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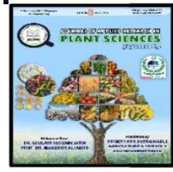

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Analytical observation Upsurge and Current Situation of Desert Locust (*Schistocerca gregaria)* in Sindh, Pakistan

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Abstract:

Schistocerca gregaria (Forskl, 1775), one of the most notorious insects in the world, significantly harms the economy and agriculture each year. It was reputedly the biggest infestation to hit Pakistan since the 1990s, destroying wheat, rice, sugarcane, cotton, and vegetable crops, and it was also the cause of the worst disaster of 2019–2020. Increases in Desert Locust swarms have had a devastating impact on Pakistan's agricultural sector, causing widespread crop failures. Financial losses throughout the two agricultural seasons in 2020 and 2021 are estimated to be between $3.4 billion and $10.21 billion. The result was a significant rise in the cost of everyday goods on the market. In addition, an increase in locust activity has been seen in some of the worst hit regions. Correct species identification is crucial for efficient management and control measures. This research aims to provide light on the reasons behind this vital management focus.

Key words: Agricultural seasons; Alertness; Crops; Damage; Desert locust; Identify, Management; Upsurge

Introduction

Throughout history, locusts have both been feared and respected. These insects, which are related to grasshoppers, congregate into gigantic swarms that travel across continents, destroying crops and causing significant agricultural harm in their wake. Since the Pharaohs ruled ancient Egypt, locust plagues have wreaked devastation on cultures and they continue to do so now. The greatest locust infestation in the past three decades has hit Pakistan. In West and North Africa, the Middle East, and Southwest Asia, the desert locust *Schistocerca gregaria* (Forskl, 1775) is regarded as a serious agricultural pest (Cressman, 2021; Lecoq, 2001; Steedman, 1990). Recurrent invasions of this insect pose a serious threat to agricultural production and have disastrous effects on food security in more than 50 countries (Brader et al., 2006; Lecoq, 2005, 2004, 2003, 2001; Samejo *et al*., 2021). Pakistan has a questionable history, with occasional swarm invasions. Moreover, the country has "outbreak zones," or areas where locusts are more likely to swarm, reproduce, and multiply rapidly, making them more likely to cause outbreaks and plagues when the conditions are right. Outbreaks of desert locusts threaten the livelihood of 10% of the population. Fewer than half a square mile can hold 40–80 million desert locusts in a swarm that covers 460 square miles. If each locust consumes its weight in plants per day, then a swarm of this size would eat 423,000,000 pounds of vegetation every day. In more than 60 districts of Sindh, Baluchistan, Punjab, and Khyber Pakhtunkhwa provinces, a recent swarm (2019–2020) destroyed important crops like wheat, cotton, rice, sugarcane, tobacco, corn, watermelon, chilies, eggplant (brinjal), okra (lady finger), mango, citrus, apple, grapes, strawberry, peaches, banana, and guava (Riffat *et al*., 2021). Losses for "rabi crops" (sown in winter and harvested in spring) might total 353 billion Pakistani rupees (2.19 billion US dollars), while losses for "kharif crops" (sown in summer) could total 464 billion Pakistani rupees (2.88 billion US dollars) (FAO 2020). These infestations have destroyed harvests incalculably, sometimes resulting in terrible famines (Dowlatchahi *et al*., 2020). The FAO has advised a preventative control strategy based on the monitoring of epidemic regions and ecological circumstances since the 1960s (Lecoq, 2004, 2003; Showler, 2019). If necessary, early intervention and consequently restricted use of pesticides are then suggested. However, continuing instability in several desert locust distribution zones, together with continued political and financial turbulence, keep the threat alive, and some outbreaks cannot be suppressed at an early stage, as was recently noticed once more (Meynard *et al*., 2020; Showler et al., 2021; Showler and Lecoq, 2021).

Material and Methods

Selection of sites, Killing and Preservation: All specimens were gathered from several Sindh districts agricultural fields and rocky abandoned areas (Fig. 3) Materials were delivered to the Department of Zoology, Entomology and Biocontrol Research Laboratory (EBCRL), University of Sindh, Jamshoro. The technique for euthanasia was modified somewhat from (Riffat et al., 2021; Riffat and Wagan, 2015) and involved killing the specimens in conventional entomological death bottles for 5–10 minutes with potassium cyanide or chloroform. Because samples colors may vary, they were not kept around for very long. Then, after killing, samples were swiftly pinched. On the pronotum, just to the right of the median carina and posterior to the transverse sulcus, an insect pin was placed. On the stretching board, the head was slightly lowered. The long axis of the body was virtually at a right angle to the pin when the left wings were placed. The back legs were bent under the body to take up less room and lessen the chance of breaking. The wings and the hind legs were not hidden by the open belly. Fully dried specimens were stored in bug cabinets with labels that included the date, habitat, location, and collector's name. In order to keep ants and other insects away, boxes were filled with naphthalene balls. The specimens were identified using the Orthoptera Species File (OSF) (Cigliano et al., 2018) and the bibliographies offered by Riffat and Wagan, 2015. An Ernst Leitz Wetzlar Germany 545187 camera lucida mounted on a microscope was used to make line drawings, which were subsequently improved using the Adobe Illustrator CC-2015 and Adobe Photoshop CS software. Measurements of different body parts were calculated in millimeters using the microscope (Oculas), 10 10 graph, compass, divider, and ruler (mm).

