Online ISSN: 2588-3526
Journal of Wildlife and Biodiversity

*Volume 8(3): 121-133 (2024) (*http://www.wildlife-biodiversity.com/*)*

Research Article

Studies on *Schistocerca gregaria* (Cyrtacanthacridinae: Acrididae: Orthoptera) from Taluka Dadu Sindh-Pakistan

Abdul Sattar Kalhoro*, Naheed Baloch, Riffat Sultana
Department of Zoology, University of Sindh Jamshoro Pakistan
*Email: askalhoro66@gmail.com

Received: 19 March 2024/ Revised: 25 May 2024 / Accepted: 25 May 2024/ Published online: 26 May 2024.
How to cite: Kalhoro, A.S., Baloch, N., Sultana, R. (2024). Studies on *Schistocerca gregaria* (Cyrtacanthacridinae: Acrididae: Orthoptera) from Taluka Dadu Sindh-Pakistan, Journal of Wildlife and Biodiversity, 8(3), 121-133. **DOI**: https://doi.org/10.5281/zenodo.11305591.

Abstract

Schistocerca gregaria is a notorious pest amongst insects populating around the globe. *S.gregaria* form swarms that can spread across millions of square kilometers daily, significantly impacting international economies, societies, and ecosystems. The invasions can devastate the rural communities in the affected areas, threatening their ability to provide for themselves and their families with food. Many millions of dollars are often spent on control measures, and the widespread use of chemical insecticides has negative consequences for the ecosystem. During the present study 597 specimen of *Schistocerca gregaria* collected from different localities of Taluka Dadu. These specimens were identified according to the four different coloration; Pink, Light Brown, Yellow, and White. Solitarious phase specimens 104 and 493 Gregarious phase collected from various localities. Besides this, the distribution, morphology, and diversity of *S.gregaria* have been presented in this study.
Keywords: *Schistocerca gregaria,* Pest, Identification, Solitarious phase, Gregarious phase

Introduction

Schistocerca gregaria is ainsect pest, bread as well as found in desert areas and eat all types of crops are a group of different species of short-horned grasshoppers belonging to the family Acrididae (Order: Orthoptera). With around 36 species and 8 sub-species, the genus *Schistocerca* (Stal) (Song, 2006) is regarded as the largest and most notable genus of the sub-family Cyrtacanthacridinae (Samejo, & Sultana, 2016). Of them, mainly *Schistocerca gregaria* (Forskal) is globally dispersed and found in Pakistan (Saha *et al.*,20210). The order Orthoptera has other species like grasshoppers and crickets. The Locust and grasshoppers insects are the same in appearance but distinguished from grasshoppers with their swarm-forming ability, body shape, size and color-changing morphological characters (Symmons & Cressman, 2001) and locusts exist

in two different behaviors states (Solitary and *Gregarious* phase) whereas most grasshoppers do not and locust generally found in desert regions. Dong *et al.*,(2023) studied the locust genus *Schistocerca* (Stal) and stated that this group has been controversial for up to a century. Amongst 50 species of this genus, *S.gregaria* was found only in old-world countries while others were found in new-world countries. Previous scientists recommended Desert locusts as migratory Locusts in America. Besides this, understanding the swarming phase of locusts sturdily tested huge traversed between cutting edges in 1988 (Atlantic Ocean to West Africa & West Indies) (Morgan, 1981). Presently known data supports the occurrence of this genus and swarming phases of locust species, while offspring of *S.gregaria* species were considered as an antecedent while locusts found in deserts were reported to be inherited from this genus. Nevertheless, it might have a small signal to understand the swarm other than 1988 which supports this type of understanding. When the population density is low, locusts behave as individuals, much like grasshoppers. The various authors (Cressman, 2016; Simpson *et al.*,1999; Skaf *et al.*, 1990; Van Huis *et al.*,2007; Collett *et al.*,1998; Lecoq, 2005; Matthews, 2021; Showler,2019; Githae & Kuria, 2021; Taylor & Thomas, 2003) have taken the specific work on taxonomic, ecological and biological aspect so locust and grasshoppers from different climatic regions.

