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PLANT PROTECTION | PERSPECTIVE ARTICLE

Early preparedness: Bangladesh proactive steps towards desert locust invasion in South Asia

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ABSTRACT

The desert locust *Schistocerca gregaria* (Forskål) is considered as the most devastating transboundary pest of all migratory pest species in the world due to its high reproduction rate, ability to migrate long distances, and destruct the crops. The ongoing spread of desert locusts in the region of South Asia represents an unprecedented threat to food security and livelihoods. Although there are many factors involved, change in climate directs unpredictable direction to wind which is responsible for this unusual spread of pest from India towards Nepal. According to the Food and Agriculture Organization of the United Nations (FAO), even before the cyclone Amphan hit the country, dry conditions prevailing in the west forced immature adult swarms to move eastward in India, crossing the entire northern India as far as Bihar and Orissa. Though the risk posed by desert locust is extremely low in Bangladesh, the chances get much lower because of the monsoon. During the monsoon it gets very humid and the potential of nymphs getting infected by pathogens is high and they die naturally being completely outside of their desert habitat. The rapid and sudden upsurge of the locust population that is unleashing destruction globally can be attributed to aberrant and erratic climatic behaviour triggered by global warming. Therefore, the government of Bangladesh is taking proactive steps to manage different trans-boundary pests to ensure food security and livelihoods.

Keywords: Desert locust, trans-boundary pest, invasion, wind, food security, South Asia

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ALL LOCUSTS are grasshoppers, but only a few grasshoppers are locusts. Generally, locusts are a kind of short-horned grasshoppers (Suborder: Caelifera; Family: Acrididae) of the insect order Orthoptera (Capinera, 2008). They are known to exhibit their density dependent behavioral, physiological, and phenotypic polymorphism (Song, 2011). Only about 18 species of large grasshoppers, which exhibit pronounced behavioral and/or morphological differences between phases, should be considered as locusts among the 6,400 described grasshopper species of the family Acrididae in the world (Latchininsky, 2013; Prathapan, 2020). Locusts have been considered as the enemies of humans since the beginning of agriculture (Arthur, 2008). Sometimes locust swarms brought devastation and caused famine to entire nations. Locusts live in the "solitary phase" characterized by camouflage coloration, in frequent social interactions, and sedentary behavior under low population densities. On the contrary, locusts develop into the "gregarious phase" often with strikingly black-and-orange colored nymphs, which march in cohesive "hopper bands" at high densities (Cullen et al., 2010, 2017; Ma

et al., 2011; Song, 2011; Ott et al., 2011).

The desert locust *Schistocerca gregaria* (Forskål, 1775) are known to change their behavior and form swarms of adults or bands of hoppers (wingless nymphs). This swarms can be dense and highly mobile. The desert locust outbreak affected 8 million people in more than 20 countries with an estimated 80 to 100% of crop lost in 2003–2005, mostly sub-Saharan Africa (Brader et al., 2006; Latchininsky, 2013). Desert locust damage can most convincingly be compared to a natural disaster like a hurricane or a tornado.

Life cycle and dispersing capacity of desert locust Desert locusts are notorious due to their high fecundity and reproduction rates (Lazar et al., 2016). Desert locust females lay eggs primarily in sandy soils at a depth of 10-15 cm below the surface in an egg pod (Symmons and Cressman, 2001) (Fig. 1). A solitary female lays higher eggs i.e. about 95-158 eggs in a pod, whereas a gregarious female lays fewer eggs i.e. 80 eggs in a pod. Females locust can lay eggs at least three times usually at an interval of about 6-11 days in their lifetime. Generally, up to 1,000 egg pods have been found in one square meter (FAO, 2020). The life cycle of locust includes a succession of three stages: egg, nymph, and adult. Although the life cycle of desert locust is extremely variable and depends mostly on weather and ecological condition, a desert locust lives a total of about three to five months (Symmons and Cressman, 2016). The life cycle comprises the duration of three stages as follows:

- Hatching of eggs is about two weeks (the range is 10-65 days)
- Development of hoppers in five to six stages over a period of about 30-40 days, and
- Maturity of adults took place in about three weeks to nine months (mostly from two to four months).

