Recent Strategies Application by using Some Biorational Products against the Desert locust *Schistocerca gregaria* (Forsk.) (Orthoptera:Acrididae) Under the Different Environmental Conditions

Presented by

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MSc. Degree of Biological Science, Faculty of Science,
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CONTENTS

Abstract

The desert Locust, *Schistocerca gregaria* (Forskål), is one of the important insect pests worldwide. This work looks at how countries and international organizations respond to complex toxicological and ecological problems that are mismatched to management capacity of the desert locust, *Schistocerca gregaria*. The study concentrates on effort by to manage the population dynamics under temperature stress using biorational bioinsecticides against the desert locust, *Schistocerca gegaria.* Desert locusts periodically invade crops and pastures, where they cause massive depredations that undermine agricultural productivity and food security.

Chemical insecticides proved effective in controlling this locust, but with a bad ecosystem impact. The use of natural insecticides that have biocidal effects against desert locusts and many insects is one of the alternatives to chemical insecticides, which are regarded as safer, cheaper, and more useful control agents. Natural products, such as biorational insecticides, pathogens, predators, parasites, IGRs, fungi, and animal venoms, form promising non- conventional insecticides against damaging pests for crops and health.

The fourth and fifth instar nymphs were fed on clover leaves treated with LC_{50} of azadirachtin, rotenone, sabadilla, and limonene.

This study evaluated the effect of temperature stress on biorational insecticides against *Sch. gregaria*. Newly moulted fourth and fifth instar nymphs of the desert locust were fed on the treated clover leaves with LC_{50} of Azadirachtin, Rotenone, Sabadilla, and Limonene. Also, the fifth nymphal instar was treated with an anti-juvenoid, precocene II, to study the morphogenic effect of *Schi. gregaria*. The obtained results revealed that the nymphal instar was more sensitive to azadirachtin, followed by rotenone, sabadill, and finally limonene

bioinsecticides, than the fifth nymphal instar. The recorded LC_{50} values of the fourth instar nymph were 3.4, 3.7, 3.8, and 4.2% due to the effects of azadirachtin, rotenone, sabadilla, and limonene, respectively. While LC_{90} was 15.2, 18.7, 26.3, and 28.1% of the same previous compounds, respectively. In the case of the fifth nymphal instar, the higher LC_{50} was 4% after treatment with azadirachtin, and the lower LC_{50} was 5.2% with the limonene compound. Meanwhile, the LC_{90} of the fifth nymphal instar was 22, 27, 34, and 36 after treatment with azadieachtin, rotenone, sabadilla, and limonene, respectively. The fourth nymphal instar suffered weight loss after treatment with all tested biorational compounds, particularly at higher concentrations, and then died. The higher and lower decreases in fourth nymphal weight were 238.4 mg and 338.7mg due to the effects of rotenone at a 20% concentration and limonene at a 5% concentration, respectively. The fourth nymphal duration was prolonged by 17.6 days by the effect of azadirachtin at 15% concentration, while limonene increased duration by 10.5 days at 5% concentration, compared with 10.2 days in control. On the other hand, the higher and lower effects of temperature stress on toxicity against the fifth nymphal instar treated with LC_{50} were recorded for 81.12% of rotenone at 35ºC and 58.1% of sabadilla at 30ºC after 96 hours post-treatment. Furthermore, limonene, sabadilla, rotenone, and azadirachtin compounds showed a decrease in the fifth nyphal haemolymph contents of protein, lipid, and carbohydrate under different temperature stress.

Extramoulted nymphs were seen following the application of the ant-juvenoid Precocene II against the fifth nymphal instar. At higher precoceneII concentrations of 1000 ppm, adult deformation was 52.2%, and at lower precoceneII concentrations of 50 ppm, adult deformation was 14.2%. Meanwhile, the nymphal adult intermediate was recorded at 7% at a

concentration of 50 ppm and at 13% at a precocene II concentration of 1000 ppm. These results suggested that the biorational compounds have the capacity to disrupt metabolites of heamolymph contents, toxicity, and deformation abnormalities against the desert locust Schistocerca gregaria.

I-INTRODUCTION

The extremely noticeable and erratic desert locust, *Schistocerca gregaria* (Forskål) (Orthoptera: Acrididiae), is a pest of agriculture that can seriously impair the local economy and lead to severe food shortages in subsistence farming systems. Due to their ability to form large, mobile swarms during their gregarious phase, locust swarms may spread over thousands of kilometers and may consist of billions of individuals migrating together in synchrony (Uvarov, 1931, 1977; Showler, 2002). *Schi. gregaria* has compromised farming generations in Africa, the Middle East, and Asia (Ceccato *et al.*, 2007). Destruction is caused as a consequence of its polyphagous feature, the high density of the population, and its nature to aggregate and swarm. A single gregarious locust can consume roughly its own weight in foliage daily (Lindsey, 2002). On the other hand, chemical control of desert locusts is carried out over large areas of land, covering a range of different landscapes and ecosystems. The extensive use of synthetic pesticides has considerable drawbacks, such as the development of insect resistance to insecticides, increased costs, handling hazards of insecticide residues, and great threats to both human and environmental health (Garriga & Caballero, 2011). The widespread use of chemical insecticides causes many negative problems, including pest resistance, environmental pollution and health hazards to farmers, food contamination, and toxicity to non-target organisms. These toxic chemicals enter the food chain and cause pollution of the environmental ecosystem (Pimentel et al., 2009).

Chemical pesticides have the potential to be a successful control method because of the long-lasting effects of the spray residue, but concerns about environmental harm and public health have grown (Brader et al., 2006). It is challenging to track the results of spray treatments, particularly for highly migratory species, because insects die within hours after chemical treatment (Langewald et al., 1997). Spraying excludes many locusts that continue the upsurge and get aggregated at high densities because only a small number of locusts are aggregated into treatable targets when an upsurge begins (VAN Huis, 2007).

The use of natural pesticides with insecticidal properties has received much attention (Schmutterer, 1990). One substitute for chemical pesticides, which are thought to be more effective, affordable, and safe, is natural insecticides (Berebaum, 1989; Sarwar and Salman, 2015). In order to combat harmful pests for agriculture and human health, natural products, including plant extracts, pathogenic bacteria, predators, parasites, IGRs, fungi, and animal venoms, combine to create potential non-conventional pesticides (Weinzierl, 1998; Nassar, 2020). Because they are biodegradable and hence safe for the environment, botanical control agents are often pest-specific and comparatively innocuous to nontarget species (Rembold, 1994). Hundreds of botanical products have established deleterious effects on insects, and botanical insecticides are presently approved for use in industrialized countries (Isman, 2006). Biorational insecticides are biodegradable, and their use in crop protection is a practical, sustainable alternative that reduces environmental contamination and human health hazards (Nassar et al., 2018). The boiorational botanical pesticides could be divided into two generations: The 1st generation included nicotine, azadirachtin, rotenone, sabadilla, ryania, pyrethrum, and plant essential oils, while the 2nd generation included synthetic pyrethroids (Catherine, 2012). The temperature stress scenario is a major factor determining insecticide efficacy, and the intensity of temperature stress is a key determinant of pesticide effectiveness. In light of this fact, two general trends in this relationship have been observed: a positive or negative correlation of measured toxicity with the effect of temperature. It has long been known that different temperatures have different effects on the chemistry of pesticides (Guthrie, 1950). According to Grafius (1986) and Turnbull & Harris (1986), organophosphates often function better in warm environments (such as 30- 32°C) or have little to no effect on temperature. At lower ambient temperatures, usually between 15 and 16°C, pyrethroids frequently show increased toxicity to arthropods (Harris & Kinoshita 1977; Hirano 1979; Sparks et al. 1983; Grafius 1986). This relationship depends on the target species, method of application, and quantity of insecticides. Schmidt and Robertson (1986) reported that permethrin was more toxic to horn flies at higher temperatures when the flies were exposed to cloth treated with permethrin, even though the results of topical application indicated a negative temperature coefficient. When Ewen et al. (1984) treated migratory grasshoppers with a range of rates of cypermethrin, they found that at doses below a rate equivalent to field application of 12g (AI)/ha, toxicity increased with increasing temperature within the range of 15– 30 °C, and at higher doses, relative toxicity declined at temperatures above 20°C.

On the other hand, temperature is a significant element for grasshopper species because, in grassland or in cereal crops, management is frequently needed under warm field conditions (25–35°C), and a negative temperature coefficient has been shown for at least one pyrethroid. Hinks (1985) showed that deltamethrin was less harmful to the nymphs of migrating grasshoppers at temperatures higher than 27°C. Also, in reaction to environmental changes, the desert locust may alter its physiology and behavior, turning swarms of innocuous solitary insects into ferocious, cohesive ones (Simpson et al., 1999). This characteristic enables locusts to endure some of the most extreme environmental circumstances on earth. Rainfall, temperature, wind, and vegetation are some of the variables that affect the desert locust's seasonal movement (Sharma 2014). According to FAO (2004), ideal breeding circumstances include wet soils that reach a depth of 10 to 15 cm, damp bare spots for depositing eggs, and green foliage that promotes hopper growth. Sparse and erratic seasonal rains support phase change from their solitary lifestyle to a group lifestyle (gregarious phase) that develops into an upsurge and eventually into a plague (VAN Huis, 2007). These density-dependent changes are adaptations for migration under heterogeneous environmental conditions.

For instance, a research study estimated the density of gregarization of desert locust hoppers in vegetation and reported that vegetation cover and height were the only characteristics that could enhance the prediction of locust phase status (Cisse et al., 2015). Meanwhile, the sporadic and unpredictable seasonal rainfall facilitates the transition from a solitary to a gregarious phase, which leads to an increase and ultimately a pandemic (VAN Huis, 2007). These density- dependent alterations are migratory responses to varied environmental circumstances. For instance, a study that quantified the density of gregarization of desert locust hoppers in vegetation found that the only features that might improve the prediction of locust phase status were height and plant cover (Cisse et al., 2015).

In light of different research, dry and green vegetation supported a high density of gregarization, presumably because of the individuals' rate of dispersal, but poor cover and dry vegetation led to a low density of gregarization. A further investigation into the impact of vegetation patterns on gregarization revealed that locust activity increased, crowding levels rose, and gregariousness increased in areas with patchy vegetation distribution (Despland et al., 2000).

Under Saharan circumstances, several chemical insecticides have been successful in stopping outbreaks of desert locusts at very early stages of invasion; nevertheless, they also cause significant mortality in other non-target insect species (Balanca & De Visscher, 1997). Additionally, the outbreaks happen in sensitive environmental regions, particularly wetlands, close to populated areas, and, to some extent, in protected areas that are home to a large number of migrating birds (Wiktelius and Ardö, 2003). Chemical pesticides are sprayed from the air to control desert locust swarms in East Africa; however, this approach has negative effects on people, animals, and the ecosystem (Kimathi et al., 2020). Even if there is still much to be done in terms of research and implementation, the concern about the use of chemical pesticides gives momentum for investment in sustainable and ecologically acceptable alternative ways of control, such as biopesticides (VAN Huis, 2007). Developing an integrated pest management program with a range of products and procedures suitable for various habitats and situations would be necessary for the effective control of desert locusts (Magor et al., 2008). This has to be connected to decreased use of pesticides, financial expenses, environmental dangers, and the length and severity of the locust threat (Showler, 2002).

Biopesticides derived from microbes and plants are among the proposed items. When employed at approved concentrations, they are non-toxic to people and cattle and have high specificity with few negative environmental effects (Kooyman, 2003). According to a simulation model, even a conservative rate of control used early in an upsurge as part of early intervention might further lower the extent of plagues and upsurges and help manage desert locust populations more effectively (Magor et al., 2008).

This study aimed to evaluate the effects of the biorational insecticides azadirachtin, sabadilla, limonene, rotenone, and rotenone against the nymph and adsult stages of the desert locust, Schistosoma gregaria. After being exposed to botanical pesticides, nymphal weight, duration, and toxicity will also be taken into consideration. Current work was also conducted to study the effect of temperature stress on the lethal and biochemical activities of biorational compounds against Schi. gregaria. On the other hand, morphogenetic abnormalities of several features of deformation, such as impaired nymph and adult morphogenesis, were caused by the effect of precocene II on the fifth nymphal instar of *Schi. gregaria*.