The life cycle of the desert locust contains 03 phases viz: adult hopper & eggs. The hatching period of eggs is observed up to 10 to 65 days or 02 weeks. The life cycle commences with the eggs, which hatch to give the nymphs, which develop to the adult stage (Erezyilmaz, 2006). It has also been found that copulation of one time is enough for the fertilization of eggs (Teng & Kang, 2007). Locust herds arrived in the Middle East from East Africa. In the meantime, the coronavirus breaks out in Iran. Govt. of Iran was engaged in controlling the spread of corona. Appropriate procedures were not taken to kill locust herds, and then locust herds (swarms) entered Baluchistan from Iran. Due to its extreme resilience, Pakistan is additionally the main country along the classic locust border. Summer and spring rearing areas include the Indian border in the barren landscapes of Cholistan, Khipro, and Tharparkar (Southern Punjab as well as Sindh), as well as the Labella/Uthal area west of Karachi, which is considered a transitional region in which locusts are intimately accessible year-round. Following the initial swarm that appeared in 1961, an enormous flock from Iran invaded Pakistan 1961, decimating crops such as maize, wheat, and cotton. Later, in November 2019, a heat wave that originated in Karachi expanded to other parts of Pakistan (Khatri, 2019; Pervaz, 2021; Panhwar *et al.*,2023). The present study was designed for the first time from Taluka Dadu Sindh-Pakistan. This study aims to describe the *Schistocerca* in this region.

Material and methods

The current study used a time-series continuous survey method to gather data on short-horned Grasshoppers (Acrididae family) and desert locusts by making multiple trips and investigations over one year across the three zones and crops or plants of Taluka Dadu mentioned above. The Acrididae family of short-horned grasshoppers that are in the subfamily Crytacanthacridinae Genus *Schistocerca* species *gregarious* phase and solitarious phase in all three zones (mentioned below) of taluka The study's targeted population consisted of Dadu. To cover all of the intended zones, multi-stage random sampling approaches were employed (River-belt or Kacho zone, Agricultural-belt or Pacco zone, and mountain desert belt or Kaachho zone) by making several, haphazard surveys of various plants/crops to ascertain overall biodiversity: Rabbi harvests/crops: wheat, onion, maize, tomato, sorghum, grass, Oat (Barsim) crops; Kharif harvests/crops: cotton, rice, sugarcane, lady-finger, spinach, and grass (lawn); Wild-plants: acacia, Drabh, Devi, Kirir, and Kandero plants, and trees. The information was gathered by eyewitness observation and the collection of the data (short-horned grasshoppers of the Acrididae family) using a 20-inch-long, 4-5-inch-diameter pest-catching net. The pests were subjected to a 10% saturated liquid chloroform solution after capture. Subsequently, using a Venire calliper, they were stretched to quantify their various internal and external dimensions in a millimeter. The place of collection, sub-location, crops, and seasons were noted in addition to the data that was gathered. Identification of species was confirmed through the available literature and Orthoptera species file online.

Results

The present study was made to investigate the *Schistocerca* from **Taluka** Dadu Sindh Pakistan. The study resulted in **the** finding of the various forms of *Schistocerca.* The details of the taxa are as follows:

Taxa

Orthoptera

Acridoidea

Acrididae

Subfamily Cyrtacanthacridinae

Diagnosis

Size large to medium. Antenna filiform. Head sub-globular or sub-conical, fastigium of vertex short. Pronotum with median carina, lateral carinae absent. Prosternal process present. Mesosternal

interspace open, its lobes rectangular. Tegmina and wings fully developed. The lower basal lobe of the hind femur is shorter than the upper one. The external apical spine of the hind tibia is absent. Male cercus of variable shape. Supra anal plate angular. Sub genital plate conical or subconical. Ovipositor short with valves curved at apices. The members of this subfamily are usually large and include some of the most destructive species *Schistocerca gregaria*.

