monsoons that activate westerly winds from the Arabian Sea can cause threat of more swarms entering Nepal, which also causes the movement of entered swarms to migrate in different directions. MoALD has urged the provincial government from Terai, Inner Terai valleys, and lower hilly areas to stay alert.

The group of locust swarm did not cause much damage, and the scattered crop damage was around 1,000 ha only. The vegetation loss at locust roosting areas around forests could not be assessed. Farmers have attempted to disturb and divert locusts with loud noises and smoke in the fields to protect their crops. The swarm movement depends upon wind direction, and any change in wind direction diverts the direction of swarms. Preliminary estimates of the crop infestation were reported in Table 2, though the details of the status on crop loss are yet to come



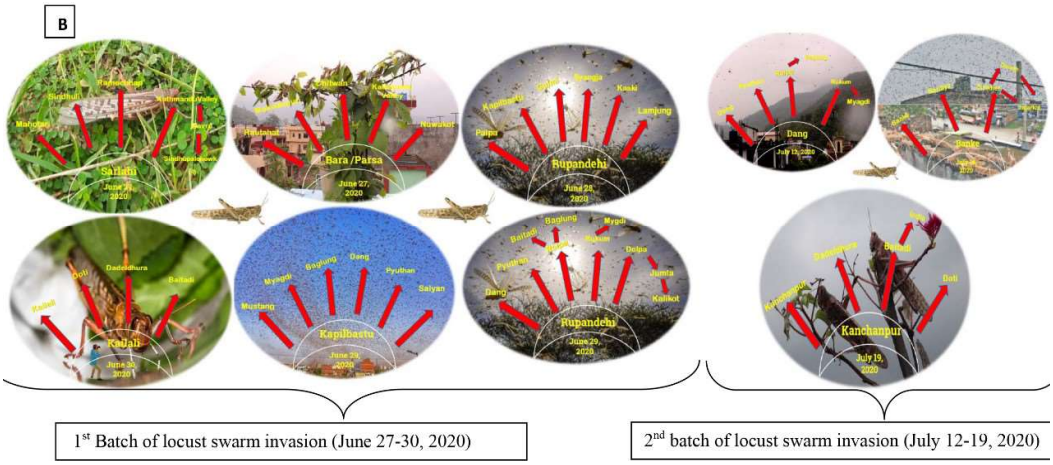



**Fig. 3 (A & B):** Desert locust invasion and its spread in border districts of Nepal

**Table 1.** Summary of the locust swarm invasion with tentative swarm population and migration in different provinces of Nepal (June 27-30, 2020)

| SN | Date | Tentative swarm population (millions) | Districts of first Invasion | Migration of desert locust (Provinces) |
|---|---|---|---|---|
| 1. | June 27, 2020 | 1.2-1.5 | Bara, Parsa | Province 2<br>Bagmati Province |
| 2. | June 27, 2020 | 0.9-1.0 | Sarlahi | Bagmati Province |
| 3. | June 27, 2020 | 1.2-1.5 | Rupandehi | Province 5<br>Gandaki Province |
| 4. | June 28, 2020 | 0.9-1.0 | Kapilvastu | Province 5 |
| 5. | June 29,2020 | 2.0-2.5 | Rupandehi | Province 5<br>Sudurpashchim Province |
| 6. | June 30, 2020 | 0.2 | Dadeldhura | Sudurpashchim Province |
| 7. | June 30, 2020 | 0.8-1.0 | Kailali | Sudurpashchim Province |
| 8. | July 12, 2020 | 1.2-3.0 | Dang | Province 5 |
| 9. | July 12, 2020 | 1.2-3.0 | Nawalparasi | Gandaki Province |
| 10. | July 16, 2020 | 2.0-3.0 | Banke | Province 5 |
| 11. | July 16, 2020 | 1.2-3.0 | Kanchanpur | Province 5 |

(Source: NPPO/Nepal, 2020)