II- LITTERATURE REVIEW

1-Geographical distribution of the desert locust, *Schistocerca gregaria*

The most damaging migratory pest is the desert locust (*Schistocerca gregaria*). The geographic distribution of desert locusts is limited to semi-arid and dry parts of Africa, the Arabian Peninsula, and South-West Asia that get less than 200 mm of annual rainfall during periods of "recession." Locust migrate periodically between winter, spring, and summer breeding grounds within this recession region. Large swarms are a serious danger to rural livelihoods and food security.

Uvarov (1928) offered an exhaustive catalog of works released up to that date. Buckell (1921) investigated the effects of plant associations on the number and presence of certain species of grasshoppers and locusts in British habitats.

Steedman (1990) reported that *Schistocerca gregaria* predominates in desert and scrub regions of northern Africa, the Arabian Peninsula, and the southwest of Asia. Symmons and Cressman (2001) cleared that even in the recession period, desert locusts *Schi. gregaria* can operate in semi-arid and arid areas in Africa, the Arabian Peninsula, and Southwest Asia, threatening 16 million km2 of food production in about 30 countries. The migration and proliferation of desert locusts caused damage to around 50 nations in West Africa and West Asia between 2018 and 2020.

Gómez et al. (2020) reported that, more precisely, the probable distribution region of the desert locusts is described together with the temperature and humidity requirements for their growth and development. For instance, a prior study that utilized product data from the European Space Agency Climate Change Initiative Soil Moisture (ESA CCI SM) employed the machine-learning approach to estimate the desert locusts' ideal breeding locations throughout the recession region.

According to the Emergency Transboundary Outbreak Pest (ETOP 2012) report, the situation with desert locusts is still not under control. In April, second generation hoppers from eggs deposited in late February were observed in southeast Algeria and northwest of Ghat, Libya. By the third day of April, ground crews had treated about 3,360 hectares in Algeria and over 3,545 hectares in Libya. Breeding might have been going on in northern Mali and northern Niger, but security issues prevented verification. In central western and coastal Oman, where breeding was recorded in March, several hoppers and immature adults were observed (ETOP 2012).

Many authors studied the morphology of eggs and egg pods. For instance, Norris (1950) examined the morphology of acridiid eggs and egg pods in *Locusta migratoria* migratorioides; Chapman and Robertson (1958) examined the morphology of eggs in some African grasshoppers; Majeed (1978) examined the morphology of eggs in Gastrimargus transversus; Bernays (1971) described the hatching process in detail in *Schistocerca gregaria; and* Bowers (1982) reported the mating habits of female insect species with percocenes I and II in Locusta migratoria, known as acridids. There were no eggs produced because the gonads did not mature.

On the other hand, Morphogenic abnormalities of desrt locusts were studied by El-Gamal (1983), who studied the morphogenic abnormalities of *Schi. gregaria* by effect of precocene II, which resulted in a large number of deformed adult females when it was administered to the newly moulted fourth- instar nymphs.

Fridman-Cohen et al. (1984) investigated the anti-allatin and fatal effects of precocene II on various Schistocerca gregaria larval instars. Precocene II lengthened the lifetime of the treated and/or subsequent instar. They also discovered that the LD50 and ED50 probit lines were parallel for various instars and that the LD50/ED50 ratio depended on the instar.

Many Authors have studied morphometrics in locusts and grasshoppers. Among them, Dirsh (1953) on *Schistocerca gregaria*, Blackith and Albrecht (1957) on *Nomadacris septemfasciatus,* Blackith and Kevans (1967) on *Chrotogonus spp.*, Symmons (1970) on *Chrotogonus terminifera*, Chapman et al. (1977) on *Zonocerus variegatus*, Lodos et al. (1978) on *Anacridium aegyptium*, khouaidjia and Fuzeau-Braesch (1982) on six strains of *Locusta migratoria*, and Seibt and Wickler (1985) on *Zonocerus elegans*.

Simpson et al. (2001) suggested that due to their phase polymorphism and strong adaptation to the harsh ecological circumstances of their environment, desert locusts are predicted to undergo significant alterations in both their adult and nymphal phases when population density rises.

Lindsey (2002) stated that the dangerous character of the desert locust *Schi. gregaria* is a consequence of its polyphagous feature, high density of the population, and its tendency to aggregate and swarm. A single gregarious locust can consume roughly its own weight in leaves daily.

Ghazawy et al. (2007) detected the effects of the azadirachtin insecticide on development, oogenesis, spermatogenesis, and mortality. The fourth and fifth instars perished around the time of ecdysis, and mortality was dose- dependent.

De Vreyer et al. (2012) found that the gregarious desert locust may travel up to 200 km per day and cover an area of hundreds of square kilometers when it disperses. An estimated 40 million locusts per square kilometer may consume the food of 35,000 people in a single day.

Maeno et al. (2016) assessed the solitary desert locusts, in particular, switch microhabitats and plant species every day, which has a wide range of destruction.

2-The pest status, outbreaks, and swarms of the migratory locust, *Schistocerca gregaria*

The greatest swarms are formed by the desert locust, Schistocerca gregaria. A 200 km2 swarm invaded Kenya at the beginning of 1954. There were an estimated 10 billion locusts in the swarm, based on the estimated density of 50 million individuals per km2. A swarm is, in my opinion, any sizable, cohesive gathering of flying insects.

According to Uvarov (1977; Chen 2002), the study of historical records dating back to the second century indicates that desert locusts nearly always occur annually. There have been fifteen desert locust epidemics since the turn of the 20th century, affecting over 30 million square kilometers across two continents and 850 million people's lives in 65 nations.

Chen (2002) reported that desert locust can spread to 28 million square kilometers, or around 20% of the planet's surface. The swarm can eat enough food in a single day to feed nearly 35,000 people, with each locust eating almost its own weight in green vegetation.

FAO. FAO (2020) mentioned that because plagues are linked to significant financial losses, immediate action is needed to protect the environment and livelihoods.

Lindsey, (2002) appesred that single gregarious locust can consume roughly its own weight in foliage daily.

Ceccato et al. (2007) pointed out that farming generation across Africa, the Middle East, and Asia has been jeopardized by the desert *Schistocerca gregaria*. Its propensity to swarm and collect, coupled with its polyphagous nature and dense population, results in destruction.

Bullen (1970) and Hamdy & Nassar (2013) reported that locusts and other species of grasshoppers always cause considerable economic problems.

FAO (2020) reported that the semiarid and arid deserts of Africa that get less than 200 mm of rainfall annually are typically the only areas where desert locust invasion occurs.

WMO and FAO (2016) state that, following significant rainfall, the desert locust epidemic struck 43 countries between 1986 and 1989. Control measures and peculiar winds that carried swarms across the Atlantic Ocean were mostly responsible for the termination of this invasion.

Latchininsky et al., 2016) assessed Similar swarms occurred between 2003 and 2005, primarily in sub-Saharan Africa, affecting over 20 countries and resulting in an estimated 80–100% loss of crops.

Mariod et al. (2017) mentioned that a single swarm of locusts can cover an area of around 1200 square kilometers per day, with up to 80 million locusts per square kilometer and the ability to fly more than 100 km in the direction of the prevailing winds.

Kimithi et al. (2020) predicted that the anticipated model showed that there was a high risk of the locust finding a breeding habitat for *Schi. gregaria* in large parts of Kenya, northeastern Uganda, and some regions of southern Sudan.

FAO. FAO (2020) recommended that in the Horn of Africa, extraordinary locust breeding was noted in 2019 and 2020. Invasions of this size had not been seen in East Africa in over 70 years. The onset of the long rainy season in East Africa would also remarkably increase the swarms, threatening food security and livelihoods.

Sharmin et al. (2020) discussed how the abrupt and rapid rise of desert locust populations may be related to erratic weather patterns brought on by climate change. However, in order to successfully apply control measures, predictions must take into account ecological elements as well as social, economic, and cultural ones.

Chen et al. (2020) reported that throughout northern, southern, and southwestern Africa, arid grasslands and deserts are home to the polyhedral herbivore *Schistocerca gregaria.*

Garriga & Caballero (2011) suggested that the widespread use of synthetic pesticides has a number of negative effects, including rising expenses, handling risks, insecticide resistance in insects, worries about pesticide residues, and serious risks to human and environmental health.

Weinzierl (1998 and Nassar (2020) reported that botanical-based natural compounds, including limonene, sabadilla, azadirachtin, rotenone, and numerous others, exhibit insecticidal properties against *Schi. gregaria*. In the meantime, a variety of promising non-conventional pesticides are being developed to combat harmful pests to crops and human health, including plant extracts, pathogenic bacteria, predators, parasites, IGRs, fungi, and animal venoms.

3-Biorational pesticides as insect growth regulators and antifeedants have effects against *Schistocerca gregaria* and many insects.

The pharmacology, toxicology, and microbiology studies report many examples of naturally occurring substances from a variety of plant secondary compounds.

Hartzell and Wilcoxon (1941) suggested that the creation of biorational inseticides is attributed to **Ragusa Dalmatia**, a woman who observed dead insets on a discarded bouquet of pyrthrin flowers. Started grinding pyrethrum into powder, resulting in the establishment of the pyrethrin industry.

Buhr et al. (1958) stated that some of the alkaloid glycosides in solanaceous plants were toxic to the larvae of the Colorado potato beetle.

Bower et al. (1976) indicated that the adult female locust *Schistocerca gregaria* may be allatectomized chemically by treatment with ethoxy- precocene. Precocenes are naturally occurring chromenes found in plants in the genus *Ageratum*.

Klocke and Kubo (1982) compared the antifeedant properties of neem seed's limonoid azadirachtin with those of three major neutral limonoids from citrus seeds, limonin, nomilin, and abacunone, against the larvae of *Spodoprera littoralis* and *Heliothis zea*. Azadirachtin has been shown to be a powerful toxicant at doses below 10 ppm due to its significant suppression of ecdysis. Citrus limonoids did not have this lethal impact at concentrations above 2500 ppm. On the other hand, azadirachtin doses below 1 ppm significantly reduced larval growth by more than 50%. Despite their relative activity, azadirachtin was a more effective as growth inhibitor.

Shankaranayana et al. (1979) stated that, applied topically, a lug compound derived from the palmitic acid ester was morphologically potent against four different lepidopterous species' adults and pupae.

Nakajima and Kawazu (1980) stated that *Eupmorium japonicum* leaf extracts were used as ovicides and larval growth inhibitors, which were then tested against *Drosophila melanogaster*. It was determined that the ovicide was a coumarin compound. Based on spectral and chemical evidence, the structure of the novel naturally occurring guaianolide known as euponin acts as a larval development inhibitor.

Elliger et al. (1981) identified and isolated a number of chemicals from the tomato leaf, *Lycoperiscon esculeatum*. These substances inhibited the growth of Heliothis zea (Boddie), the tomato fruit worm, as a larva. Tomatine, chlorogenic acid, rutin, and a novel caffeyl derivative of aldaric acid were the main allelochemices.

Bentley et al. (1982) examined extracts from over 100 nonhost plant species found in eastern North America that were used in feeding bioassays with the spruce budworm, *Choristtoneura fumfierana*, in its sixth instar. Strong deterrent properties were exhibited by plants that contained alkaloids, such as members of the genera Solanum, *Lupumus Valeriana*, and Tussilago. Also, they demonstrated the presence of ecdyson-type hydroxylated steroids in several Chenopodiaceae.

Bentley et al. (1984) mentioned that the sixth instar larva of the spruc bud worm was bioassayed with five Solanum alkaloids: tomatidin, tomatine α-solanine, α-chaconine, and solandine. Chorisatoneura fumiferana, and they found that the levels of deterrence were significantly lower.

Deshmukh and Renapurkar (1987) evaluated the in-set growth-regulating abilities of petroleum ether extracts from ten native plants using topical application techniques and continuous exposure to *C. piptens* and *Musca domestica*. Only when these extracts were applied at higher concentrations, *Acorus calamus* and *Azadirahta indica* of the ten plants exhibited insect growth-regulating IGR activity.

Mahmoud et al. (1987) extracted and identified the B-setosterol and S-insecticidal properties from the extract of *Argemone Mexicana* used against *C. piptens* and *M. domestica*.