The following abbreviations appear in the text:

AS Antennal segment;
AL Antennal length;
LH Length of Head;
DBE Distance between Eyes;
DDP Department of Plant Protection
LP Length of Pronotum;
LT Length of Tegmina;
LW Length of Wing;
LF Length of Femur;
LTi Length of Tibia;
SEMJ Sindh Entomological Museum Jamshoro
TBL Total Body Length;

The distributions of the species that reached were mapped using GPS coordinates. These specimens are deposited in the Sindh Entomological Museum Jamshoro, Department of Zoology, University of Sindh, Jamshoro (TN: 938 SEM) (SEMJ). Pakistan.

Results

Systematic account

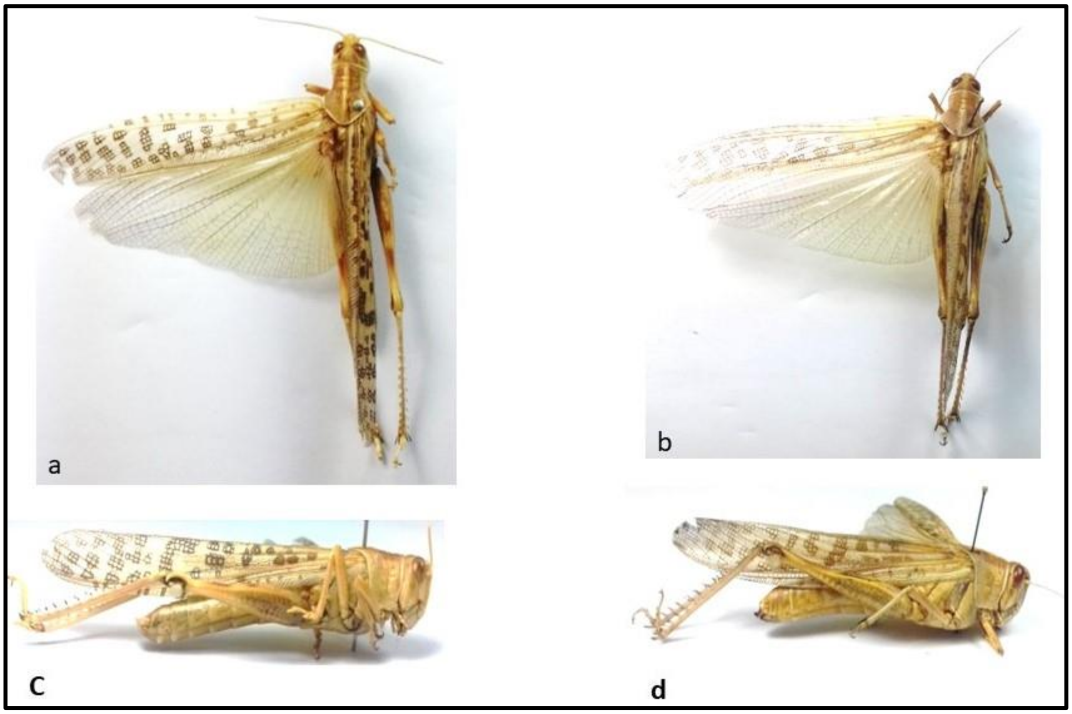
Cyrtacanthacridinae

Cyrtacanthaciridini

***Schistocerca* Stål, 1873**

***Schistocerca gregaria* (Forskal, 1775)**

Diagnostic features (Figs.1-2 a-k): Body large in size with yellowish brown in color but slightly smaller than female. Filiform antennae that a little bit longer than the pronotum and head combined. Longer pronotum than head, Fastigium of vertex trapezoidal extends from the vertex over the pronotum. Pronotum has with a low median carina in prozona. Prosternal