Depending on the wind, desert locusts usually fly at a speed of about 16-19 km h^{-1}. In a day, swarms of desert locust can travel about 5-130 km or more (Pedgley, 1981). Adult locusts can stay in the air for long periods of time. For example, desert locusts cross the Red Sea regularly, a distance of 300 km. This group of desert locust travels a long way during daytime destructing the crops and take rest at night. Desert locust swarms can vary from less than one square kilometer to several hundred square kilometers. At least 40 million and sometimes as many as 80 million locust adults can be accommodate in each square kilometer of swarm. It was reported that a swarm that invaded Kenya covered an area of 200 km^2 in early 1954. The predictable density was 50 million individuals km^{-2} giving an entire number of 10 billion locusts in that swarm (Rainey et al., 1979; Rainey, 1989; COPR, 1982).

Damaged area caused by desert locust Desert locust is extremely polyphagous. They can attack more than 500 plant species and includes all kinds of agricultural crops. An adult desert locust can consume fresh food of roughly its own weight per day, which approximately weighs about two grams every day. A 1 km^2 size swarm contains about 40 million desert locusts eat the same amount of food in one day as about 35,000 people (Cressman, 2016). This is based on eating an average of 2.3 kg of food per day by a person, according to the USDA.

Ecology of the locust Desert locust increases in numbers when the conditions are favorable for reproduction and numbers decrease either by natural mortality or through migration when the conditions are adverse (Fig. 2). Most favorable conditions for breeding of the desert locust 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. Seasonal rains in the deserts trigger the growth of green vegetation, which attracts the desert locusts (Cressman, 2016). This species is extremely sensitive to changes its density, and phase transformation occurs very frequently and rapidly. Females often form cluster to lay eggs, which starts and/or lead to the gregarization. They exist in different conditions known as recessions (with low and intermediate numbers), rising to outbreaks, and extremely high densities or plagues (Magor et al., 2008). Desert locust plagues started, spread and declined long before application of effective pesticides and suitable methods existed (Rainey et al., 1979; Tratalos et al., 2010). Three factors are playing a role in ending plagues of desert locust. They are (i) Insufficient rainfall, (ii) Movement of swarms to areas unsuitable for breeding and survival, and (iii) Control efforts - predominantly based on chemical methods.

Affected countries by the desert locust During quiet periods (known as recessions) desert locusts are usually restricted to the semi-arid and arid deserts of Africa, the Near East and South-West Asia that receive less than 200 mm of rain annually (Dinku et al., 2010). This is an area of about 16 million square kilometers, comprising of about 30 countries (Fig. 3). Desert locusts may spread over a massive area of some 29 million km^2 during plagues and extending over or into parts of 60 countries (Latchininsky, 2013). This is more than 20% of the total land surface of the world. The desert locust has the potential to damage the livelihood of a tenth of the world's population during plagues (FAO, 2020).

The desert locust invasion in south Asia Though the desert locust upsurge remains critical in East Africa, Yemen and Southwest Asia has become vul-