Bamby and Klocke (1987) reported that tobacco budworm larvae in their last instar were injected orally with mg of azadirachtin (isolated from Azadirachta indica). Heliothis virescens lowers the moulting hormone titer throughout its entire body and hemolymph, compared to control larvae. Also decreased production of prothoracicotropic hormone by the thoracic glands in the brain. The proper development of the pupal stage was hindered by the decrease in the hemolymph titer of the moulting hormone.

Weinzierl (1998) stated that natural products of plant origin have insecticidal activity against *Schi. gregaria*. Meanwhile, plant extracts, pathogenic bacteria, predators, parasites, IGR’s, fungi, and animal venoms form promising non-conventional pesticides against damaging pests for crops and health.

Schmutterer and Freres (1990) reported the activity varied in *A. indica* (79.62%), *Jatropha curcas* (78.92%), and *Solenostemma argel* (56%) showed varying levels of action against the desert locust, *Sch. gregairia*, with substantial death rates of 43.39%, 40.54%, and 20.70%, respectively, over a 7- day treatment period. Moreover, morphogenetic abnormalities of the wings, legs, and antennae, as well as difficulties in molting, were caused by *A. indica* seed oil.

Sorya (1991) stated that the synthetic pyrethroids caused histological and cytological effects on the desert locust, *Shi. gregaria*.

Watanabe et al. (1990) reported that *Plocmium telfairiae*, a red algae, yielded two insecticidal polyhalogenated monoterpenes and telfairine. These two compounds had strong insecticidal effects, as demonstrated by both compounds against *Anopheles gambiae* mosquito larvae and German cockroaches, *Blattella germanica*.

Binder et al. (1991) reported that the ant-juvenile hormones precocene I and II were identified in three plants of the ninienama, *Hydrophyflacoae* species. Also, precocene was found in *N. sandwicense.*

Dimetry et al. (1992) bioassayed three compounds. The efficacy of Neem-azal and "Margosan-O" has an insecticidal effect on the bean aphid, *Aphis fabae.*

Keamy et al. (1994) submitted that the anti-feeding activity of *A. indica* against the desert locust *Schi. gregaria*.

Nassar (1995) studied the toxicity of *Solanum dubium* due to its alkaolidal content, triterpenoid saponines, and alkaloids reported in several *Zygophyllum simplex* strains that have been affected by *Muscina stabulans*.

Begun et al. (1995) isolated triterpenoids from the aerial parts of *Lantana.* *camara*, which acts against insects.

Rembold (1997) mentioned that *Azadirachta indica* and *Melia volkensii* were the most studied plant species belonging to the family Meliaceae, which contains biologically active limonoids. Also, *Calotropis procera, Fagonia bruguieri*, and *Peganum harmala* extracts contain active ingredients against desert locust *Schi. gregaria but* were not identified.

Diop and Wilps (1997) suggested that the field experiments demonstrated the use of *M. volkensii's* crude powder against *Schi. gregaria*, causing acute toxicity, growth retardation, and 80% malformations that resulted in 100% death after 14 days.

Kabaru and Gichia (2001) showed that extracts made from several *Rhizophora mucronata* parts have insecticidal and antifeedant properties against *Schi. gregaria*, the desert locust.

Hadidi (1977) mentioned that *Zygophyllum simplex* (L.) contains flavonoids, which were identified as Kaempeferol 3-glucoside and quercetin 3.7-diglucosids, which have biological activity against insects.

Nassar (1995) assessed the effect of cardenolides, steroids, tannins, glycosides, phenols, terpenoids, sugars, flavonoids, alkaloids, and saponins from *Calotropis procera* extracts against *Muscina stabulans.*

Abbassi et al. (2003) revealed how *Calotropis procera*, *Zygophyllum gaetulum,* and *Peganum harmala* affected the survival, feeding, and reproduction of the desert locust *Schi. gregaria*. The findings suggest that all of the alkaloids that were isolated from the plants decreased food intake, accelerated weight loss, and significantly increased mortality.

Bowers and Nishida (1980) identified two compounds from *Ocimum basilicum;* the sweet basit oil had strong juvenile hormone action. The compounds were evaluated on *Oncopltus fasctatus* (Het. Lygaeidae), *Phrrhocorris opterus* (Het. Pyrrhocoridae), and *Tenebrio molitor* (Coleop.Tenebrionidae).

Guerrero et al. (2005) described novel biorational techniques for insect management by suppressing enzymes involved in important life processes of insects, namely the growth, molting, and development of larvae and the intraspecific communication of adults. Pheromone biosynthesis and degradation enzymes, oxidoreductases, juvenile hormone epoxide hydrolases, proteases, molting hormones, and phenoloxidases are some of these enzymes.

Roger (2005) reported that the biorational botanical insecticides have the ability to induce various modes of action, including repellence, growth inhibition, and modifications in their physiology and structure.

Abbassi et al. (2003) revealed that the *Calotropis procera, Zygophyllum gaetulum, and Peganum harmala* affected the survival, eating, and reproduction of the desert locust. The findings suggest that all of the alkaloids that were isolated from the plants decreased food intake, accelerated weight loss, and significantly increased mortality.

Sh Hk (2013) suggested that when *Nigella sativa* extracts were compared with those of *A. indica, N. sativa* caused a decrease in the body weight of desert locust *Schi. gregaria*. It was also found that the alkaloid has been formulated to produce a commercial anti-feeding product that controls the desert locust *Schi. gregaria* and a wide range of plant pests without harming beneficial insects.

Messgo-Moumene et al. (2015) According to a related study, the desert locust was subjected to morphological alterations, inhibition of molting, and anti-feeding effects by treatment with *Calotropis procera, Schouwia purpurea, and Zizyphus lotus* alkaloids. The study also found that after five days of treatment, desert locusts had a substantial death rate, ranging from 45% to 53%.

Wafukho *et al.* (2013) suggested that the highly versatile chemical structures arise from the enormous biosynthetic capabilities of plant origin.

Saleh and El-Outtar, *et al*. (2014) As identified, the flavonoids in a number of *Zygophyllum species have a* biological effect on *Schi. gregaria.*

Ismail *et al*. (2016) reported that the botanical extract of *L. inermis* affected morphology and mortality activity against *Locusta migratoria*.

Biswas *et al. (*2016) examined the activity of *L. inermis* versus the red flour beetle, *Tribolium castaneum*.

Ghoenim et al. (2014) stated that in an experiment, adult desert locust *Schi. gregaria's* fat bodies had reduced alkaline phosphatase (AlP) activity and increased acidic phosphatase (ACP) activity due to the effect of fruit extracts from *Ammi visnaga*. This was attributed to the existence of furocoumarins and couramins.

Manssour et al. (2015) highlighted the mixture of three essential oils: Gaultheria procumbens, Citrus aurantium dulcis, and Carum carvi. It's interesting to note that after 24 hours of treatment, an 80% mean death rate of desert locusts was recorded. Additionally, topical use of essential oils derived from ten distinct plant species was evaluated against desert locusts. The locusts found that *Allium cepa* oil was the most poisonous, followed by *Petroselinum sativum* oil. Other plants, *Pelargonium radula, Cuminum cyminum, Ocimum basilicum, Origanum vulgare, and Matricaria chamomilla,* were investigated and had varying effects against *Schi. gregaria*.

Nassar *et al. (*2017, and (2018) reported that the search for new environmentally friendly biorational insecticides against *Schi. gregaria* and *Culex pipiens* (diptera: culicidae) became an important task.

ABDELKADER et al. (2019) Examine, in a controlled laboratory setting, the toxicity and antifeedant properties of Zygophyllum geslini aqueous extract against *Schistocerca gregaria*, the desert locust. Results showed weight loss, reduced food intake, and biocidal activity against both sexes.

Abd ell Razzik *et al*. (2018) examined *L. inermis* extracts against *Solenopsis tinsley*.

Abdelbagi et al. (2019) mention that plant alkaloids have been reported to affect the desert locust *Schi. gregaria* in different ways. For instance, azadirachtin from *A. indica* has an anti-feeding activity that inhibits feeding and molting.

Jaoko et al. (2020) submitted *Melia volkensii* extracts against desert locust and other pests. For instance, this extract has larval growth-inhibiting and anti-feeding properties.

Abdelatti and Hartbauer (2020) stated that although botanical extracts have demonstrated promise as bio-pesticides, their use in controlling desert locusts is still in the experimental phase. Essential oils have been shown in several trials to be effective against desert locusts, suggesting that they may be employed as natural controls.

Al-Maroug et al. (2022) reported that the biorational insecticides limonene, sabadilla, azadirachtin, rotenone, and many others have insecticidal activity against *Schi. gregaria*.

Disha Varijakzhan *et al. (*2020, El-Shazly *et al. (2019),* and El-Sonbati *et al.* (2014) reported that plants are considered one of the richest sources of natural bioinsecticides that can be used as pest control agents. They used bioinsecticides, toxicants, repellents, synergists, growth regulators, and antifeedants against many insects.

Khambay *et al.* (2003) and Lushchak *et al.* (2018). Suggested the mode of action and bioactivity of biorational insecticides, Azadirachtin, Rotenone, Sabadella, Limonene, and other chemicals against desert locust, *Schi*. *gregaria*.

4-Botanical insecticides against *Schistocerca gregaria* and other insects

A number of authors have studied the effects of botanical extracts on grasshoppers, locusts, and other insects. The botanical control agents are generally pest-specific and relatively harmless to non-target organisms, including humans. They are fast biodegradable, more safe, and harmless to the ecosystem.

Rao and Mehrotra (1978) used extracts of *Calotrpis gigantea* against *Locusta migratoria.*

Rao (1982) studied the phagostimulants and antifeedents from the *Centaurea gigantean* plant on *Schistocerca gregaria* (Forskal).

Nasseh et al. (1993) and Wilps et al. (1993) studied the effects of neem products on *Schistocerca gregaria*.

Ibrahim et al. (2001) isolated limonene oils to refer to their repellent, insecticidal, and antimicrobial properties against many pests.

Ghoneim and Ismail (1995a and b) revealed that the effects of IGR, fenoxycarb, and pyriproxyfen on Schistocerca gregaria resulted in an increase in extramoult and mortality, along with abnormalities of the nymphal and adult instars.

Lomer *et al.* (2001) stated that botanical insecticides act quickly, degrade rapidly, and have low mammalian toxicity.

Jacobson (1989) found that extracts of botanical origin were effective against many pests.

Saleh et al. (1990) mentioned that steam distillate extracts of *Aretmisia monosperma* possess bioinsecticidal activities against *M. domestica* and *Tribolium castneum.*

Nassar et al. (2018) studied the effect of biorational botanical insecticides, *Azadirachta indica* and *Citrullus colocynthis*, against the desert locust *Schistocerca gregaria*.

5-Integrated control of desert locust

Uvarov (1921) put forward the "prevention and control" strategy for desert locusts to prevent pest population buildup.

Lecoq (2001) deduce IPM always includes forecasting, which offers the information needed to make judgments on whether or not to undertake control methods, together with the economic injury level.

Flint and Van den Bosch (2012) mentioned that although IPM programs may vary from one environment or situation to another in the specific elements, they are always the same in the basic components. The choice to put controls in place is also made; the many alternatives for controls must be carefully chosen based on their efficacy as well as the safety of people and the environment. Furthermore, it is important to make sure that every control choice is compatible.

Van Huis (1995) reported that desert locust *Schi. gregaria* control started in 1860, mainly by digging ditches, trapping, and burning to reduce the population.

Ceccato *et al.* (2007) mentioned that the chemical control of desert locust is carried out over large areas of land, covering a range of different landscapes and ecosystems.

Lomer et al. (2001), Magor et al. (2008) Measures that serve to prevent desert locust populations from reaching a damaging level are priorities in any IPM program, which are usually chemical control, ecological management, and biological control.

Abate et al. (2000) and Lecoq (2003) reported that comprehensive preventive and control measures for the prevention and control of desert locusts are required in order to save money, safeguard the environment and nontarget species, and tackle the problems of medication resistance. The World Bank, FAO, and other organizations also want to include desert locusts in the purview of integrated management.

Posamentier and Magor (1997) and Krall et al. (2012) stated that it is an acceptable and effective method to manage desert locusts, *Schi. gregaria*, by using reasonable, comprehensive control methods. Experience over the years has shown that the integration of chemical, biological, and ecological controls has produced an ecological niche that is favorable to the development and propagation of desert locust. The following are the precise techniques for complete prevention and control: based on the idea that early warning and monitoring are crucial, the preventive and control indicators and the right time are chosen based on the movement, occurrence location, and density of desert locusts.