process has cylindrical, slightly inclined. Lower basal lobe of the hind femur is shorter than the upper. The hind tibia's external top spines are absent. Tegmina and wings fully developed. Tegmina covered with plenty of brownish spots. Tegmina have slightly larger than wings. Abdomen is smaller than tegmina. Body has yellowish brown in color. Head has yellowish, eyes brownish. Fastigium of vertex show yellowish median band runs from the vertex over the pronotum. Lateral sides of pronotum are brown and dorsal side slightly dark brown. Femur yellowish with light dark shaded pattern noticed from the lateral side. Median carina present on pronotum is slightly white in color. Femur is dark brown inside and light brown outside. Tibia has yellowish with multiple dark pointed spines. Tegmina have with numerous brownish spots. Wings show pale color from the base up to the center of the wing while remaining area hyaline.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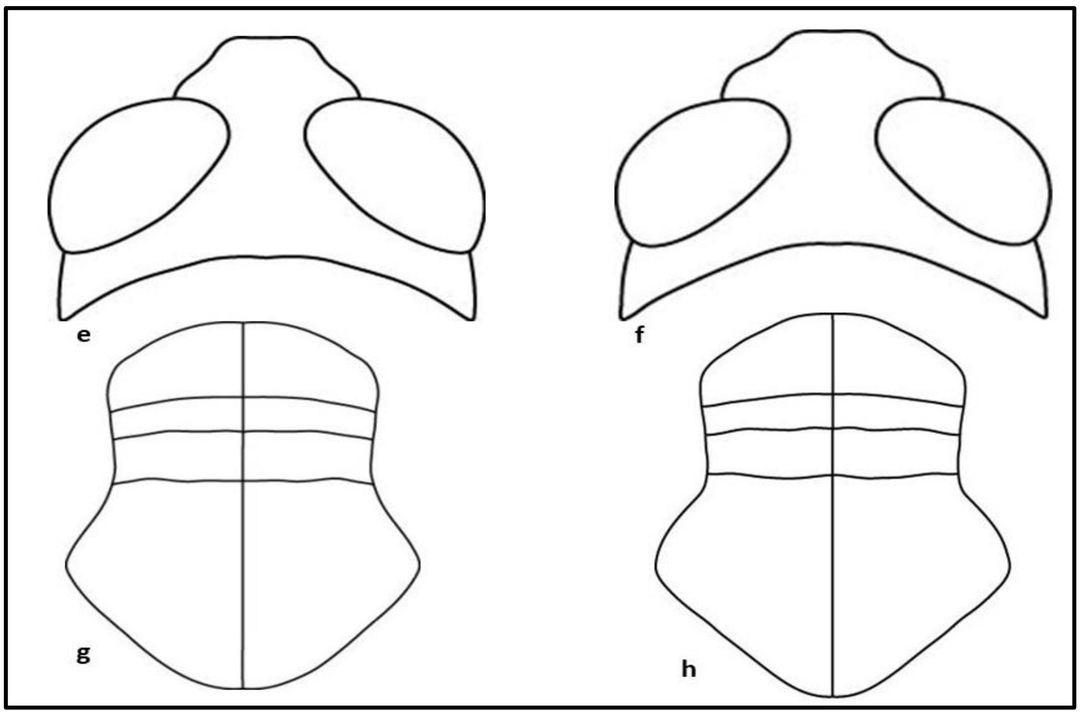
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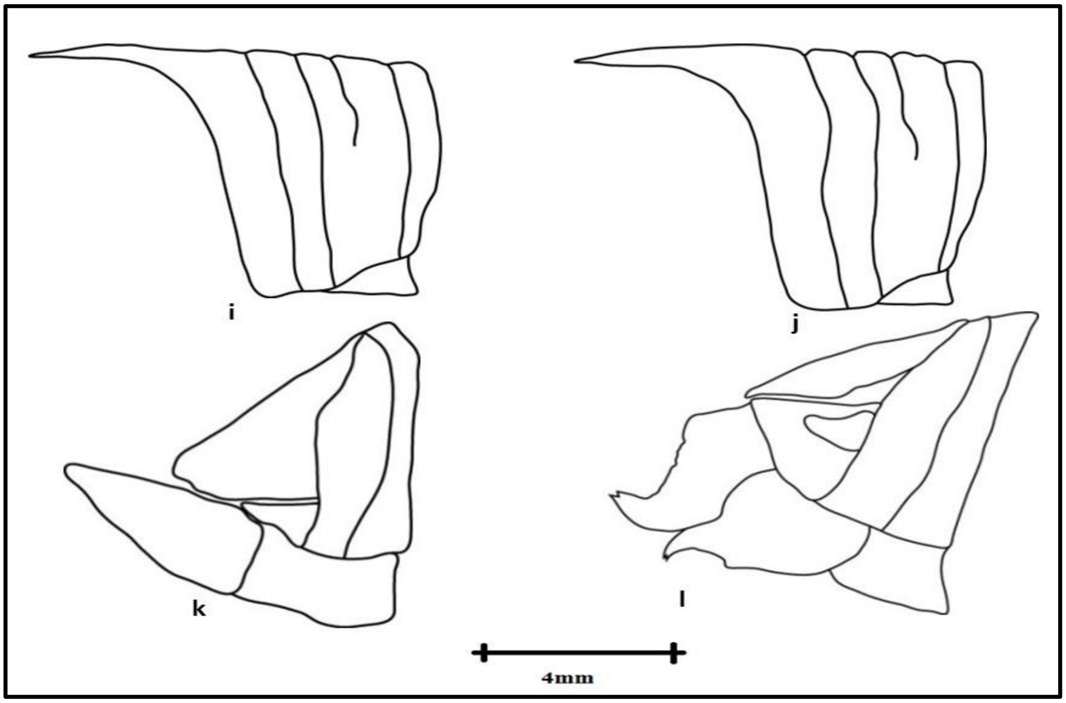