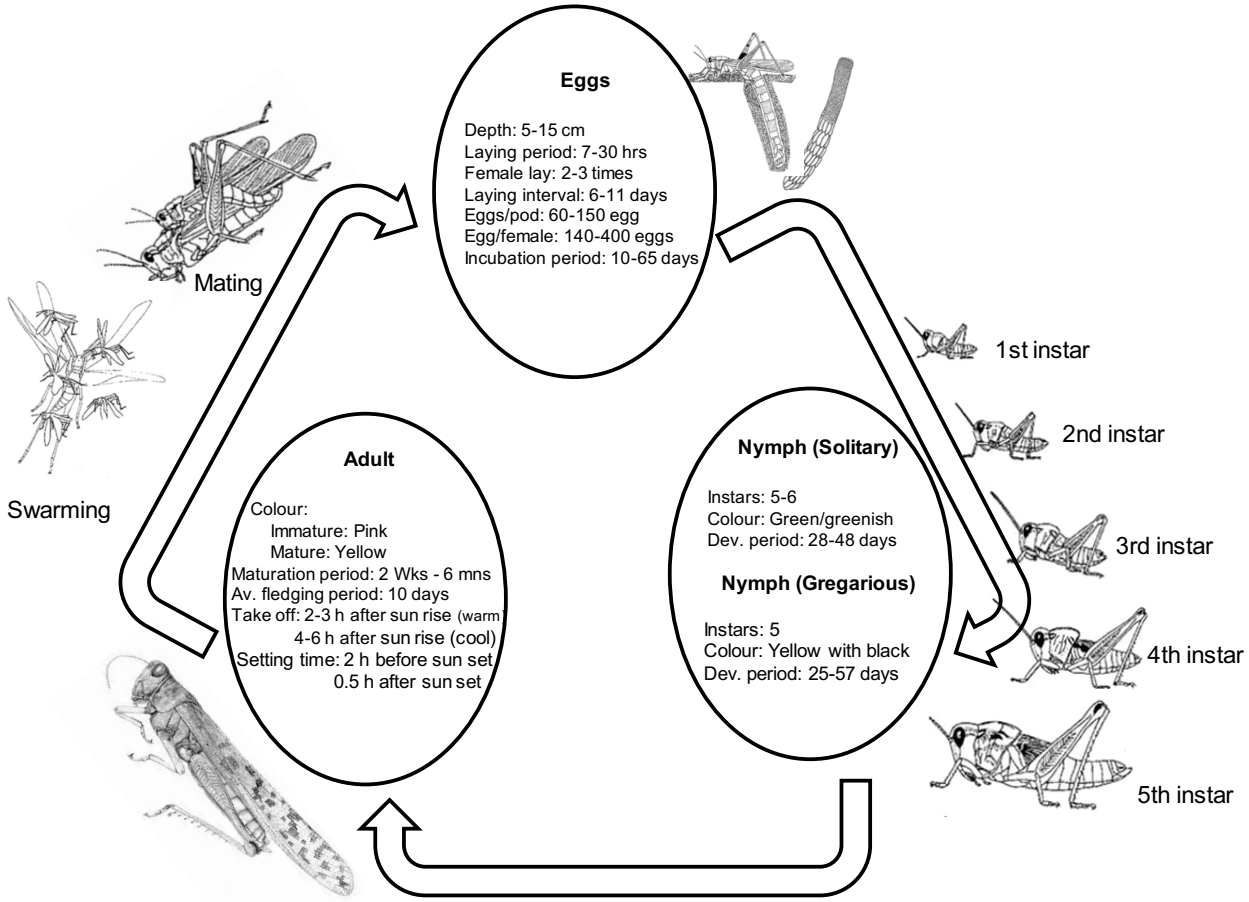

Figure 1. Life cycle of desert locust, *Schistocerca gregaria*. Modified from Latchininsky (2013)

nerable to their population. In Pakistan, desert locust has been found infesting in Balochistan, Sindh, Panjab and Khyber Pakhtunkhwa province. The Food and Agriculture Organization of the United nations (FAO) estimates losses to Pakistan agriculture from locusts in 2020 could be as high $2.2 billion (PKR 353 billion) for winter crops, including wheat and potatoes, and nearly $3 billion for summer crops (Thomson Reuters Foundation, 2020). In the same time, around 3.75 lakh hectares of crops had been devoured by locust attacks in India with a loss of over Rs 100 crore in 2019-20. Locusts has destroyed over 2 lakh hectares of crops in India since the beginning of May 2020 and threatened another 6 lakh hectares of crops (ThePrint, 2020).

Usually, locusts arrive in India during the monsoon months, between July and October in previous years. But in 2020, the first sighting was reported as early as April 11. The trigger for this unusual pattern occurred in 2018, related to the cyclonic storms Mekunu and Luban, which impacted Oman and Yemen. These storms turned large desert areas in those countries into lakes, which created ideal places for the locusts to breed (FAO, 2020). In fact, as per a FAO report, locust swarms have been breeding 400 times more than usual, and this explosive multiplication spell bigger disasters for large parts of Asia and Africa (FAO, 2020). Following the aforementioned cyclones, locust armies continued to build through 2019, and once the population peaked, the swarms began spreading to east Africa by November 2019. The invasion in Iran and Pakistan was complete by the start of 2020 until they finally reached India towards the end of April.

Spring-bred immature adult groups and swarms that arrived in Rajasthan, India from Pakistan and continued to move towards east and to the central states of Madhya Pradesh and Maharashtra (Fig. 4). Much of these movements were associated with strong westerly winds from cyclone Amphan in the Bay of Bengal. Several such successive waves of desert locust invasions were felt until July 2020 in Rajasthan with eastward surges across northern India as far as Bihar and Orissa followed by westward movements. The swarms return to Rajasthan on the changing winds associated with the monsoon. These movements ceased as swarms begin to breed and become less mobile.