Tounou et al. (2008) recommended that in the locust medium-density area (Grads II and III), biological pesticides (insecticidal fungi, plant-derived medications), natural enemy control, and other strategies be used. Such as utilizing locust microsporidia and *M. anisopliae* to control desert locusts.

Lomer et al. (1999) determine the best ways to combine biological pesticides (such as insecticidal fungi and plant-derived pesticides), low-concentration chemical pesticides, low toxicity, and low residues (such as fenitrothion, deltamethrin, and deltamethrin) in densely populated regions.

Zhang et al. (2019) reported that the control impact of locusts can reach 85% or more through the IPM development of ecological control, biological control, joint prevention, and other techniques; as a result, the usage of chemical pesticides can be decreased by around 10%.

6-Effects of the biorational insecticides on the metabolites haemolymph of desert locust and other insects

The protein, carbohydrate, and lipid composition of hemolymph reflects both a reaction to specific physiological circumstances and the balance between the synthesis, storage, transport, and breakdown of structural and functional resources throughout metamorphosis.

Carlisle et al. (1987) reported that protein synthesis is necessary for the maintenance of body growth and reproduction. Many factors have been implicated in the control of protein synthesis.

Said (2014) reported that the spinosad bioinsecticide caused a reduction of hemolymph total protein in the fifth nymphal instar of *Shistocerca. gregaria* 2, 4, and 6 days post-treatment.

Soltan (2014) revealed a reduction in the total Haemocyte count (THC) by Neem on the *Schistocerca gregarea* nymphal instar. In order to convert dopa into melanin sequentially, phenoloxidase (PO) is necessary. The findings of that investigation also showed that P. tomentosa alkaloids significantly reduced the amounts of protein and carbohydrates.

Berebaum (1989) and Sarwar and Salman (2015) mentioned that natural insecticides are one of the alternatives to chemical insecticides, which are regarded as safer, cheaper, and more useful control agents.

Chippendale (1978) reported that carbohydrate contributes to the structure and functions of all insect tissues.

Agosin (1978) and Adel et al. (2014) suggested that proteins are essential to the process of cell division and control many reactions in the cellular metabolism.

Downer (1978 and Daylan et al. (2014) mentioned that, when evaluated, lipids are essential structural elements of the cuticle and cell membrane. They also include vital hormones and pheromones and offer a rich source of metabolic energy during times of prolonged energy demand.

Taha et al. (1989) deduced that the fourth nymphal instar of *Schistocerca gregaria*, which had previously been treated with *V. rosea* acetone extract, had a highly substantial decrease in glycogen content. Additionally, they saw a significant drop in the total lipid and protein levels of the nymphs.

Zhang and Chiu (1992) found that dosing *Pieris rapae* L. larvae with toosendanin, a naturally occurring chemical produced from the chinaberry bark, decreased the activity of proteinases in the larvae's midgut.

Abo El-Ghar et al. (1995) demonstrated that applying extracts of *Melia azedarach* and *Vinca rosea* to *Agrotis ipsilon* larvae in their sixth instar led to a significant decrease in their overall protein, fat, and carbohydrate content.

Schmidt et al. (1998) proved that protein content in the hemolymph of *Sposdoptera littoralis* and *A. ipsilon* was decreased significantly due to larval treatment with *M. azedarach* extract.

Ghoneim et al. (2014) discovered that *A. visnaga* extracts commonly cause lipid perturbation in *Schi. gregaria*, which has a suppressive effect on the lipid content in the hemolymph of nymphs and adults, with the exception of a small number of early- and mid-aged nymphs whose lipid content increased significantly or somewhat in response to ethanol extract alone.

Shoukry and Hussein (1998) showed inhibition of lipid content had been reported in the 3rd instar larvae of *G. mellonella* after treatment with extracts from *L. camara* and *V. agnus castus.*

Bream (2002) found depletion of lipid level was recorded in pupae of *Rh. ferrugineus* by Azadirachtin and Jojoba oil.

Chippendale (1978) found that carbohydrates play an important role in the structure and function of all insect tissues during insect life. Their content in the hemolymph is an important indicator of the level of metabolism and utilization by different tissues.

Ghoneim et al. (2006) observed that, depending on the day of life and concentration level, Margosan-O (a neem product) and Jojoba oil had either an inhibitory or stimulatory effect on the amount of carbohydrates during the pupal stage of *M. domestica*.

Khatter and Abuldahb (2010) mentioned increasing carbohydrates in the hemolymph and fat bodies of *S. littoralis* larvae after treatment with oils extracted from *R. communis* and *B. nigra*.

Abo El-Ghar et al. (1995) and Chitra and Reddy (2000) discovered that extracts from *Ammi majus, Apium graveolens, Melia azedarach,* and *Vinca rosea* significantly reduced the amount of carbohydrates in the hemolymph of *Agrotis ipsilon* and *S. littoralis*.

Bakr et al. (2002) showed a great reduction in carbohydrate content was determined after treatment of *S. littoralis* larvae with different plant extracts.

Zhu et al. (2012) examined sublethal doses of hexaflumuron, an inhibitor of chitin formation, and their effects on the hemolymph physiology and development of *Spodoptera litura,* a cutworm.

Downer (1985) suggested that lipids are essential structural components of the cell membrane and cuticle of insect biochemistry. Their turnover in insects has been regulated by neuroendocrine-controlled feedback loops.

Canavoso et al. (2001) mentioned that food and the demands for reserves made by functions including upkeep, development, and reproduction appear to be the key causes of the lipid quantity available for the reserves. The principal organ for storage, the fat body, accounts for half of the insect's fresh weight and serves as the main hub for metabolism.

7-Morphogenesis effect of the anti-juvenoides, PrecoceneII against *Schistocerca gregaria* and other insect

A remarkable form of phenotypic plasticity is locust-phase polyphenism, where a variety of physiological, morphological, and behavioral features are expressed in response to variations in the density of the local population.

Depending on the direction of the change, all of the intermediate stages of this continuous polyphenism can be found in between the two extreme phases. Conversely, JH has two unique biochemical effects, one in the larval stage and one in the adult stage. JH inhibits metamorphic transformation during moulting in larvae, and during ovarian development in adults, it stimulates the production of vitellogenin.

Lange et al. (1983) deduced that precocene II may have an inhibitory effect on the hemolymph and fat body protein levels of Schi. gregaria locusts following precocenes therapy.

Salem et al., (1982) Deduced within Orthoptera, premature adultoids were produced by exposing the fourth instar nymphs of *Schistocerca gregaria*, the desert locust, to Precocene II (15 µg/cm2).

Alrubeai (1986) proposed that the Mediterranean superb grasshopper *Heteracris littoralis* underwent varying degrees of premature metamorphosis as a result of exposure to dosages of PI and PII (20–100 µg/insect).

Tarrant et al. (1982) proposed that Precocene II, when given by contact exposure or fumigation, caused premature transformation in the kissing bugs *Rhodnius prolixus* and *Triatoma dimidiata.*

Roberto et al. (1998) suggested that the development of the mealworm beetle Tenebrio molitor's final instar larvae was suppressed by many anti-JH chemicals, including derivatives of chromene and precocene.

Staal et al. (1981) showed that Lepidopter's juvenile hormone analogues (JHAs) can interact with natural JHs as agonists, antagonists, or a combination of the two. Retnakaran et al. (1985) mentioned IGRs, insect growth regulators.

In “Comprehensive Insect, Physiology, Biochemistry, and Pharmacology on Insect Morphogenesis,.

Mondal and Parween, (2000) reported that the biological effects of JHA are very complex, and vary from one analogue to another.

Davies et al. (2007) mentioned that the response to different compounds differs among species. In addition, the repeated use of many conventional insecticides has caused resistant insect strains to emerge.

Gäde and G.J. Goldsworthy (2003) highlighted that, as an alternative to conventional insecticides, eco-friendly pesticides have drawn interest from all around the world recently. These substitute substances possess a brief half-life in their surroundings, exhibit reduced toxicity towards non-target species, and demonstrate efficacy even at reduced doses.

Tiryaki and Temur (2010) mentioned that eco-friendly pesticides have been shown to biodegrade into innocuous molecules, allowing for the avoidance of environmental contamination issues.

Bede et al. (2001) reported that over the last forty years, research has focused on the potential screening of novel targets in JH biosynthesis inside the corpora allata (CA), the insect organs responsible for generating JH.

Nandi and Chakravarty (2011) suggested that novel pesticides against insect pests may be made from substances that interact with JH, promote JH production, inhibit JH biosynthesis, or obstruct its catabolism.

Staal (1986) discovered that the anti-juvenile hormone agents compactin, fluoromevalonate, imidazoles, and precocene are insect growth regulators (IGRs). These compounds either directly influence the corpora allata (CA), the organ that makes JH, or they alter the mevalonate pathway in JH production.

Hoffmann and Lorenz (1998) reported that precocenes either inhibit JH biosynthesis or are inhibitors of enzyme action.

Sariaslani et al. (1987) indicated that precocenes and other anti-JH agents are widely used as effective tools in the experimental endocrinology of arthropod animals and have been considered prototypes of "fourth-generation pesticides.

Bede et al. (2001) showed that creating JH mimics or anti-JH compounds is a successful approach to finding insecticides.

Bowers (1982) indicated that the anti-JH compounds are regarded as novel examples of insect growth regulators that do not have some of the drawbacks associated with juvenoid-type compounds.

El-Ibrashy (1982) proposed that the anti-JH activity chemicals are potentially very effective for controlling the major insect pests, where most of the damage is caused by larval stages.

Yasyukevich and Zvantsov (1999) reported that PI and PII exhibited growth-inhibiting activities for the control of *A. aegypti, An. sacharovi,* and *An. stephensi*.

Li et al., (1993) Deduced, precocene II was inhibited in the vitellogenesis of the housefly *Musca domestica vicina*.

Nasiruddin and Mordue (1994) have shown that the release of morphogenic peptides may be blocked by Precocene II growth suppression of *E. plorans*, altering the titer of juvenoid and ecdysteroid. Additionally, tissues and cells going through mitosis may be impacted by PII.

Ayoade et al. (1996) observed precocious metamorphosis in the brown plant hopper *Nilaparvata lugens* after exposure to PII.

Farazmand and Chaika (2008) observed in Coleoptera that topical application of PreceoceneI and PrecoceneII onto the 2nd larval instar of *L. decemlineata* induced the precocious adultoids.

Darvas et al. (1990) reported that precocenesdarvas had caused precocious metamorphosis in a number of Dipteran insects, including the flesh fly Neobellieria bullata.

Balamani and Nair (1989) reported Fluoro Mevalonate (FMev) against the fall webworm *Hyphantria cunea*.

Yoshi da et al. (2000) studied the effect of precocene against *B. mori*. Treatment of *N. bullata* larvae with KK-110 and J-2710 resulted in precocious pupation.

Brooks and McCaffery (1990) discussed how to induce precocious fourth-instar nymphs after exposing 2nd-instar nymphs of *E. plorans plorans* to Precocene II, or precocious adultoids, after fourth-instar nymphs were exposed to the biorational botanical compounds. It is well known that precocenes selectively destroy the cells of Corpora allata, CA, the organs in insects that produce juvenescence.

Wilson (2004) has shown that interference with the expression or function of several genes, most notably the broad complex (br-C) transcription factor gene, which drives changes during metamorphosis, may represent the molecular foundation of JH activity.

Erezyilmaz et al. (2006) examined how br contributed to the early adult molt in *O. fasciatus* following the administration of PII to nymphs in their third instar and proposed that br mRNA was lost during this stage of the molt.

El-Gammal and M.A. Taha (1984) observed permanent (over-aged) nymphs of *Schi. gregaria* (Orthoptera) after treatment with certain IGRs.

Gadenne et al. (1990) show that the amount and timing of applying Fenoxycarb, a juvenile hormone analogue, to the fifth instar larvae of the European corn borer *Ostrinia nubilalis* (Lepidoptera) were responsible for inducing permanent larvae. Ghoneim and Ismail (1995) discover that the permanent larvae of the grey meat fly *Parasarcophaga argyrostoma* (Diptera) were generated following the topical administration of 100 µg/larva of chlorfluazuron (an inhibitor of chitin production) to final instar larvae.