Figure. 1. *S. gregaria* (a-b) DV (c-d) LV (e-f) DV head (g-h) DV pronotum (i-j) LV pronotum (k) Cerci (l) Ovipositor

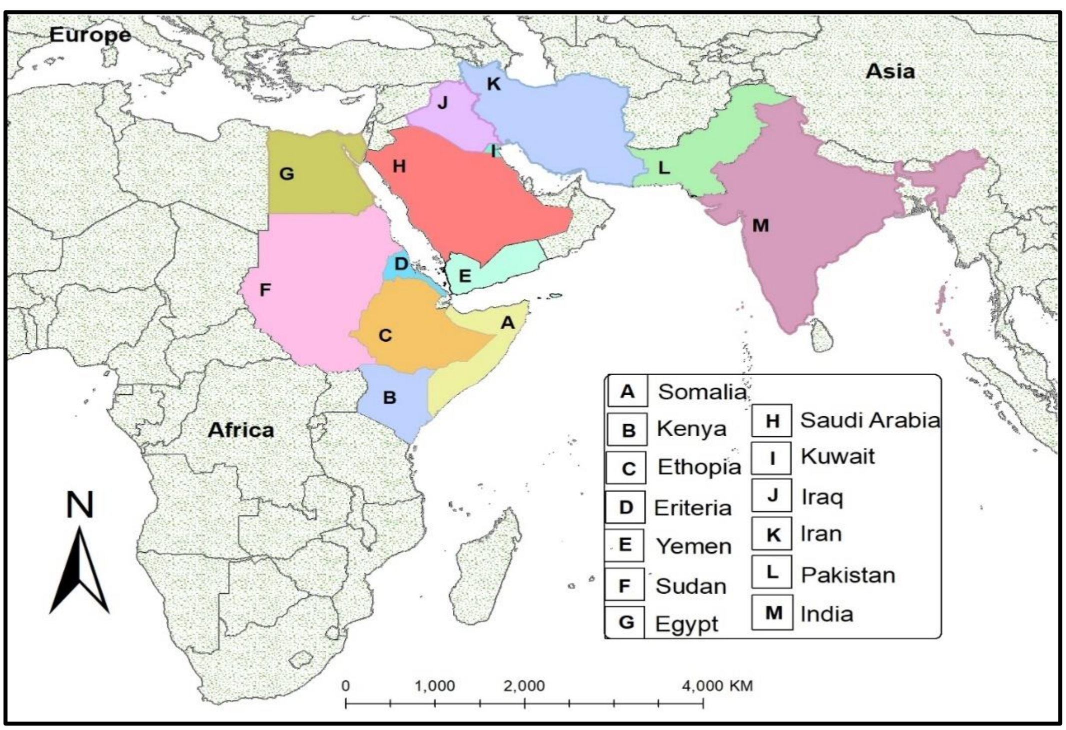

Figure. 2. Desert Locust upsurge (2019–2021) in different countries

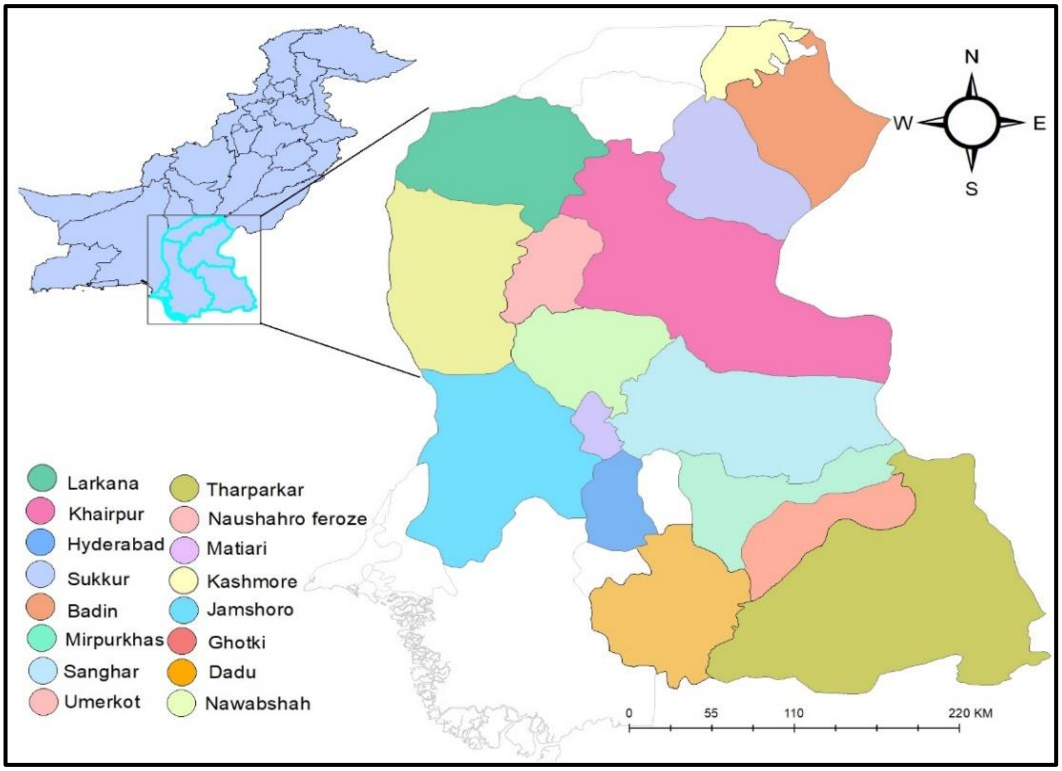

Figure. 3. Desert Locust upsurge (2019–2020) in different districts of Sindh.

Table 1: List of affected crops with updated price status after upsurge in various districts of Sindh

Districts	Major infested crops		Family	Deterrent status	Price status	
	Botanical name	**Common ID**			**Old**	**New**
Benazir abad	*Musa acuminata*	Banana	Musaceae	Moderate threat	90	148/1 Dozen
	Brassica oleracea	Cauliflower	Brassicaceae		30	50/1kg
	Daucus carota	Carrot	Apiaceae		40	60/1kg
Dadu	*Zea mays*	Maize	Poaceae	Susceptible	45	60/1kg
	Cenchrus americanus	Pearl Millet	Poaceae		65	90/1kg
	Oryza sativa	Rice	Poaceae		70	120/1kg
Ghotki	*Gossypium arboreum*	Cotton	Malvaceae	Severe threat	135	194/1kg