Diagnosis of genus *Schistocerca*

Body large size, integuments finely punctuate. Antenna thick, filiform, longer than head and pronotum together. Head sub-globular, eyes oval, situated in the middle part of the head; fastigium of vertex trapezoidal with shallow longitudinal depression frontal ridge low, with parallel sides, slight depression at ocellus. Pronotum constricted at prozona, granulose, median carina low, which is sometimes indistinct in the anterior part, dorsum crossed by three sulci, metazona slightly longer than prozona, its posterior margin. The prosternal process is cylindrical, slightly widened in the middle and slightly narrowed at apex, which is obtuse, and moderately inclined backward. Mesosternal interspace gradually narrows backwardly about twice longer than its greatest width. Metasternal inter-space open. Tegmina and wings fully developed. The hind femur does not reach as far as the tip of the abdomen, hind tibia spinose. Arolium large. Male cerci wide, strongly compressed, with almost truncate, slightly incurved apex. Sub-genital plate with deeply incised apex. Valves of ovipositor short, robust, with curved apices, lower valve on external sides with obtuse lateral projection.

Description of *Schistocerca gregaria* (Forskal, 1775)

Male: Size large, Antenna filiform, 28 segmented, slightly longer than head and pronotum together. Head sub-globular and smaller than pronotum; fastigium of vertex wide, trapezoidal, slightly concave, extending roundly over frons, lateral carinae distinct, slightly flat; fastigial foveolae indistinct; frontal ridge wide and flat but narrow near median ocellus. Pronotum flat, slightly constricted and narrowed at prozona; median carina low; lateral carinae absent; dorsum crossed by three sulci; prozona nearly equal to metazona in length; prozona slightly raised than metazona; acute rounded at posterior margin. The prosternal process is cylindrical, widened in the middle, with an obtuse rounded apex. Mesosternal interspace open, longer than its greatest width, slightly larger than its lobes, narrowing posteriorly. Metasternum open. Tegmina and wings are well developed, obtusely rounded at apices, wings shorter than tegmina. Hind femur denotes dorsal carina, ventral genicular lobes larger than dorsal ones. Hind tibia with 9-11 black-tipped and white-

based spines. Arolium medium to large size. Supra anal plate elongated and triangular. Cerci flat, dorso-ventrally compressed, with wide rounded apices. Sub-genital plate bilobed with a median triangular incision

Coloration

Yellowish to brown. Antennae brown or yellow. Tegmina is semitransparent, paler brown, with scattered brown spots. Wings hyaline, light paler at the base. Hind femur brown or paler brown, with dark bands on the outer margin. Hind tibia paler to light brown.

Female

Similar in appearance to males but larger. Cerci are small, conical, hairy, basally compressed, with obtuse rounded apices. Ovipositor stout, small and curved, dorsal valves hook-like with pedestals, ventral valves with basal lateral projections. Subgenital plate is trilobed of which lateral lobes are short while the median elongated and pointed.

Diversity in *Schistocerca gregaria* (gregarious and solitarious phases)

There are more than 597 specimen of *Schistocerca gregaria* collected from different localities of Taluka Dadu. These specimens were identified according to the four different coloration; Pink, Light Brown, Yellow and White. Solitarious phase specimens 104 and 493 Gregarious phase collected from different localities.

Figure 1. Showing Swarm variant colors (a) Yellow, (b) Pink, (c) White, (d) Brown

Table 1. Month-wise presence and absence number of *S.gregaria (*gregarious phase and Solitarious phase) (Pink) during January to December 2020 in different areas of Taluka Dadu.

S.N	Coloration	Months	Hafiz Meer M.kalhoro	Khudabad	Amirani	Total
01	*Schistocerca gregaria* **(Pink)** *gregarious* phase	**January**	11	09	04	24
		February	10	11	06	27
		March	12	13	08	33
		April	12	10	10	32
		May	09	14	07	30
		June	13	16	14	43
		July	10	10	09	29
		August	08	12	07	27
Total Specimen			**85**	**95**	**65**	**245**
01	Solitarious phase	**September**	02	03	04	09
		October	03	02	04	09
		November	04	01	03	08
		December	02	02	01	05
Total Specimen			**11**	**08**	**12**	**31**