Swarms were less likely to reach Bangladesh. The reason being existing distance from the swarm, the opposite wind direction and Bangladesh begin too wet and green the environment which is totally unfavourable for the locust (Cressman Keith, Senior Lo-

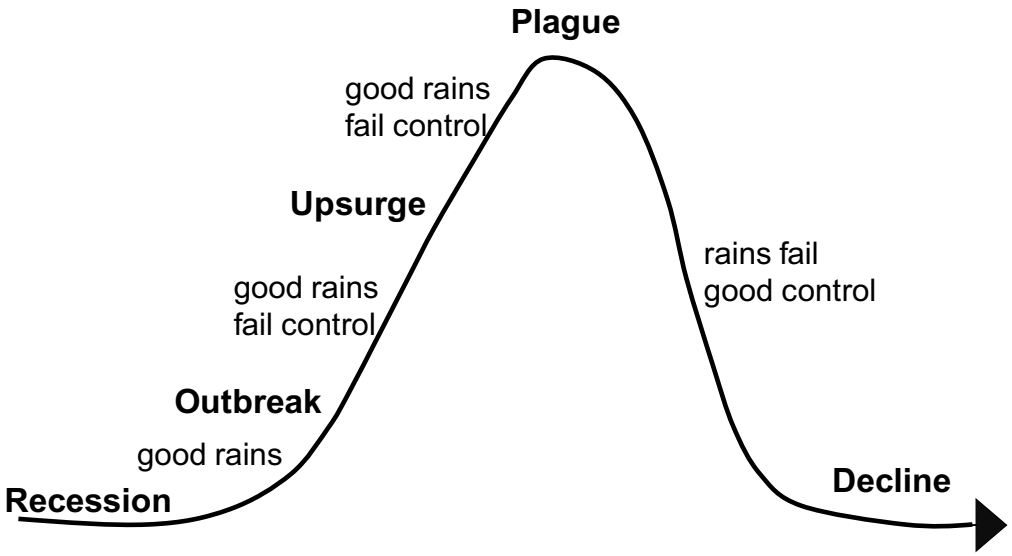

Figure 2. Growth formation of desert locust in an ecosystem

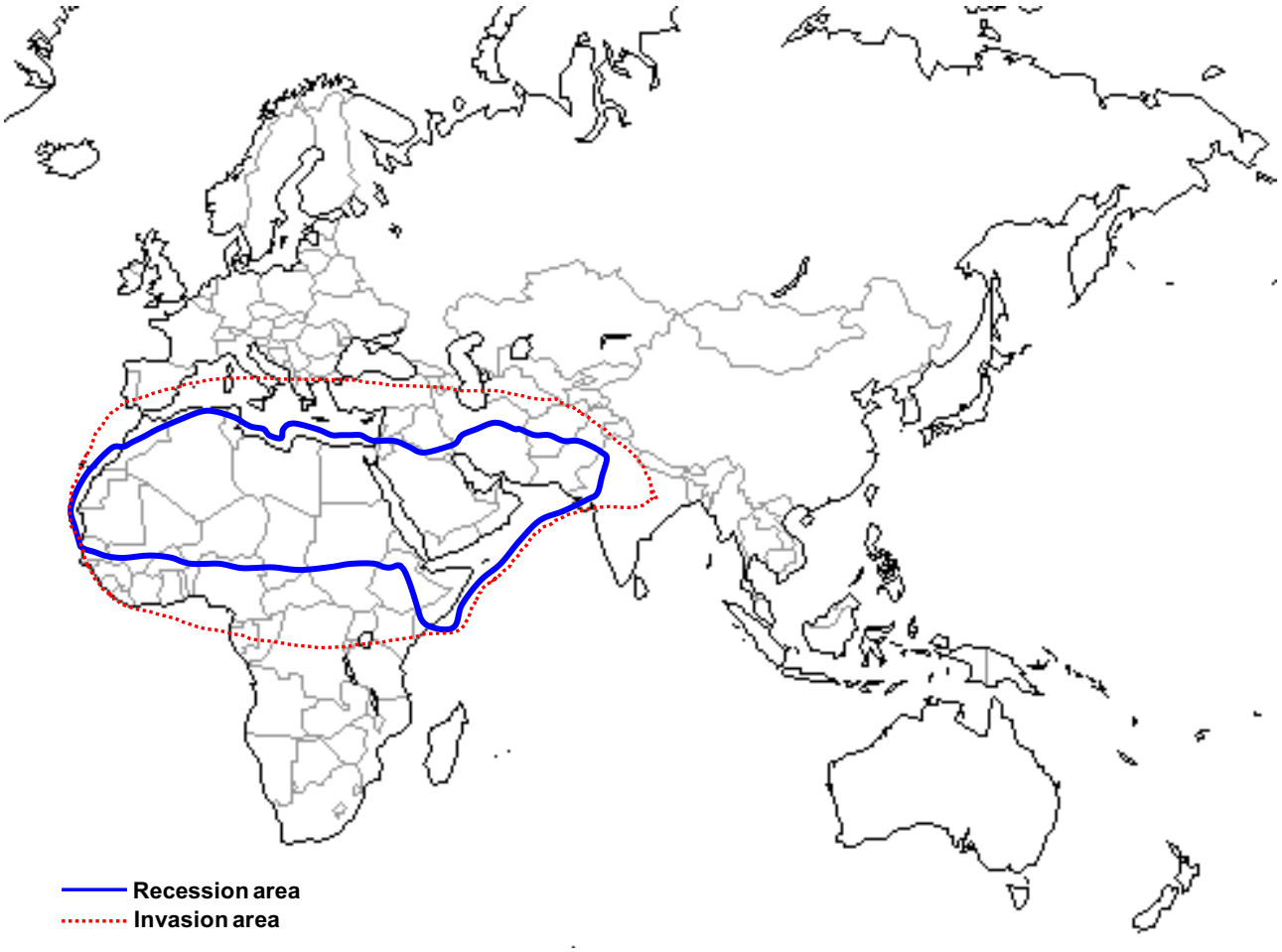

Figure 3. Recession and invasion area of desert locust. Modified from Symmons and Cressman (2001)

Figure 4. Desert locust swarms' situation in globally including South Asia as of July 2020. Modified from FAO (2020)

cust Forecasting Officer, FAO). Therefore, striking of cyclone Nisarga formed over the Arabian Sea on the Indian state of Maharashtra in June 2020, had some impact of desert locust expansion. With remote chances of locusts entering into Bangladesh, it is still good to stay alert and keep communication with FAO as they play a vital role in monitoring and controlling the deadly insect with supreme expertise. With these consequences Bangladesh Agricultural Research Council (BARC) arranged a discussion meeting early June 2020 about 'Locust Outbreak and Management'. At the same time FAO arranged a comprehensive discussion session through video conferencing where more than 145 renowned scientists (mostly entomologists) from different research organizations including MoA, DAE, NARS institutions, Universities, FAO, CIMMYT, USAID participated. Unfortunately, swarms of locust, first seen in the Terai on 27 June 2020, moved to various hilly districts in Nepal (Fig. 4). The swarms are believed to have broken off from a larger unit in India and were likely blown towards Nepal with the wind blowing north from south. After that, the locusts have quickly spread to 27 districts