**Table 2.** Locust infestations and damage caused by the swarm that entered Nepal during June 27-30, 20220

| SN | Districts | Crops | Areas of Infestations (ha) | Damage level | Current Status |
|---|---|---|---|---|---|
| 1. | Makawanpur | Maize and Vegetables | 105 | Minor to Medium | Not present currently |
| 2. | Sindhuli | Maize | NA | Minor | Not present currently |
| 3. | Dang | Maize and Vegetables | 580 | Minor | Not present currently |
| 4. | Pyuthan | Maize, fruits, Vegetables, and Soy bean | 283 | Minor to Medium | Only few numbers are active but many moved to North |
| 5. | Arghakhanchi | Maize and Vegetables | 100 ha | Minor | Not present currently |
| 6. | Palpa | Maize and Vegetables | 50 | Minor | Not present currently |
| 7. | Rolpa | Maize | Minimal | Minor | Still active but few numbers only |

(Source: NPPO/PQPMC, 2020)

Presence of first batches of desert locusts were reported from various districts such as Bara, Parsa and Sarlahi districts of province 2; Rupendehi, Kapilbastu, Dang, Nawalparasi, and Banke districts of province 5; and Kailali and Dadeldhura districts of Sudurpaschim province. Udayapur, Khotang, Jhapa and Pachthar districts of province 1; Rautahat, Siraha and Saptari districts of province 2; Ramechhap, Bhaktapur, Lalitpur, and Dolakha districts of Bagmati province; Mustang, Manang, Lamjung, and Tanahun districts of Gandaki province; Bardiya district of province 5; Surkhet, Kalikot, Jajarkot, and Dolpa districts of Karnali province; and Kanchanpur, Bajhang, and Baitadi districts reported the scattered population of desert locusts with no economic loss. The districts of Nepal that reported relatively smaller swarms and nominal economic loss of agricultural crops were Bara, Parsa, Sarlahi and Mahottari districts of province 2; Chitwan, Sindhuli, Kavre, Kathmandu, Sindhupalchok and Nuwakot districts of Bagmati province; Baglung, Myagdi, Nawalpur, Kaski and Syangja districts of Gandaki province; Nawalparasi, Rupendehi, Kapilvastu, Gulmi, Rolpa and Rukum Purba districts of Province 5; Jumla and Rukum Paschim districts of Karnali province; and Kailali and Dadeldhura districts of Sudurpaschim province. Relatively large swarms of desert locusts causing economic loss were reported from Makwanpur district of Bagmati province; Dang, Arghakhachi, Palpa and Banke districts of province 5; and Salyan district of Karnali province (Table 2, Fig. 3 A&B).

The second batches of locusts, which entered Nepal on June 29, 2020, had damaged crops and fruits mainly in two districts of Surkhet and Pyuthan. According to the Locust

Information Center, the locusts damaged maize and mango grown in around 1,100 hectares of land of the two districts and to date no actual data of losses was received from them. The first batch of locusts was seen in Nepal on June 13, and they had damaged crops in around 1,118 hectares of land in six different districts (NPPO/PQPMC, 2020). The loss caused by the second batch of locust swarms is comparatively higher than the first batch of the insects – the locusts damaged crops in Surkhet and Pyuthan, as the two districts did not receive rainfall. Three locust swarms entered Nepal in two days on July 12 and July 16. A group of locusts entered Nepal via Dang and another two groups via Mahendranagar and Nepalgunj. The group of locust swarms went to Pyuthan from Dang and damaged maize crops in different areas including Swargadwari Municipality and Pyuthan Municipality of Pyuthan district. As per the information received from locals, there was no significant loss by locusts in other districts except for Puythan and Surkhet districts. Locust swarms are still flying in different areas of Surkhet district as the locusts did not go away; even locals tried to chase them away by beating utensils. However, the locusts that reached Pyuthan from Dang traveled to the mountain area, so there was no need to be worried about further damage to crops. The swarmlets of Desert Locust which entered into Nepal earlier, have moved northwards from the headquarters of Mustang District (Jomsom) on July 24, 2020. Some of those locusts have moved further north towards the China border. As the locust communication center reports, the swarms arrived in the lower belts of Mustang on 23rd, 2020, many of them died there because of the cold weather, and have not done any economic damage to the crop. During that periods.