In Table 1 presents the population of *Schistocerca gregaria* Solitarious Phase from January to December 2020. In January Hafiz Meer M. Kalhoro represented 11 specimens, Khudabad with 9 specimens and Amirani with 4 specimens respectively. In February Hafiz Meer M. Kalhoro

represented 10 specimens, Khudabad with 11 specimens and Amirani with 6 specimens respectively. In March Hafiz Meer M. Kalhoro represented 12 specimens, Khudabad with 13 specimens and Amirani with 8 specimens respectively. In April Hafiz Meer M. Kalhoro represented 12 number of specimens, Khudabad with 10 specimens and Amirani with 10 specimens respectively. In May Hafiz Meer M. Kalhoro represented 9 specimens, Khudabad with 14 specimens and Amirani with 7 specimens respectively. In June Hafiz Meer M. Kalhoro representing 13 specimens, Khudabad with 16 specimens and Amirani with 14 specimens respectively. In July Hafiz Meer M. Kalhoro represented 10 specimens, Khudabad with 10 specimens and Amirani with 9 specimens respectively. In August Hafiz Meer M. Kalhoro represented 8 specimens, Khudabad with 12 specimens and Amirani with 7 specimens respectively. In September Hafiz Meer M. Kalhoro represented 2 number of specimens, Khudabad with 3 specimens and Amirani with 4 specimens respectively. In October Hafiz Meer M. Kalhoro represented 3 specimens, Khudabad with 2 specimens and Amirani with 4 specimens respectively. In November Hafiz Meer M. Kalhoro represented 4 number of specimens, Khudabad with 1 specimens and Amirani with 3 specimens respectively.In December Hafiz Meer M. Kalhoro represented 2 specimens, Khudabad with 2 specimens and Amirani with 1 specimen respectively.

Table 2. Month-wise presence and absence number of *S. gregari*a *(*gregarious phase and Solitarious phase) (Light brown) from January to December 2020 in different areas of Taluka Dadu

S.N	Coloration	Months	Hafiz Meer M.kalhoro	Khudabad	Amirani	Total
02	*Schistocerca gregaria* **(Light brown) gregarious phase**	**January**	04	06	05	15
		February	06	05	03	14
		March	08	06	05	19
		April	10	05	04	19
		May	07	06	06	19
		June	14	08	08	30
		July	09	05	04	18
		August	07	02	02	11
Total Specimen			**65**	**43**	**37**	**145**
02	*Schistocerca* **solitarious** phase	**September**	01	01	01	03
		October	02	00	01	03
		November	00	03	00	03
		December	02	01	00	03
Total Specimen			**05**	**05**	**02**	**12**

In table 2 presents the population of *Schistocerca gregaria* Solitarious phase during January to December 2020. In January Hafiz Meer M. Kalhoro represented 4 number of specimens, Khudabad with 6 specimens and Amirani with 5 specimens respectively. In February Hafiz Meer M. Kalhoro represented 6 specimens, Khudabad with 5 specimens and Amirani with 3 specimens respectively. In March Hafiz Meer M. Kalhoro represented 8 specimens, Khudabad with 6 specimens and Amirani with 5 specimens respectively. In April Hafiz Meer M. Kalhoro represented 10 specimens, Khudabad with 5 specimens, and Amirani with 4 specimens respectively. In May Hafiz Meer M. Kalhoro represented 7 specimens, Khudabad with 6 specimens and Amirani with 6 specimens respectively. In June Hafiz Meer M. Kalhoro represented 14 specimens, Khudabad with 8 specimens, and Amirani with 8 specimens respectively. In July Hafiz Meer M. Kalhoro represented 9 specimens, Khudabad with 5 specimens, and Amirani with 4 specimens respectively.In August Hafiz Meer M. Kalhoro represented 7 specimens, Khudabad with 2 specimens and Amirani with 2 specimens respectively. In September Hafiz Meer M. Kalhoro represented 1 number of specimens, Khudabad with 1 specimen and Amirani with 1 specimen respectively. In October Hafiz Meer M. Kalhoro represented 2 number of specimens, Khudabad with no specimens and Amirani with 1 specimens respectively. In November Hafiz Meer M. Kalhoro represented no number of specimens, Khudabad with 3 specimens and Amirani with no specimens respectively.In December Hafiz Meer M. Kalhoro represented 2 specimens, Khudabad with 1 specimen, and Amirani with no specimens respectively.