Dorn et al. (1986) noted that several isolated plant products or botanical plant extracts have been shown to generate permanent nymphs in a variety of insects, including the milkweed bug Oncopeltus fasciatus (Hemiptera), after injecting azadirachtin into the just-molted final instar nymphs.

Fernandes et al. (2013) conclude that following topical administration of *Manilkara subsericea* (Sapotaceae) extracts onto fourth-instar nymphs, *O. fasciatus* and the cotton stainer insect *Dysdercus peruvianus* (Hemiptera) generate persistent nymphs.

Guar and Kumar (2010) reported induced permanent nymphs of *S. litura* (Lepidoptera) after treatment of larvae with an acetone leaf extract of *Withania somnifera* (Solanaceae).

Lingampally et al. (2013) deduced that treating larvae in their fifth and sixth instars with 1µg/µl of andrographolide, a terpenoid derived from the leaves of *Andrographis paniculata*, Acanthaceae, will result in the production of permanent nymphs and the confused flour beetle *Tribolium confusum* (Coleoptera).

El-Gammal et al., (1986) Observed permanent nymphs in *Schi. gregaria* after exposure to gamma irradiation (dose of 20 gray) against the 3rd instar nymphs.

Gaur and Kumar (2010) indicated that the bioactive substance may interfere with the metabolism of ecdysteroid or, conversely, might directly prevent the production of the hormone that triggers ecdysis.

Attathom (2002) As suggested, the imidazole compound KK-42 was found to delay or inhibit ecdysteroid production in *O. nubilalis* and *Schi. gregaria*.

Tan (1992) reported that imidazole SDIII exerted strong anti-JH and anti-ecdysteroid actions on *B. mori*.

Yoshida et al. (2000) revealed that the 3-pyridine derivatives temporarily act as anti-ecdysteroids against *B. mori*.

Wang and Liu (2016) claimed that "insect growth regulators" (IGRs) are a class of substances that, although not immediately harmful, selectively affect an insect's ability to grow, develop, transform, and/or reproduce by interfering with physiological processes that are controlled by hormones.

Resmitha and Meethal (2016) demonstrated that IGRs are utilized to manage a variety of insect pests due to their low toxicity, low environmental pollution, great selectivity, and minimal impact on human health and natural enemies.

8-Temperature stress affects bioinsecticides against *Schi. gregaria* and other insects.

According to previous studies, when temperature rises, insecticides with a positive temperature coefficient become more toxic; conversely, insecticides with a negative temperature coefficient become more harmful when temperature falls. The effectiveness of insecticides used in pest control is significantly impacted by environmental temperature. Chemical pesticides work best at a single temperature because different phenotypes of resistance may have different resistance patterns. Similarly, when local conditions fluctuate greatly, it might not be appropriate to assume that a control tool performs consistently over an area. Further investigation is required to determine the impact of temperature on the practical efficacy of insecticide-based therapies.

Weis-Fogh (1956) and Roffey (1963) stated that the temperature affects the migratory patterns of desert locusts, *Schi. gregaria*. Typically, 20°C is considered the threshold temperature for locust flight, while 22–24°C permits migration and 19.5–33°C is ideal for the continuous flight of lone desert locusts.

Huque, Jaleel (1970), and Chen (2002) suggested that the temperature at which desert locust eggs hatch is between 21 and 45°C. When the temperature is 42–43°C, the eggs grow the fastest and can hatch in 9 days; at 21°C, it takes 23 days. Furthermore, when the temperature is between 15.5°C and 45°C, the eggs do not mature.

Chen (2002) mentioned that under the conditions of 24°C, the period of nymph of *Schi. gregaria* is about 62–64 d; the period is only 21 d at 41°C; when the temperature is around 20°C or below, the activity of locust decreases.

Uvarov (1977) and Hemming (1978) conclude that the optimum temperature for *Schi. gregaria* nymphs and adults is about 40°C.

Nevo (1996) deduces that when the temperature is higher than 40°C, the activity begins to weaken.

Guthrie (1950) declared that the primary determinant of pesticide effectiveness is temperature. After treatment, there are two broad tendencies in this connection that have been noted: a positive or negative association between the measured toxicity and temperature. It has long been known that there are variations in how temperature affects the chemistry of insecticides.

Grafius (1986) and Turnbull & Harris (1986) mention that organophosphates tend to perform better under warm conditions (30–32 °C) or show little or no dependence on temperature.

Harris & Kinoshita (1977), Harris & Turnbull (1978), De Vries & Georghiou (1979), Hirano (1979), Sparks et al. (1.1983), Grafius (1986), and Turnbull & Harris (1986) reported that at lower ambient temperatures, usually between 15 and 16°C, pyrethroids frequently show increased toxicity to arthropods.

Sparks et al. (1982) discovered that when applied to the cabbage looper, *Trichoplusia ni* (Hubner), fenvalerate and deltamethrin had a negative temperature coefficient (i.e., performed better at lower temperatures), but when applied to the tobacco budworm, Heliothis virescens (F.), or the fall armyworm, *Spodoptera frugiperda* (J. E. Smith), they had a neutral or positive relationship.

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Ewen et al. (1984) Temperature is a significant element for grasshopper species because, in grassland or in cereal crops, management is frequently needed under warm field conditions (25–35°C), and a negative temperature coefficient has been shown for at least one pyrethroid.

Hinks (1985) found decreased toxicity of deltamethrin to migratory grasshopper nymphs at temperatures above 27°C.

Ewen et al. (1984) found that temperature effects were blamed for the widespread failure of cypermethrin to control grasshoppers in Saskatchewan.

Daniel (1990) concluded that the field trial showed an effective rate of 20 g alphamethrin/ha. Confirmation and more evidence that warmth raises pesticide toxicity were supplied by the lab experiment. The lower rates of physiological and metabolic processes at 15 and 19°C correlate with the slower activity at these low temperatures. Ewen et al. (1984) and Hinks (1985) mentioned that the high temperatures are not expected to make alpha- or deltamethrin less effective against grasshoppers. If high temperatures hinder metabolism, the impact either vanishes at room temperature or is compensated for at the rates used.

Hinks (1985) discovered that at 15.6, 21.1, 26.7, 32.2, and 37.8 OC, the second-instar *M. sanguinipes* nymphs' relative deltamethrin doses were 1.0, 1.0, 1.1, 1.9, and 2.8, respectively. Decis EC, Hoechst Canada, produced the emulsifiable concentrate formulation of deltamethrin.

Brown (1987) found that the fenvalerate, flucythrinate, and permethrin-treated tobacco budworm had an LD50 at 26°C of 27, 140, and 13 times that of 16°C. However, it is important not to overstate the risks associated with pyrethroids' negative temperature coefficients while controlling grasshopper populations. One frequently cited example of the alleged impact of a negative temperature coefficient on the efficacy of a pyrethroid for grasshopper control is the claimed widespread failure of cypermethrin in Saskatchewan.

Mukerji & Ewen (1983) found that effective mortality (85, 90, 92, 95, and 97% mortality in 1, 2, 3, 4, and 5 d, respectively) was obtained at a field rate of 15 g/ha cypermethrin. However, when administered at the suggested rate of 20–28 g/ha, growers and business officials found the product to be significantly less successful.

Ewen et al. (1984) attributed the inconsistent experimental results by stating that "evening/night air temperatures below l00°C for the 5 days following cypermethrin application against the migratory grasshopper, *Melanoplus sanguinipes*." Ten randomly selected sweeps from each subplot in the treated plots served as the sample unit.

Johnson et al. (1986) demonstrated that in a pyrethroid field trial, estimates of mortality obtained by collecting grasshoppers using sweep nets were skewed. The real variation in cypermethrin effectiveness estimates may be explained by this sample.

9-Biorational insecticides retarded the developmental growth of *Schistocerca gregaria*

a) Effect of biorational insecticides on the nymphal weight of *Schi. gregaria*:

After treating the penultimate instar nymphs of *Schi. gregaria* with the biorational botanical insecticides of limonene, sabadilla, rotenone, and azdiracthtin, the somatic weight increase was lower than that of the control nymphs in the current study.

Armbruster and Hutchinson (2002) submit that body weight, and hence weight gain, is one of the most valuable indicators for evaluating culicidae insect growth.

Sieber and Rembold (1983) reported that growth inhibition was recorded for the migratory locust *Locust migratoria* after treatment with a botanical from the neem tree *Azadirachta indica*.

Jagannadh and Nair (1992) mention that the lepidopteran *Spodoptera mauritia* larvae were inhibited in growth after treatment with azadirachtin.

Ghoneim (2015) apparently, acetylcholinesterase activity in the fat bodies and hemolymph of *Schistocerca gregaria* (Forskal) (Orthoptera: Acrididae) was disrupted by pomegranate extracts (*Punica granatum* Linn.).

Osman (1993) found that there was no significant effect of a neem extract on the body weight gain of *Pieris brassicae* larvae.

Huang *et al.* (2000) deduced that the essential oils of garlic significantly suppressed the growth rate of the coleopterans *Sitophilus zeamais* and *T. castaneum.*

Nascimento *et al.* (2004) mention that the acetonic and ethanolic extracts from tubercula and various compounds of *Aristolochia pubescensi* inhibited the larval growth of *T. castaneum*.

Akhtar and Isman (2004) found that *Melia volkensii* (Meliaceae) extract exhibited a potent growth inhibitor effect on the cabbage looper *Trichoplusia ni* (Lepidoptera).

Cespedes *et al.* (2005) suggested that the development of Tenebrio molitor and Spodoptera frugiperda was hampered by a methanolic extract derived from the aerial parts and roots of Myrtillocactus geometrizans (Cactaceae).

Senthil Nathan (2006) revealed that the growth of *S. littoralis* larvae was suppressed by *Trichilia americana* extract, whereas the growth of Cnaphalocrocis medinalis, a rice leaffolder, was inhibited by Melia azedarach extract (Lepidoptera). Abdel-Ghaffar *et al.* (2008) mentioned that jojoba oil prohibited the pupal growth of the red palm weevil *Rh. ferrugineus.*

Amer et al. (2004) reported that jojoba oil did not affect the larval growth of *M. domestica*.

Sieber and Rembold (1983, Barnby and Klocke (1990), and Linton *et al.* (1997) proposed that the growth inhibition in Schi. gregaria produced by plant extracts results from the blocking of morphogenic peptide release, which modifies juvenoid and ecdysteroid titers.

Nasiruddin and Mordue (1994) reported that *N. sativa* extracts may affect the tissues and cells undergoing mitosis in *Schi. gregaria*.

b) Effect of biorational insecticides on nymphal duration of *Schistocerca gregaria*

The application of biorational botanica insecticides to *Schi. gregaria* penultimate instar nymphs may have caused development to be slowed down, as evidenced by the lengthened developmental period and parallel regression of the developmental rate to the concentration level.

Urishalom *et al.* (1988) mention that, more or less, prolonged developmental duration was a good indicator of the inhibited development of the migratory locust *L. migratoria* after treatment with zadirachtin.

Hamadah et al. (2013) submitted that applying *N. sativa* extracts to *Schi. gregaria* penultimate instar nymphs altered their developmental length by showing a notable inhibitory impact (significantly extended developmental duration). Conversely, treatment of the final instar Schi. gregaria nymphs resulted in slightly accelerated development by n-butanolic extract and somewhat postponed growth length by methanolic extract.

Mwangi and Rembold (1988 ; Wilps *et al. (*1993), and Amr *et al.* (1995) observed that the extracts from *M. volkensii* (Meliaceae) caused a conspicuous prolongation of larval duration development in the orthopteran *Schi. gregaria.*

Amr *et al.* (1995) observed a significant prolongation in the larval duration of *S. littoralis* by the ethanolic extract from *Nerium oleander*.

El-Shazly *et al.* (1996) observed the prolongation of the developmental duration of *M. stabulans* by the effect of *Nerium oleander* extract.

Rani and Jamil (1989) reported the prolongation of duration by the effect of *Eichlornia crassipes* (Ponteriaceae) extract on the coleopteran *T. castaneum.*

Zhong *et al. (*2001) submitted that the prolongation of *Schi. gregaria* was obtained due to the effect of *A. conyzoides* extract.