**Control measures suggested for desert locust management**

While it appears that the current locust damage in Nepal is not too severe, local people, predominantly farmers, have attempted to disturb and divert locusts with loud noises and smoke in the fields to protect their crops. Management measures, including chemical control, have been recommended by the Desert Locust Taskforce. The ultimate goal in locust control is the use of preventive and proactive methods that disrupt the environment to the least possible extent. Upon receiving the message of locust swarm invasion, farmers also take the following traditional and non-chemical desert locust control measures.

**A. Non-chemical desert locust control measures**

Desert locust needs sandy soil as breeding grounds, which is not present in Nepal. Therefore, breeding of the locust in Nepal is unlikely. The locust swarms that reached Nepal had immature and mature adults. Considering the long history of desert locust, the farmers have developed a variety of cultural and physical control measures over a period of time before the availability of chemical control measures. Sharma (2014), Aryal *et al.* (2020) and Chiluwal (2020) mentioned various traditional control measures of desert locust such as:

***Smoking or making loud music and heavy noise (metallic)***

This physical control measure prevents the swarms of desert locust from settling in the crops. Creating heavy noises of metallic sound, steel drum beating, playing loud music or lighting fires to create smoke prevented swarms from settling on crops/plants at night. The first abdominal segment of desert locust consists of tympanal organ (Tympanum), which is a hearing organ (Sharma, 2014). The locust can be chased away by making high decibel sounds with musical instruments, using the bike or tractor with removal of silencer, banging metallic plate, bell, and others (Latchininsky, 2007).

***Trapping of desert locusts***

Collection and trapping is also one of the methods to reduce locust populations. The desert locust rests after sunset on the trees or crops. After sunrise, the entire swarm comes to ground to prepare itself for the flight ahead. This time is considered a small window of opportunity to trap the desert locusts. The trapped locusts can either be killed or can be used for food and feed purposes. Desert locust is richer in protein and calories than other insects. There is the tradition of using desert locust for food in African and Middle Eastern and eastern Asian countries (Sharma, 2014). Some of the municipalities announced the prices of the desert locust collected which also helped to manage the population.

***Beating or trampling on the hoppers***

Desert locusts that are settled in the ground can be beaten or trampled upon. This control measure is applicable only for small numbers of desert locusts (Sharma, 2014).

***Shaking of the crops***

The desert locusts settled on crops can be removed by shaking of the crops. This method is useful for agricultural crops but not for trees. Two individuals can hold the ends of a long rope and move it in a back and forth direction to shake the crops within the length of the rope (Sharma, 2014).

***Ploughing fields infested with egg pods***

Destruction of egg pods by ploughing fields can be done in the area where breeding of locust occurs (Sharma, 2014).

***Driving hoppers into trenches***

The hoppers can be driven into trenches and then burned, drowned, or crushed.

***Conservation and attracting predatory birds***

This can be done around the crop field by preparing bird perches if the swarms occur frequently.

***Protection of smaller areas with net***

The nurseries and poly houses can be protected by netting with the help of insect net.

**B. Chemical control of desert locust**

Chemical control measures should be recommended only after analysis of the locust populations and damage to the crops. Chemical pesticides can cause more damage to the environment and public health, so priority is to avoid spraying pesticides. Pesticides are recommended as a last resort. There are several different types of insecticidal or behavior-modifying products of potential use for locust control (Guo *et al*., 2020). They can be differentiated by the pesticide mode of action: Conventional insecticides including organochlorines, organophosphates, carbamates, pyrethroids and phenylpyrroles. Safety measures should be adopted while spraying chemical pesticides including the use of personal protective equipment. Liquid sprays are the most commonly used formulation for locust control.

The chemical control measures for desert locust recommended by the locust technical taskforce committee formed under MoALD includes the below in Table 3.