Table 3. Month-wise presence and absence number of *S. gregaria (*gregarious phase and Solitarious phase) (Yellow) from January to December 2020 in different areas of Taluka Dadu

S.N	Coloration	Months	Hafiz Meer M.kalhoro	Khudabad	Amirani	Total
03	*Schistocerca gregaria* **(Yellow) gregarious phase**	**January**	03	04	01	08
		February	02	05	01	08
		March	02	03	04	09
		April	03	03	02	08
		May	02	03	03	08
		June	05	07	06	18
		July	02	04	01	07
		August	02	03	02	07
Total Specimen			**21**	**32**	**20**	**73**
03	*Schistocerca* solitarious phase	**September**	00	00	01	01
		October	01	01	01	03
		November	00	01	01	02
		December	01	01	00	02
Total Specimen			**02**	**03**	**03**	**08**

In Table 3, we present the population dynamics of the *Schistocerca gregaria* Solitarious phase throughout the year 2020. In January, Hafiz Meer M. Kalhoro observed 3 specimens, while Khudabad and Amirani reported 4 and 1 specimen(s) respectively. February saw Hafiz Meer M. Kalhoro documenting 2 specimens, with Khudabad and Amirani recording 5 and 1 specimen(s) respectively. The trend continued in March, with Hafiz Meer M. Kalhoro noting 2 specimens, and Khudabad and Amirani reporting 3 and 4 specimens respectively. April brought in 3 specimens for Hafiz Meer M. Kalhoro, and 3 for Khudabad, while Amirani observed 2 specimens. May showed a similar pattern, with Hafiz Meer M. Kalhoro, Khudabad, and Amirani recording 2, 3, and 3 specimens respectively. June witnessed a notable increase, with Hafiz Meer M. Kalhoro observing 5 specimens, Khudabad reporting 7 specimens, and Amirani noting 6 specimens. July maintained consistency, as Hafiz Meer M. Kalhoro, Khudabad, and Amirani documented 2, 4, and 1 specimen(s) respectively. In August, Hafiz Meer M. Kalhoro, Khudabad, and Amirani observed 2, 3, and 2 specimens respectively. September marked no observations from Hafiz Meer M. Kalhoro, while Khudabad reported no specimens, and Amirani noted 1 specimen. October showed a slight decline, with Hafiz Meer M. Kalhoro, Khudabad, and Amirani observing 1 specimen each. November saw no observations from Hafiz Meer M. Kalhoro, while Khudabad and Amirani reported 1 specimen each. December concluded the year, with Hafiz Meer M. Kalhoro documenting 1 specimen, Khudabad noting 1 specimen, and Amirani reporting no specimens.

Table 4. Month wise presence and absence number of *S. gregaria* (gregarious phase and Solitarious phase) (White) during January to December 2020 in different areas of Taluka Dadu.

S.N	Coloration	Months	Hafiz Meer M.kalhoro	Khudabad	Amirani	Total
04	*Schistocerca gregaria* **(White) gregarious phase**	**January**	01	01	01	03
		February	01	01	01	03
		March	01	01	01	03
		April	01	01	02	04
		May	01	01	01	03
		June	03	02	04	09
		July	01	01	01	03
		August	01	00	01	02
Total Specimen			**10**	**08**	**12**	**30**
04	*Schistocerca* solitarious Sphase	**September**	00	00	01	01
		October	01	01	00	02
		November	01	00	00	01
		December	00	00	00	00
Total Specimen			**02**	**01**	**01**	**04**

Table 4 presents the population of *Schistocerca gregaria* Solitarious phase during January to December 2020. In January Hafiz Meer M. Kalhoro represented 1 number of specimens, Khudabad with 1 specimen and Amirani with 1 specimen respectively. In February Hafiz Meer M. Kalhoro represented 1 number of specimens, Khudabad with 1 specimen and Amirani with 1 specimen respectively. In March Hafiz Meer M. Kalhoro represented 1 number of specimens, Khudabad with 1 specimen and Amirani with 1 specimen respectively. In April Hafiz Meer M. Kalhoro represented 1 number of specimens, Khudabad with 1 specimens and Amirani with 2 specimens respectively. In May Hafiz Meer M. Kalhoro represented 1 number of specimens, Khudabad with 1 specimen, and Amirani with 1 specimens respectively. In June Hafiz Meer M. Kalhoro represented 3 specimens, Khudabad with 2 specimens and Amirani with 4 specimens respectively. In July Hafiz Meer M. Kalhoro represented 1 number of specimens, Khudabad with 1 specimen, and Amirani with 1 specimen respectively.In August Hafiz Meer M. Kalhoro represented 1 number of specimens, Khudabad with no specimens and Amirani with 1 specimen respectively. In September Hafiz Meer M. Kalhoro represented no number of specimens, Khudabad with no specimens and Amirani with 1 specimen respectively. In October Hafiz Meer M. Kalhoro represented 1 number of specimens, Khudabad with 1 specimen, and Amirani with no specimens respectively. In November Hafiz Meer M. Kalhoro represented 1 number of specimens, Khudabad with no specimens and Amirani with no specimens respectively. In December Hafiz Meer M. Kalhoro represented no number of specimens, Khudabad with no specimens, and Amirani with no specimens respectively.