	Oryza sativa	Rice	Poaceae		70	120/1kg
	Triticum aestivum	Wheat	Poaceae		40	55/1kg
Jamshoro	*Hordeum vulgare*	Barley	Poaceae	Calm	35	55/1kg
	Triticum aestivum	Wheat	Poaceae		40	55/1kg
Kashmor	*Zea mays*	Maize	Poaceae	Calm	45	60/1kg
	Oryza sativa	Rice	Poaceae		70	120/1kg
	Triticum aestivum	Wheat	Poaceae		40	55/1kg
Matiari	*Oryza sativa*	Rice	Poaceae	Calm	70	120/1kg
	Saccharum officinarum	Sugarcane	Poaceae		110	169/1kg
Naushahro Feroza	*Solanum lycopersicum*	Tomato	Solanaceae	Susceptible	30	51/1kg
Tharparkar	*Cyamopsis tetragonoloba*	Guar	Fabaceae	Danger	65	80/1kg
	Cenchrus americanus	Pearl Millet	Poaceae		65	90/1kg
Umerkot	*Cenchrus americanus*	Pearl Millet	Poaceae	Danger	65	90/1kg
	Vigna radiata	Mung Bean	Fabaceae		105	150/1kg
	Sesamum indicum	Sesame	Pedaliaceae		180	233/1kg
	Capsicum annuum	Chilies	Solanaceae		190	280/1kg
Sanghar	*Gossypium arboreum*	Cotton	Malvaceae	Danger	135	194/1kg
	Triticum aestivum	Wheat	Poaceae		40	55/1kg