of Nepal, including districts as high as Khotang, Okhaldhunga, Rukum West, Mustang and Solukhumbu. Approximately, seven to eight million locusts have entered in Nepal mentioned by Plant Quarantine and Pesticide Management Centre's. They cause severe damages of many crops in Nepal. This poses a threat to Bangladesh because of the infestation of swarms of locust in a neighboring country like India and Nepal.

The spotted Coffee Grasshopper in Teknaf, Bangladesh About 18 species of large grasshoppers, those that form swarms, are considered as locusts. In Indian sub-continent (specially in India and Pakistan), three species of locusts occur—the desert locust (*Schistocerca gregaria*), migratory locust (*Locusta migratoria*) and the Bombay locust (*Nomadacris succincta*). The tree locust (*Anacardium rubrispinum*) and the coffee locust (*Aularches miliaris*) are not true locusts, as they do not form swarms. Amid COVID lockdown the news channels buzzed in Bangladesh on arrival of some pest in swarms which were partially covering some crops in Teknaf Upzilla, Cox's Bazar. The Ministry of Agriculture (MoA), Bangladesh took immediate steps and the team from with Department of Agricultural

Extension (DAE), Bangladesh Agricultural Research Institute (BARI) and other NARS organization rushed to the site to collect samples, identify and take up immediate steps for its management. Professor Dr. Mohammad Shaef Ullah, Department of Entomology, Bangladesh Agricultural University reported that the insect was identified as 'Spotted Coffee Grasshopper' and is not a new pest in Bangladesh (Josephrajkumar et al., 2011), however as it was never seen in such a huge intensity the farmers were overwhelmed. This species is also reported in June 2020 in Bankura district, West Bengal, India.