Discussion

Scistocerca gregaria is an individual of various species of short-horned grasshoppers that belong to the family Acrididae (Orthoptera). It is a severe insect pest that is also edible and may be found in arid areas and on various sorts of crops. With around 36 species and 8 sub-species, the genus *Schistocerca* is regarded as the largest and most notable genus of the sub-family Cyrtacanthacridinae (Panhwar & Mustafa, 2022). The present study was conducted from taluka Dadu Sindh Pakistan. About 597 specimens of *Schistocerca gregaria* were collected from different localities of Taluka Dadu. These specimens were identified according to the four different coloration; Pink, Light Brown, Yellow and White. Solitarious phase specimens 104 and 493 Gregarious phase collected from various localities. Cullen *et*

al., (2010),stated that the locusts are grasshoppers that are subjected to particular environmental cues and evolve into phenotypic varieties such as *gregarious* phase , swarming, and solitarious phase . It is discovered that there are clear differences in the morphology, physiology, and behavior of these traits. While morphology and physiology are examples of features with polyphenism that can change over several generations, certain species have behaviour that can change in a matter of hours. Basher *et al.*, (2018), solitarious phase female locusts in the Red Sea region tended to ovipositor near Heliotropisms sp. and millet plants during the time of year when it rained. Notably, these plants were also the favoured food source for solitarious phase nymphs. It was shown by field experiments conducted in cages that solitarious phase females favoured to oviposit near such flowers. Conversely, ovipositor assay results in the lab demonstrated that, in two-choice trials with untreated controls, solitarious phase females were drawn to the froths of egg pods of both phases. In a further study, McCaffery *et al.*, (1998) demonstrated that exposing solitarious phase female egg pods to *gregarious* phase female froth extracts also predisposed the hatchling to *gregarious* phase traits. More recently, Baloch *et al.*,(2023) provided a detailed checklist of Acridoidea of Punjab, Pakistan. They described 04 species: *Schistocerca gregaria, Anacridium rubrispinum, Cyrtacanthacris tatarica* and *Chondracris orientalis* of Subfamily Cyrtacanthacridinae. The present study provides a comprehensive study of both the phases of locusts.

Conclusion

The study concluded that we found four different colors of *Schistocerca gregaria*. They are cryptic to other allies' species of Acridoidea if found in different color forms. In addition to this, it was noted that they feed upon several fodder crops and wild plants.

References

Basher, M. A., Stiller-Reeve, M. A., Saiful Islam, A. K. M., & Bremer, S. (2018). Assessing climatic trends of extreme rainfall indices over northeast Bangladesh. *Theoretical and Applied Climatology, 134*, 441-452.

Baloch, N., Wagan, M.S & Panhwar, W.A. (2023) .An annotated Checklist of grasshoppers (Acridoidea: Orthoptera) of Punjab, Pakistan.. *Zoo Botanica, 1*(2), 65-70.

Collett, M., Despland, E., Simpson, S. J., & Krakauer, D. C. (1998). Spatial scales of desert locust gregarization. *Proceedings of the National Academy of Sciences*, *95*(22), 13052-13055.

Cressman, K. (2016). Desert locust. *Biological and environmental hazards, risks, and disasters*, 87-105.

Cullen, D. A., Sword, G. A., Dodgson, T., & Simpson, S. J. (2010). Behavioural phase change in the Australian plague locust, Chortoicetes terminifera, is triggered by tactile stimulation of the antennae. *Journal of Insect Physiology*, *56*(8), 937-942.