	Abelmoschus esculentus	Lady Finger	Malvaceae		80	160/1kg
Mirpurkhas	*Gossypium arboreum*	Cotton	Malvaceae	Moderate threat	135	194/1kg
	Saccharum officinarum	Sugarcane	Poaceae		110	169/1kg
	Mangifera indica	Mango	Anacardiaceae		90	150-1kg
	Abelmoschus esculentus	Lady Finger	Malvaceae		80	160/1kg
	Triticum aestivum	Wheat	Poaceae		40	55/1kg
Badin	*Gossypium arboreum*	Cotton	Malvaceae	Danger	135	194/1kg
	Oryza sativa	Rice	Poaceae		70	120/1kg
	Saccharum officinarum	Sugarcane	Poaceae		110	169/1kg
	Triticum aestivum	Wheat	Poaceae		40	55/1kg
	Abelmoschus esculentus	Lady Finger	Malvaceae		80	160/1kg
	Sorghum bicolor	Sorghum	Poaceae		240	300/1kg
Sukkur	*Triticum aestivum*	Wheat	Poaceae	Danger	40	55/1kg
	Gossypium arboreum	Cotton	Malvaceae		135	194/1kg
	Zea mays	Maize	Poaceae		45	60/1kg
	Saccharum officinarum	Sugarcane	Poaceae		110	169/1kg
	Fragaria ananassa	Strawberry	Rosaceae		360	450/1kg
	Vitis vinifera	Grapes	Vitaceae		110	150/1kg
Hyderabad	*Gossypium arboreum*	Cotton	Malvaceae	Severe threat	135	194/1kg
	Oryza sativa	Rice	Poaceae		70	120/1kg
	Triticum aestivum	Wheat	Poaceae		40	55/1kg
Khairpur	*Gossypium arboreum*	Cotton	Malvaceae	Danger	135	194/1kg
	Oryza sativa	Rice	Poaceae		70	120/1kg
	Triticum aestivum	Wheat	Poaceae		40	55/1kg
	Saccharum officinarum	Sugarcane	Poaceae		110	169/1kg
	Nicotiana tabacum	Tobacco	Solanaceae		180	250/1kg
	Abelmoschus esculentus	Lady Finger	Malvaceae		80	160/1kg
	Brassica oleracea	Cabbage	Brassicaceae		40	80/1kg
	Pisum sativum	Peas	Fabaceae		70	150/1kg
	Citrus limetta	Citrus	Rutaceae		110	150/1kg
	Cucumis melo	Melon	Cucurbitaceae		65	150/1kg
	Citrullus lanatus	Water-Melon	Cucurbitaceae		30	60/1kg
Larkana	*Oryza sativa*	Rice	Poaceae	Danger	70	120/1kg
	Triticum aestivum	Wheat	Poaceae		40	55/1kg
	Psidium guajava	Guava	Myrtaceae		70	130/1kg
	Malus domestica	Apple	Rosaceae		100	150/1kg
	Cucumis sativus	Cucumber	Cucurbitaceae		70	100/1kg
	Prunus persica	Peaches	Rosaceae		200	280/1kg
	Solanum tuberosum	Potato	Solanaceae		40	70/1kg
	Allium cepa	Onion	Amaryllidaceae		45	90/1kg
	Solanum melongena	Eggplant (Brinjal)	Solanaceae		35	60/1kg

Table 2. Field survey and random collection of desert locust in various districts of Sindh 2019-2021

Districts	Trip -I	Trip-II	Trip-III	Trip-IV	Total
Benazir abad	567	431	513	499	**2010**
Dadu	752	661	703	531	**2647**
Ghotki	691	585	519	603	**2398**
Jamshoro	731	591	689	571	**2582**
Kashmor	621	601	727	697	**2646**
Matiari	843	521	651	782	**2797**
Naushahro Feroza	711	496	433	551	**2191**
Tharparkar	891	803	701	753	**3148**
Umerkot	808	731	692	909	**3140**
Sanghar	523	656	631	531	**2341**
Mirpurkhas	499	591	602	692	**2384**
Badin	545	611	639	743	**2538**
Sukkur	643	586	720	783	**2732**

Hyderabad	526	599	491	501	**2117**
Kahairpur	803	762	883	759	**3207**
Larkana	782	704	864	873	**3223**
Total	**10936**	**9929**	**10458**	**10778**	**42101**

Table 3. Current status of locust emergence in Sindh (Solitary Phase) during 2022