Spotted Coffee Grasshopper, *Aularches miliaris*, is a monotypic grasshopper species of the genus Aularches, belonging to the family Pyrgomorphidae (Fig. 5). The bright colours on their body keep away predators and their defense when disturbed includes the ejection of a toxic foam (Hingston, 2009). The insect has been called by coffee locust, ghost grasshopper, northern spotted grasshopper, and foam grasshopper. *Aularches miliaris* is a minor insect pest of coffee, banana, arecanut, coconut, teak, dadap, mango, cardamom, cassava, castor, durian, guava, maize, mango, mulberry, oil palm, rice, sugar cane, chillies, cocoa, cotton, custard apple, jute, pigeon pea, rubber, sesame, sorghum and pine, causing occasional economic damage (Josephrajkumar et al., 2011). These grasshoppers are not a major pests but outbreak can be done due to (i) Ecological disruptions e.g. effect of relatively prolonged hot weather of grasshopper development increasing the number of generations per season, (ii) incessant and indiscriminate pesticide use affecting the natural enemies causing a phenomenon we term as a natural enemy ravine, (iii) changes in the soil (as grasshopper lay eggs here) and crop practices or husbandry (e.g. dense crop canopy or density; pruning rounds), and (iv) any evidence of migration from other areas. CABI Plantwise with help of Subject experts from DAE and University made Pest management decision guides for the pest which stated its management strategy based on IPM.

Possibility of desert locust infestation in Bangladesh and measures should be taken Although it was forecasted that swarms are less likely to reach Nepal and Bangladesh, it has already invaded in Nepal. A National Task Force could be formed to monitor the desert locust or any invasive insect pests in Bangladesh. Nevertheless, Bangladesh is encouraged to take some anticipatory actions:

1. Early warning in locust populations increases through improved locust survey
2. Monitoring vegetation, rain fall and soil moisture in potential seasonal breeding areas to restrict areas which are suitable for breeding in a definite season (using aerial and ground survey, satellite imagery, weather reports and information from local inhabitants)
3. Surveying suitable breeding habitats to establish locust distribution and numbers by teams of experienced local locust scouts
4. Controlling any gregarious or gregarizing locusts. Survey teams may control small group infestations but call for help if the locust numbers are large
5. Hoppers can be destroyed by mechanical means; digging trenches using earthmover machines and burying marching hopper bands are a common method
6. Research on improved locust and survey control including trials on alternatives to chemical pesticides is essential
7. To procure and evaluate the biopesticide consists of the spores of a fungus that is pathogenic to locusts, called *Metarhizium acridum*. CABI has standardized the production formulation and application of this biopesticide and with its ongoing current research it is aiming to predict its application for optimal use.
8. Early reaction against locust outbreak through strengthening control capacity, increasing the pesticide treatment efficacy, reducing environmental and health hazards of spraying
9. Vehicle-mounted sprayers or aerial sprayers are effective against swarms. Direct application of chemical pesticides on swarms roosting on vegetation, during morning and evening is the most effective method
10. Lastly, different formulations of insecticides with verified dose rates for the desert locust should be available

Role of FAO in locust control FAO has a mandate to provide information on the general locust situation to all interested countries. They also provide timely warnings and forecasts to those countries in danger of invasion by desert locust. Therefore, FAO employ a centralized desert locust Information Service (DLIS) within the Locust Group at FAO Headquarters, Rome, Italy. Affected countries by desert locust transfer their field data to DLIS, who in turn analyze this information in connection with weather and habitat data. The satellite imagery in order to assess the current locust situation in worldwide provide forecasts up to six weeks prior to invasion and issue warnings on an ad-hoc basis. Monthly bulletins and periodic updates were prepared on the desert locust situation and forecasting, migration and breeding on a country basis. Moreover, FAO supports training

Figure 5. Spotted coffee grasshopper in Teknaf of Bangladesh in 2020

and formulates publications on various features of locusts. FAO also assist the control operations during locust plagues.

Nevertheless, Bangladesh is encouraged to take anticipatory action by (1) familiarizing with desert locust, distinguishing them from other grasshoppers to avoid confusion and misinformation, (2) using an Android app, eLocust3m, for reporting to national authorities and FAO, and (3) mounting a public awareness campaign to avoid any unnecessary confusion and panic. As per mandate of FAO has to provide general information on the locust situation to interested countries and to give timely warnings and forecasts of invasion, Bangladesh Government can closely work together to create the awareness, formulate a long-term durable strategy and remove the desert locust panic.

Conflict of Interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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