Hamadah et al. (2013) mentioned the enhanced development (as indicated by the remarkably shortened developmental duration) in the desert locust *Schi. gregaria* by various extracts from *N. sativa.*

Saxena *et al. (*1993) mention similar enhancing development effects of different plant species like *Annona squamosa* (Annonaceae**)** against the mosquito *An. stephensi.*

Darvas *et al.* (1996) reported that *Ajuga reptans* (Lamiaceae) against the sarcophagid *Neobellieria bullata*.

Jbilou *et al.* (2008) studied the effect of *Launaea arborescens* (Asteraceae) and *Pteridium aquilinum* (Polypodiaceae) against the coleopteran *T. castaneum.*

Abdel-Ghaffar *et al.* (2008) submitted that jojoba oil was enhancing development against the coleopteran *Rh. ferrugineus*.

Al-Sharook *et al*. (1991) reported no effect on the developmental duration of *M. volkensii* (Meliaceae) extract on the mosquito *Culex pipiens*.

Quadri and Narsalah (1978; Linton *et al. (*1997 and Hamadah et al. (2013) noted that the plant extracts' ability to postpone the ecdysis and transformation of insects can account for the lengthening of the developmental phases and, in turn, the slowed development of *Schi. gregaria.*

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III- Materials and methods

a-Insect Colony:

The susceptible strain of desert locust, *Schistocerca gregaria*, was obtained from the locust Research Department, Ministry of Agriculture, Dokki, and Giza and is being used throughout the present investigation. A stock colony was reared in cages measuring 45x45x65 cm. Except for the front side, which was made of glass, all the other three sides of the cages were made of wood, with a small window closed by wire gauze for ventilation. Each cage was supplied every morning with a suitable amount of fresh food, consisting of clover leaves and a small petri dish containing one spoon of yeast mixed with dry milk.

These cages have small doors on the front side to facilitate daily routine feeding and cleaning. They were fed clover *Trifolium alexandrinum* introduced daily as feeding materials, along with dry wheat bran fortified with yeast powder as a source of vitamins. The cages were cleaned daily to avoid contamination and kept under conditions at a temperature of 25 ± 2 °C and 50–60% relative humidity (RH).

The cages were provided with pots of moistened, sieved sand to serve as ovipositional sites. Every day, the sand pots were checked for laid eggs, and those laid eggs were isolated into empty cages until hatching, and the resulting offspring were used in experiments. The insect colony was followed and reared according to the method of Hoste et al. (2002), with some modifications. The locust culture and the experimental tests were kept in a light room, which was provided by a set of 60-watt electric bulbs. A bulb was hung in front of the glass side of each cage. All bulbs were connected to an automated timer switch.

b-Biorational compounds

Biorational natural compounds, such as rotenone, sabadilla, limonene, azadirachtin, and the anti-jivenoids precocene II, were obtained from Aldrich and Sigma chemical companies. Azadirachtin, rotenone, sabadella, and limonene were prepared to study their effects against the desert locust, *Schi*stocerca *gregaria,* according to Al-Maroug et al. (2022). The fourth and fifth nymphal instars, 12 hours old, of *Schhisocerca gregaria* were feeding on the treated clover leaves (dipping technique) with different concentrations of the botanical insecticides. Considering the biorational insecticides as 100%, a known volume of the biorational insecticides, Azadirachtin, Rotenone, Sabadilla, and limonene, was added to a similar volume of the acetone solvent to obtain a stock solution. All treated and control nymphs were kept under the controlled conditions of 25 ± 2 °C and 50–60% relative humidity (RH).

c- PrecocenII administration:

Anti-juvenoid precocene II was diluted in acetone organic solvent to prepare a series of doses: 50, 125, 250, 500, and 1000 ppm. A dipping technique of clover leaves was applied for feeding the fifth nymphal instars of *Schi. gregaria*. After acetone evaporation, groups of 10 newly moulted nymphs of 12-hour-old fifth (penultimate) nymphal instars of *Schi. gregaria* were fed on treated clover leaves with different concentrations of precocene II. All treated and control nymphs were kept under the controlled conditions of 25 ± 2 °C and 50–60% relative humidity (RH). Treated nymphs were followed until the next molting and adult emergence, and any deformation was described.

d- Metabolic biochemical studies on the haemolymph of *Schi. gregaria*

The determination of body metabolites in hemolymph was gathered from fifth-instar nymphs. Haemolymph total proteins, total lipids, and total carbohydrates were estimated after treating nymphs with lethal concentrations (LC_{50}) of biorational insecticides, Rotenone, Sabadilla, and Limonene. Using a tiny hole in the hind leg membrane and under the dorsal pronotal shield membrane, the hemolymph was extracted and placed into dry centrifuge tubes in accordance with the procedure method of Metaweh *et al.* (2001). A group of control and treated subjects was placed under the same conditions for 14:10 hours (light and dark) (Robert *et al.*, 2002). Haemolymph was drawn into an Eppendorff pipette containing a few milligrams of phenoloxidase inhibitor (phenylthiourea) to prevent tanning or darkening and then thinned with a saline solution of 0.7%. The hemolymph tests were then centrifuged at 2000 r.p.m. for 5 min, and the supernatant fractions were studied for evaluation directly or frozen until use. Three replicates of the treated fifth nymphal instars were used for the determination of the main body metabolites. The total protein content of the hemolymph was determined according to Doumas (1975) by a kit from Bioadwic Company at a spectrophotometer of 500nm. The total carbohydrate (as glycogen) content of hemolymph was quantitatively determined by using the anthrone reagent according to Singh and Sinha (1977) at 580nm. Quantitative determination of the total lipid content of hemolymph was conducted according to the technique of Folch et al. (1957) using the spectrophotometer at 530 nm. The biochemical contents of the hemolymph of the treated insects were calculated after 24 hours post-treatment.

1. Determination of total proteins

Calculated total proteins by using method of the Bradford (1976) technique. 50 µl of the sample solution or 50 µl of serial solutions containing 10 to 100 µg of bovine serum albumin were pipetted into test tubes for the creation of the standard curve. Before and after two minutes, the absorbance at 595 nm was measured against a blank made of five milliliters of protein reagent and one milliliter of phosphate buffer. Protein content is equal to (test absorbance / standard absorbance) x standard absorbance.

2. Determination of total lipids

By preparing a phosphovanillin reagent and a standard solution, the total lipids were calculated using the technique of Knight et al. (1972). After 45 minutes, the developed color was assessed at 525 nm against the reagent blank. The amount of lipids was calculated by multiplying the absorbance of the standard of the test sample, and 250 µl was handled in the same way as the sample solution. The fifth nymphal instars of *Schi. gregaria* were fed on clover leaves in the control experiment without receiving any medication.

3. Determination of total Carbohydrates

Total carbohydrates were estimated in the acid extract of the sample by the phenol-sulfuric acid reaction of Dubios *et al*. (1956). Blanks were prepared by substituting distilled water for the sugar solution. The absorbance of the characteristic yellow-orange color is measured at 490 nm against a blank. Total carbohydrate is expressed as µg glucose/gm fresh weight. Carbohydrate concentration was expressed as mg glucose/100 ml hemolymph. Total carbohydrates = (absorbance of test / absorbance of standard) x absorbance of standard.

e- Bioassay

To create the stock solution, a known volume was added to an equivalent amount of the acetone solvent while taking into account the biorational chemicals limonene, sabadilla, rotenone, and azadirachtin at 100%. For every boiorational insecticide, five concentrations (5, 10, 15, 20, and 25%) were created. *Schisocerca gregaria* fourth and fifth nymphal instars, 12 hours old, were fed on treated clover leaves by dipping them in each concentration for 25 seconds before letting the acetone solvent evaporate.

After the fourth and fifth instar nymphs of *Sch. greagaria* were treated with varying doses at room temperature (25 ± 2.3), the LC_{50} of each natural biorational compound was calculated. The fourth and fifth nymphal instars were fed on treated clover leaves. In the control experiment, all nymphs were fed on clover leaves without any treatment.

Toxicity, heamolymph biochemicals, nymphal weight, duration, and the effect of temperature stress on the treated insects were calculated at different times.

On the other hand, the nymphs and adult deformation of *Schi. gregaria* due to the effects of precocene II were recorded and described.

f- Statistical analysis:

Ten fourth and fifth nymphal instars of *Schi. gregaria* were transferred into a 150-mL glass beaker covered with muslin in order to feed on treated clover. The efficacy of biorational insecticides, sabadilla, limonene, azadirachtin, and rotenone, on mortality of nymphal instars of *Schi. gregaria* was calculated and corrected using Abott's formula (1925). The obtained results were analyzed by the student's t-distribution and refined by Bessel correction (Moroney, 1956) for the test significance of the difference between means. Nymphal mortality, lethal toxicity (LC_{50} and LC90), temperature stress toxicity, duration, weight of the biorational compounds, and morphogenesis effects of precocene II were recorded. Biochemical data as well as temperature stress at different times due to the effects of biorational compounds were analyzed using the software SPSS (Version 10.0 for Windows, SPSS (2009) Inc., Chicago, USA).

IV- Results

1-Toxicity Effects of the biorational insecticides on the fourth nymphpal instar of *Schistocerca gregaria*:

The represented data in Table (1) and Figure 1 show the toxicity impact of biorational pesticides on the fourth nymphal instar of *Schistocerca gregaria*. The fourth instar nymph was affected by the studied biological insecticides, sabadilla, rotenone, azadirachtin, and limonene. The greatest concentrations of azadirachtin, rotenone, sabadilla, and limonene at 25% resulted in death rates of 100, 87, 82, and 79%, respectively. With the same prior biorational chemicals,
the lower concentration of 5% resulted in 65, 63, 62, and 55% mortalities, respectively (table 1, figure 1). The LC_{50} and LC_{90} of azadirachtin on *Schi. gregaria* fourth nymphal instars resulted in the highest toxicity levels of 3.4 and

15.2%, respectively (table 2). However, Table 2 shows that the LC_{50} and LC_{90} limonene impacts caused lower toxicity on fourth-nymphal instars by 4.2 and 28.1%, respectively.

Table 1: Mortality response of *Schi. gregaria* by the effect of the biorational botanical insecticides on fourthnymphal instar.

Mortality% effect of biorational insecticides on fourthnymphal instar of *Schi. gregaria*				
%Concentration	**Azadirachtin**	**Rotenone**	**Sabadilla**	**Limonene**
5	62	61	60	48
10	78	66	62	62
15	82	69	66	63
20	87	84	68	66
25	100	87	82	79
Control	00	00	00	00

Figure 1: Mortality of *Schi. gregaria* by the effect of the biorational botanical insecticides on fourthnymphal instar.