Districts	GPS	Stages		Vegetation	
		Hopper	Adults	State	Density
Benazir abad	26.2988° N, 68.2385° E	7	3	Greening	Low
Dadu	26.7341° N, 67.7795° E	13	2	Drying	Medium
Ghotki	28.0271° N, 69.3235° E	23	--	Green	Dense
Jamshoro	25.4304° N, 68.2809° E	---	7	Green	Low
Kashmor	28.4482° N, 69.5857° E	21	9	Drying	Dense
Matiari	25.5922° N, 68.4442° E	5	3	Green	Medium
Naushahro Feroza	26.8463° N, 68.1253° E	7	7	Green	Medium
Tharparkar	24.8777° N, 70.2408° E	26	11	Greening	Dense
Umerkot	25.3549° N, 69.7376° E	9	13	Greening	Medium
Sanghar	26.0436° N, 68.9480° E	31	8	Drying	Dense
Mirpurkhas	25.5065° N, 69.0136° E	9	3	Green	Low
Badin	24.6459° N, 68.8467° E	--	5	Green	Low
Sukkur	27.7244° N, 68.8228° E	7	11	Greening	Low
Hyderabad	25.3960° N, 68.3578° E	9	12	Drying	Medium
Khairpur	27.5256° N, 68.7551° E	17	6	Greening	Dense
Larkana	27.5570° N, 68.2028° E	3	---	Dry	Low

Morphometry (mm): Solitary Phase ♂♀. AS. 26.4 ± 0.54, 26.8 ± 0.83, AT, 16.38 ± 1.68, 16.94 ± 1.34, LH 0.65 ± 0.05, 0.65 ± 0.05, DBE 0.36 ± 0.01, 0.34 ± 0.03, LP12.0 ± 1.0, 14.2 ± 1.09, LT54.0 ± 4.30, 54.0 ± 4.30, LW51.9 ± 4.18, 62.3 ± 3.05, LF, 29.8 ± 2.38, 31.4 ± 0.54, LTi, 26.6 ± 2.07, 28.8 ± 1.30, TBL54.2 ± 4.08, 60.8 ± 1.09.

Gregarious Phase ♂♀ AS 17.8 ± 3.83, 16.8 ± 0.83, AL 11.4 ± 2.01, 11.6 ± 0.30, LH 0.70 ± 0.03, 0.69 ± 0.02, DBE 0.39 ± 0.02, 0.34 ± 0.05, LP 11.0 ± 0.70, 13.0 ± 1.22, LT 47.6±1.64, 57.9±2.55, LW 42.0±2.47,53.7±7.46, LF 26.6 ± 2.40, 29.4 ± 2.79, LTi, 24.6 ± 2.88, 24.4 ± 1.67, TBL 54.6 ± 5.07, 55 ± 1.58.

Affected host plants: Locusts consume plants. As a result, when they invade a nation, they destroy its pastures, crops, and natural vegetation. In most cases, the damage causes considerable crop losses. The data speaks for itself. Every crop is destroyed by the desert locust. It has a significant influence on cattle productivity since it may seriously harm the natural vegetation. (Table. 1). Huge varieties of crops, such as Jowar (*Sorghum vulgarei*), Barley (*Hordeum vulgare*), and Pearl millet (*Pennisetum glaucum*), were grown during the 2019–2020 growing season. A small number of samples were also taken near *Ziziphus (Ziziphus nummulariai), Euphorbia* (*Euphorbia neriifolia*), and Bermuda grass (*Cynodon dactylon*). The damage was incalculable due to the enormous swarm that was seen during the current study, which consumed all vegetation in its *grgareous* phase. The farmers were extremely concerned since they had witnessed the destruction of their crops firsthand. Both crops and non-crop plants were largely consumed.

Global distribution: India, Iran, Yemen, Iraq, Egypt, Kenya, Ethiopia, Eriteria, Somalia, Sudan, Kuwait, Saudi Arabia and Pakistan. Its presence in Sanghar, Badin, Nangarparkar, Umerkot, Chachro, Diplo and Mithi, Khairpur, Thar and Nara, Sindh, Pakistan (Table 2, Fig. 3).

Recent emergence of desert locust: Both in Baluchistan and many areas of Sindh, a thorough study was planned. In June 2022, the situation with the Desert Locust remained stable. In several parts of Sindh and Balochistan where no control operation was carried out, only small numbers of solitarious hoppers and adults continued to exist (Table 3). With the exception of a few districts, Sanghar Tharparkar, Ghotki, and Kashmor, i.e., 31, 26, 23, and 21 correspondingly, where hoppers have emerged, the situation is generally excellent and the present locust emergence is peaceful in visited places. Small-scale breeding will take place in the deserts of Nara, Thar, and Cholistan over the projected period. Due to this, locust populations will marginally rise but will still be quite low. If there is rainfall throughout the expected timeframe, limited breeding may also take place in Balochistan and the interior of Punjab.