Dong, Y., Zhao, L., & Huang, W. (2023). *Monitoring of desert locust in Africa and Asia*. Springer Nature.

Erezyilmaz, D. F. (2006). Imperfect eggs and oviform nymphs: a history of ideas about the origins of insect metamorphosis. *Integrative and Comparative Biology*, *46*(6), 795-807.

Githae, E. W., & Kuria, E. K. (2021). Biological control of desert locust (*Schistocerca gregaria* Forskål). *CABI Reviews*, (2021).

Khatri, I. (2019). Current locust threats and measures in Pakistan: Department of Entomology, Sindh Agriculture University, Tandojam, Pakistan. *Pakistan Journal of Agriculture, Agricultural Engineering and Veterinary Sciences*, *35*(1), 67-71.

Lecoq, M. (2005). Desert locust management: from ecology to anthropology. *Journal of Orthoptera Research*, *14*(2)179-186.

Matthews, G. A. (2021). New technology for desert locust control. *Agronomy*, *11*(6), 1052.

Mccaffery, A. R., Simpson, S. J., Islam, M. S., & Roessingh, P. E. T. E. R. (1998). A gregarizing factor present in the egg pod foam of the desert locust Schistocerca gregaria. *Journal of experimental Biology*, *201*(3), 347-363.

Morgan, W. J. (1981). 13. Hotspot tracks and the opening of the Atlantic and Indian Oceans. *The oceanic lithosphere*, *7*, 443.

Panhwar, W. A., Khatri, I., & Soomro, F. (2023). Records of Orthoptera in Fauna of British India within present bounderies of Pakistan. *Journal of Applied Research in Plant Sciences*, *4*(02), 567-570.

Panhwar, W. A., & Mustafa, S. B. (2022). Phenotypic plasticity in grasshoppers and locusts: a review. *Asian Journal of Science, Engineering and Technology (AJSET)*, *1*(1), 38-51.Pervaz, B. (2021). Locust attack in Pakistan: assessing and dealing with the threat. *Policy Perspectives*, *18*(1), 109-121.

Saha, A., Rahman, S., & Alam, S. (2021). Modeling current and future potential distributions of desert locust *Schistocerca gregaria* (Forskål) under climate change scenarios using MaxEnt. *Journal of Asia-Pacific Biodiversity*, *14*(3), 399-409.

Samejo, A. A., & Sultana, R. (2016). Comparative study on fecundity of solitary and gregarious phases of *Schistocerca gregaria* from Thar Desert, Pakistan. *Sindh University Research Journal-SURJ (Science Series)*, *48*(4) 717-720

Showler, A. T. (2019). Desert locust control: the effectiveness of proactive interventions and the goal of outbreak prevention. *American Entomologist*, *65*(3), 180-191.

Simpson, S. J., McCaffery, A. R., & Hägele, B. F. (1999). A behavioural analysis of phase change in the desert locust. *Biological reviews*, *74*(4), 461-480.

Skaf, R., Popov, G. B., & Roffey, J. (1990). The Desert Locust: an international challenge. *Philosophical Transactions of the Royal Society of London. B, Biological Sciences*, *328*(1251), 525-538.

Song, H. (2006). *Systematics of Cyrtacanthacridinae (Orthoptera: Acrididae) with a focus on the genus Schistocerca Stål 1873: Evolution of locust phase polyphenism and study of insect genitalia*. The Ohio State University.

Symmons, P. M., & Cressman, K. (2001). Desert locust guidelines: biology and behaviour. *FAO, Rome*, 1-42.

Taylor, G. K., & Thomas, A. L. (2003). Dynamic flight stability in the desert locust Schistocerca gregaria. *Journal of Experimental Biology*, *206*(16), 2803-2829.

Teng, Z. Q., & Kang, L. (2007). Egg-hatching benefits gained by polyandrous female locusts are not due to the fertilization advantage of nonsibling males. *Evolution*, *61*(2), 470-476.

Van Huis, A., Cressman, K., & Magor, J. I. (2007). Preventing desert locust plagues: optimizing management interventions. *Entomologia Experimentalis et Applicata*, *122*(3), 191-214.