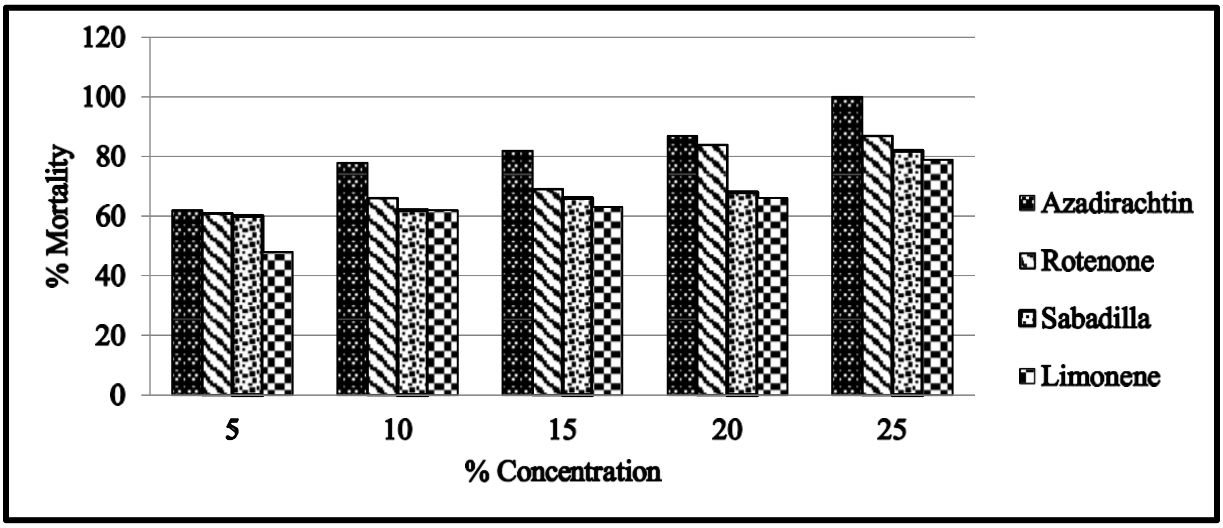


Table 2: Lethal (LC_{50} & LC_{90}) effect of biorational insecticides on fourthnymphal instars of *Schi. gregaria*

Toxicity effect	Toxicity of the biorational insecticides			
	Azadirachtin	Rotenone	Sabadilla	Limonene
LC_{50}	3.4	3.7	3.8	4.2
LC_{90}	15.2	18.7	26.3	28.1

2-Potential effects of the biorational compounds on % mortality of fifth nymphal instar of *Schistocerca gregaria*

The mortality effect of the biorational insecticides against the fifth nymphal instars of *Schi. gregaria* is represented in table (3) and figure (2). Results showed that all the tested biorational insecticides had potential toxicity against the fifth instar nymph of *Schi. gregaria*. Higher mortalities were 92, 86, 79, and 72% after 72 hours post-treatment of fifth nymphal instars with the highest concentrations of azadirachtin, rotenone, sabadilla, and limonene, respectively. While at the lower concentration, 5% produced lower mortality rates of 59, 57, 55, and 48% with the previous biorational compounds, respectively (Table 3 and Figure 2). In order of toxicity, the highest toxicity at the LC_{50} level was 4.2%, caused by the effect of azadirachtin on the fifth nymphal instars of *Schi. gregaria*. While the lowest toxicity of LC_{50} was 5.2%, obtained after fifth nymphal treatment with limonene compounds, The LC90 of biorational compounds against the fifth instar nymphs of *Schi. gregaria* was 22.4, 27.5, 34.3, and 36.4% of azadirachtin, rotenone, sabadilla, and limonene, respectively (Table 4). These results could suggest strong bioactivity and mortality effects against *Schistosoma gregaria* by the tested biorational compounds.

Table: 3 Effect of biorational compounds on the mortality of fifth nymphal instars of *Schistocerca gregaria*

Mortality% effect of biorational insecticides on fifth nymphal instar of *Schi. gregaria*				
	Azadirachtin	**Rotenone**	**Sabadilla**	**Limonene**
5	59	57	55	48
10	67	65	61	57
15	79	71	68	63
20	84	78	73	64
25	92	86	79	72
LC50	4	4.3	4.5	5.2
LC90	22	27	34	36
Control	00	00	00	00

Figure 2: Toxicity effect of biorational compounds on the mortality of fifth nymphal instars of *Schistocerca gregaria*

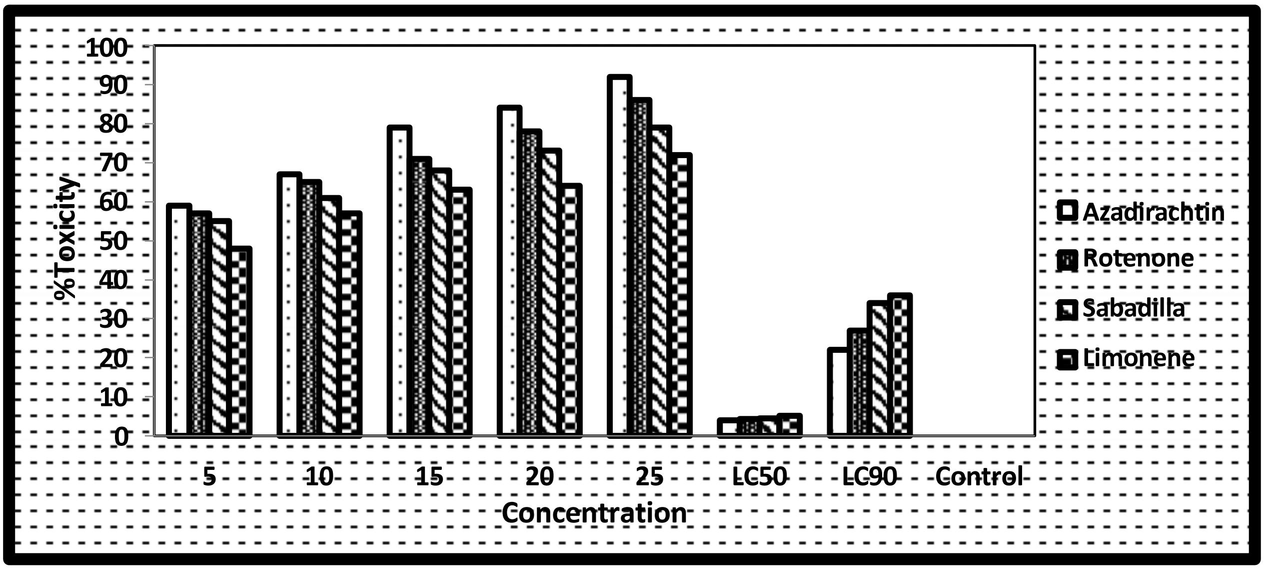


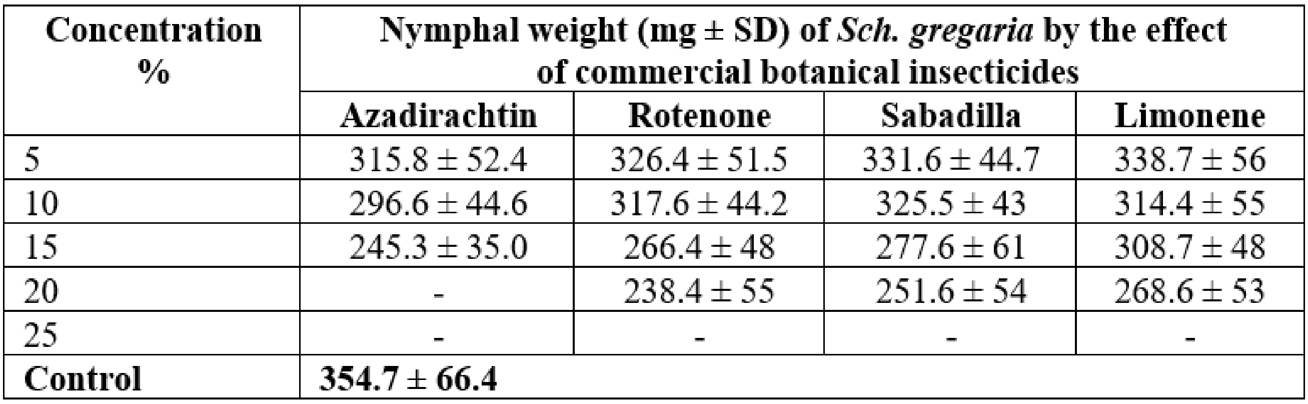
Table 4: Lethal (LC_{50} & LC_{90}) effect of biorational insecticides on 5th nymphal instars of *Schi. gregaria*

Toxicity effect	Toxicity of the biorational insecticides			
	Azadirachtin	Rotenone	Sabadilla	Limonene
LC_{50}	4.2	4.5	4.6	5.2
LC_{90}	22.4	27.5	34.3	36.4

3.Effect of biorational compounds on the fourth Nymphal Weight of *Schi. gregaria*

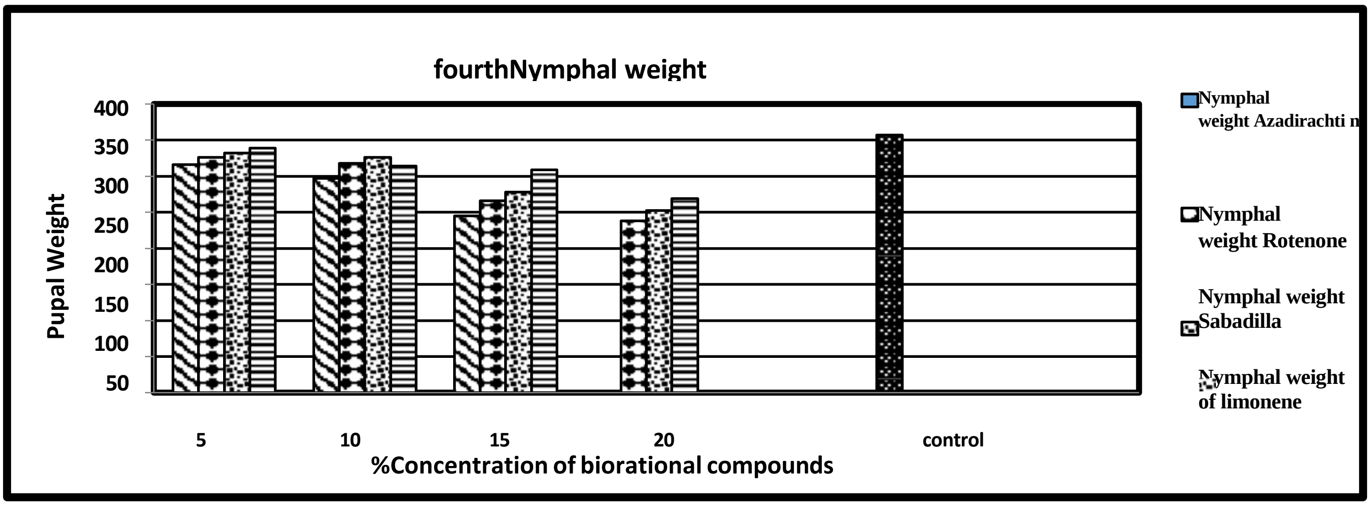
The data represented in Table (5) and Figure (3) indicated that the penultimate fourth-star nymphs of *Schi. gregaria* gained somatic weight less than that of control congeners. However, the most drastic suppressing effect on weight gain was exhibited at the higher concentration level compared with that of the control nymphs. The decrease in nymphal weight was 238.4 mg at a concentration level of 20% of the rotenone compound vs. 354.7mg in the control. While the nymphal weight decreased by 338.7mg at concentrations of 5% of the limonene compound. In addition, at a concentration of 20%, all nymphs died after treatment with azadirachtin; however, at a concentration of 25%, all nymphs died from all tested bioinsecticides. Furthermore, the loss of nymphal weight was 268.6 after nymphal treatment with limonene at a concentration of 20% vs. the control treatment (354.7mg). Additionally, when the doses of the applied botanical pesticides increased, the fourth nymphal weight decreased. (Table 5 and figure 3).

Table 5: Effect of biorational botanical insecticides on weight of the fourth nymphal instar of *Schi. gregaria*



Concentration %	**Nymphal weight (mg ± SD) of *Sch. gregaria* by the effect of commercial botanical insecticides**			
	Azadirachtin	**Rotenone**	**Sabadilla**	**Limonene**
5	315.8 ± 52.4	326.4 ± 51.5	331.6 ± 44.7	338.7 ± 56
10	296.6 ± 44.6	317.6 ± 44.2	325.5 ± 43	314.4 ± 55
15	245.3 ± 35.0	266.4 ± 48	277.6 ± 61	308.7 ± 48
20	-	238.4 ± 55	251.6 ± 54	268.6 ± 53
25	-	-	-	-
Control	**354.7 ± 66.4**			

Figure 3: Bioinsecticide effect on weight of the fourthnymphal instar of *Schi. gregaria*



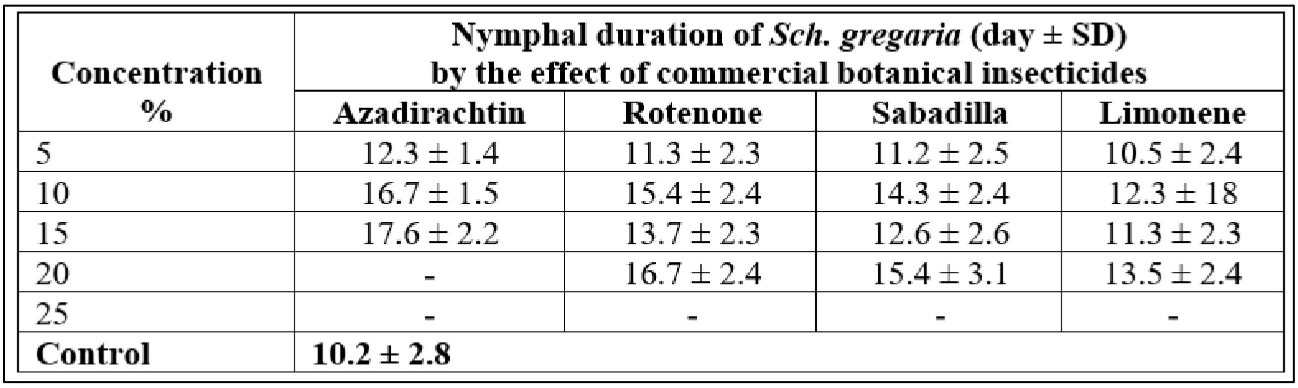
3- Effect of the biorationa insecticides on the fourth nymphal Duration of *Schi. gregaria*

The results obtained showed that the duration of *Schi. gregaria* fourth-star nymphs was inhibited by the biorational insecticides (table 6 and figure 4). Since the nymphal duration of the penultimate instar was prolonged, particularly at concentration levels of 10, 15, and 20%, The data presented in table 5 and figure 4 indicate that longer prolongation periods were obtained after treatment with azadirachtin at concentrations of 10 and 15% (16.7 and 17.6 days, respectively, vs. 10.2 days for the control). While the same previous concentrations caused a nymphal duration of 15.4 and 13.7 days for roetenone and 14.3 and 12.6 days for sabadill, the nymphal duration was prolonged by

12.3 and 11.3 days in the case of limonene, respectively (table 5 and figure 4). Nymphal duration was 16.7 and 15.4 days after the nymph was fed on treated clover leaves with concentrations of 10 and 20% of the rotenone compound.