**Table 3.** Recommended chemical pesticides for desert locust management

| Recommended Chemical pesticide | Pesticide (kg) a.i/ha* | Pesticide(ml) use /liter of water | Pesticide(ml) use/ha of land area | Pesticide solution (liter) use / ha of land area (l) |
|---|---|---|---|---|
| Malathion 50% EC | 0.925 | 3 | 1850 | 600 |
| Lambda-cyhalothrin 5% EC | 0.002 | 0.77 | 400 | 600 |
| Chlorpyrifos 20% EC | 0.225 | 1.88 | 1125 | 600 |
| Deltamethrin 2.8% EC | 0.125 | 0.75 | 450 | 600 |
| Deltamethrin 11% EC | 0.125 | 0.20 | 120 | 600 |

Source: Revised from Aryal *et al*. (2020a, 2020b).

A technique using much smaller quantities of spray liquid, called ultra-low volume (ULV) spraying, is the most efficient high-quality method available and recommended for locust control (Latchininsky, 2007). This technology produces droplet sized liquid (50-100µm), which is consistent and most appropriate for acridid targets (Dobson, 2001; Latchininsky, 2007). It involves applying between 0.5 - 3 liters of spray liquid per hectare. This small quantity of concentrated insecticide is not mixed with water or any other liquid - the special ULV formulation is supplied ready to spray. In order to spread this very small volume over each hectare, the liquid must be broken up into small droplets light enough to be carried easily by the wind. To prevent these small droplets from evaporating in the hot conditions that are typical during locust control operations, ULV sprays are based on oil rather than other solvents, which may be too volatile. These small droplets do not deposit (land on surfaces) very easily. They fall very slowly, so they tend to be carried sideways by the wind and not to sediment ('rain down') onto horizontal surfaces. In addition, if they are too small

or the wind is too light, they tend to go around objects rather than to hit them, somewhat like smoke. However, if the droplets are the right size and there is sufficient wind, they impact onto vertical surfaces such as vegetation or locusts. Application is usually done with specialist ULV spray equipment, which can be portable, vehicle, or aircraft-mounted.

There are various types of sprayers in use for locust control. They can be characterized by looking at the method by which they break the insecticide up (atomizer type), the means by which they are carried during spraying (sprayer platform), and the method of dispersal/transport of droplets after atomization (droplet transport).

## WAY FORWARD

Below are key recommendations to mitigating the desert locust that focus on the need to coordinate and control operations throughout Nepal in order to avert significant impacts on food security and people's livelihoods. There is also a need to establish a sustainable mechanism to manage future desert locust invasions and outbreaks that are expected to become more frequent due to climate change. The technical information on desert locusts, swarm existence, and their possible migration should be shared among the different nations where the desert locust risks are anticipated. To achieve the efficient control of the desert locusts, some of the research and development tasks to be performed are listed below:

1. Strengthen monitoring mechanism of locust movement (using GIS, MAP, Drone etc.)
    i. Survey on locust swarm population
    ii. Survey ecological conditions
    iii. Survey of green vegetation
2. Test Spraying technique for the EC and ULV formulation using drone and helicopters
3. Pilot testing of vehicle mounted spray mechanism
4. Investigation on the solitary phase of desert locust
5. Awareness and promotional program for locust identification and management

## CONCLUSION

Climate change and its impact on monsoons is perhaps one of the causes of locust range expansion. The origin of the current locust upsurge was the spring-bred population at Empty Quarter of Southern Arabian Peninsula from May to October 2018 that occurred due to heavy rainfall induced by cyclones. Recent invasion of desert locust in Nepal appeared after 24 years. Due to the unfavorable environment and breeding conditions for desert locust, the damage caused to agricultural crops in Nepal is minor. Successive invasion depends upon the buildup of locust population when environmental conditions like weather, soil and vegetation are favorable; crucial is the wind direction for adult swarm migration. Control of locusts at breeding areas is one of the major steps toward prevention and reducing risks of invasion to other countries. Therefore, with strong coordination among all concerned

authorities, the following areas should be addressed for research and development activities: survey on locust swarm population, ecological conditions, and green vegetation, testing and use of different spray equipment, studies on the possibility of locust breeding, and awareness raising activities on different aspects of locusts among stakeholders.

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