Discussion

Africa, the region north of the equator, the Middle East, the Arabian and Indo-Pakistani peninsulas, and occasionally Mediterranean Europe make up the habitat of the desert locust. Over 20% of the world's land area is covered by the 57 countries. The locusts retire to the driest regions of their typical habitat between two successive invasions, where they might go undiscovered for several years (Lecoq 2004). This insect is not merely a problem of the past, and spectacular incidents still happen occasionally (Belayneh, 2005; Latchininsky *et al*., 2011; Latchininsky, 2013). For a variety of reasons, some outbreaks cannot be stopped at an early stage (Lecoq, 2005, 2001), the swarms spread quickly over an expanding area, the control measures become more and more expensive and difficult to organize, the villagers are typically powerless in the face of the swarms' sudden and massive arrival, and crop damage can be significant (Brader *et al*., 2006; Lecoq, 2005). The current upswing that began in 2018 and continued through 2019–2020 serves as evidence of this. It is concerning for the food security of many developing and underdeveloped nations as this swarm, which originated in the southern Arabian Peninsula, has invaded a significant portion of East Africa, the Middle East, and Southwest Asia up until Pakistan and India (FAO, 2021; Meynard et al., 2020). According to earlier research (De Vreyer *et al*., 2015), the effects of such catastrophes on the economy, society, and environment can occasionally last or manifest themselves years later. We both concur on this account. Vegetable costs in particular have risen rather sharply in several regions of the nation, with retail prices nearly universally ranging from 25% to 200%. Price increases of up to 200% have been seen in the price of tomato, wheat, rice, potatoes, and lemon, which have seen the biggest increases (Please refer Table 1). Other variables, such as the increase in oil prices that began in April 2020 have impacted the prices of all food commodities on the FAO index by raising the expenses of food production and transportation. Because of the COVID epidemic, there are fewer people available to raise, harvest, process, and distribute food, which is another common reason why commodities prices are rising. Approximately 20% of Pakistan's GDP comes from agriculture, and desert locust-related damage decreased agricultural production by 2% in fiscal year 2020. (The Economic Times 2020). Crop damage by desert locusts exacerbated problems brought on by a longer-term state of declining water availability and a drought lasting 2-3 years (Committee International Rescue, 2020).

According to DDP, across the provinces of Baluchistan, Khyber Pakhtunkhwa, Punjab, and Sindh, a total of 300,595 ha was sprayed after an estimated 932,580 ha area was inspected for desert locust activity (Ahmed 2019). 14 districts in Punjab Province were impacted, while the most heavily infested districts in Baluchistan were Kaachi and Kharan, Laki Marwat, and Tank districts of Khyber Pakhtunkhwa Province, while the most heavily infested districts in Sindh Province were Khairpur, Kashmoor and Benazir Abad, National Locust Control Center, 2021. Due to the extensive use of chemicals and pesticides during locust control activities, there may be adverse environmental repercussions (Lazar *et al.,* 2016). The ecosystems inevitably suffer collateral damage as it is difficult to distinguish between locust swarms and other benign animals and plants. Intoxication from the utilized chemical pesticides may also occur in humans, in addition to the direct effects on the surrounding ecology (Brader *et al*., 2006; Riffat, 2020). Experts on climate change also anticipate an increase in temperature. The rate of locust growth and swarm migration is governed by temperature. Thus, the protracted maturation and incubation periods during the spring may be shortened as a result of climate change, allowing an additional generation of breeding to take place in North-West Africa, the Arabian Peninsula, and South-West Asia. This might raise the annual locust production rate in certain areas and the danger of plague in general. Any modifications to wind circulation, speed, or direction are anticipated to have an impact on Desert Locust migration and may open up new travel opportunities for adults and swarms at various periods of the year. The ecological, habitat, and meteorological circumstances will determine if they can survive, reproduce, and establish themselves in these new locations (WMO & FAO, 2016). According to (Sharma, 2014) the arrival of the rainy season in March is projected to cause the locust epidemic to spread even further, as well as food shortages and humanitarian concerns. Considering the current situation, this study supports (Sharma, 2014).

Conclusion

Due to the impact of a significant desert locust swarm in 2019–2020, Pakistan's economic situation has declined. Increased regional collaboration between nations is crucial for management programs since locust outbreaks are frequently of an international nature and transboundary migration is frequent. Strong procedures must be put in place to provide ongoing financial assistance at the national and international levels so that treatment programs may be implemented quickly as a component of effective sustainable preventative management strategies. Furthermore, functional genome sequencing may reveal a variety of molecular targets that might aid in management.

Author Contributions: field surveys N.S & methodology R.S Conceptualization, analysis and drafting S. K analysis & methodology, S.S. field surveys Conceptualization, S.M. The manuscript's published form was approved by all authors once they had read it.
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Conflicts of Interest: The authors declare no conflict of interest.

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