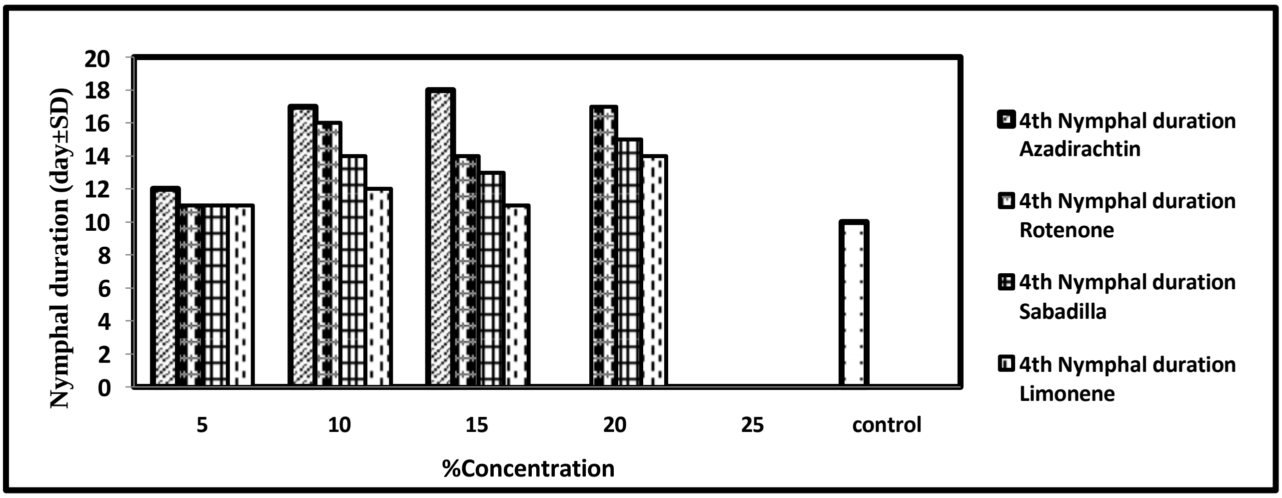
Meanwhile, at the highest concentration, 25% of the all-treated nymphs did not emerge into the next stages. Unexpectedly, at concentrations of 15%, the nymphal duration was prolonged gradually by 13.7, 12.6, and 11.3 days by the effects of rotenone, sabadilla, and limonene, respectively (table 6 and figure 4).

Table 6: Effect of biorational botanical compoundes on fourth nymphal duration (day± SD) of *Schi. gregaria*



Concentration %	Nymphal duration of *Sch. gregaria* (day ± SD) by the effect of commercial botanical insecticides			
	Azadirachtin	**Rotenone**	**Sabadilla**	**Limonene**
5	12.3 ± 1.4	11.3 ± 2.3	11.2 ± 2.5	10.5 ± 2.4
10	16.7 ± 1.5	15.4 ± 2.4	14.3 ± 2.4	12.3 ± 18
15	17.6 ± 2.2	13.7 ± 2.3	12.6 ± 2.6	11.3 ± 2.3
20	-	16.7 ± 2.4	15.4 ± 3.1	13.5 ± 2.4
25	-	-	-	-
Control	**10.2 ± 2.8**			

Figure 4: Effect of biorational insecticides on fourthnymphal duration of *Schi. gregaria*



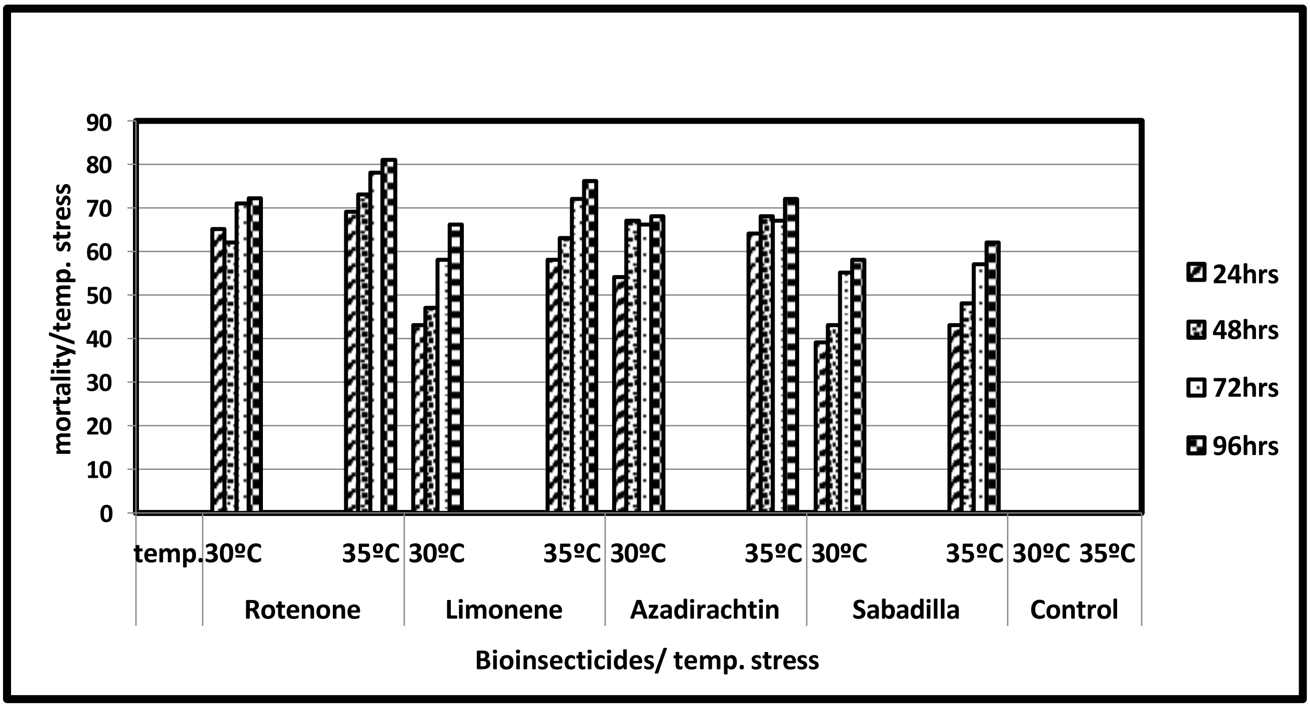
4- Temperature stress effects on the fifth nymphal instars of *Schi. gregaria* Treated with the LC_{50} of the biorational compounds

Data in table 7 and figure 5 provided the effect of temperature stress (30ºC, 35ºC) on the fifth nymphal instar treated with LC_{50} of different biorational insecticides at 24, 48, 72, and 96 hours post-treatment. The obtained results indicate that rotenone was the most potent, followed by limonene, azadirachtin, and sabadilla. The lower and higher effects of temperature stress on nymphal mortality were obtained by the effects of rotenone LC_{50} (65.13) and (81.12%) under temperatures of 30ºC and 35 ºC after 24 and 96 hours post- treatment, respectively. The least effect of temperature stress on fifth nymphal mortality was obtained by sabadill, which gave 39.13 and 62.11% at temperatures of 30 ºC and 35ºC after 24hrs and 96hrs post-treatment, respectively. Meanwhile, the mortality of the fifth nymphal instar was temperature-dependent on temperature and time of exposure, which increased by increasing these two factors. Mortality of the fifth nymphal instar of *Schi. gregaria* of Azdirachtin was recorded at 54.11 and 72.12% at 30ºC and 35ºC after 24hrs and 96 h post-treatment, respectively. While the limonene compound caused 43.11 and 76.23% of nymphal mortalities at the same previous factors, respectively (table 7 and fig. 5)

Table (7): Effect of Temperature stress on fifth nymphal instars of *Schi. gregaria* treated with LC$_{50}$ with the different biorational compounds and variable times.

Biorational materials	Temp.°C	cumulative mortality percent of fifth nymphal instar, *Sch gregaria* under temperature stress			
		LC$_{50}$ of bioinsecticides at different periods			
		24hrs	48hrs	72hrs	96hrs
Rotenone	30°C	65.13	62.11	71.11	72.19
	35°C	69.12	73.14	78.16	81.12
Limonene	30°C	43.11	47.13	58.11	66.1.7
	35°C	58.12	63.14	72.10	76.23
Azadirachtin	30°C	54.11	67.12	66.13	68.11
	35°C	64.15	68.14	67.12	72.12
Sabadilla	30°C	39.13	43.12	55.12	58.10
	35°C	43.12	48.11	57.11	62.11
Control	30°C	00.00	00.00	00.00	00.00
	35°C	00.00	00.00	00.00	00.00

Figure 5: Temperature stress effect on fifth nymphal instars of *Schi. gregaria* treated with LC$_{50}$ of the biorational compounds at different times.



5- Temperature stress effect on metabolic heamolymph relationships of fifth instar nymph after it was treated with biorational compounds

Temperature stress was impacted on the hemolymph, protein, carbohydrate, and lipid contents of treated fifth nymphal instars after treatment with LC_{50} of limonene, rotenone, azadirachtin, and sabadilla. These findings suggest that biorational compounds have been affected by the biochemical contents of the fifth nymphal instar, *Schistocerca gregaria*

a. Metabolic Effect of the biorational insecticides on total carbohydrate of 5th nymphal haemolymph of *Schi. gregaria* under different temperature stress.

The total amount of carbohydrates decreased with rising temperature for all tested bioinsecticides as compared to the control (Table 8 and Figure 6). At a temperature of 35°C, the nymph treated with LC_{50} of sabadilla bioinsecticides showed a greater decrease in total carbohydrates (35.13 mg/ml) than the control insect (47.14 mg/ml). After the nymph was fed on the treated leaves with limonene compound at 20 °C, the lower decrease of carbohydrates was 49.11 mg/ml, compared to 52.37 mg/ml of the control. Total carbohydrate in hemolymph was decreased at 30 °C by 39.16, 40.14, and 41.12 mg/ml due to the effects of azadirachtin, rotenone, and limonene, respectively, compared to 48.36 mg/ml in the control. The same previous compounds recorded 37.16, 37.13, and 38.21 mg/ml, respectively, compared to 47.14 mg/ml for the control nymphs at a temperature level of 35 °C, respectively (table 8, figure 6). Conversely, in the biorational compounds, the rate of the fifth nymphal hemolymph's carbohydrate index increased with increasing temperature (table 8 and figure 6). For the sabadilla compound, the index rates of carbohydrates were 4.27, 5.17, 5.43, and 5.19 at 20, 25, 30, and 30 °C, respectively. Following nymphal treatment with limonene at temperatures of 20, 25, 30, and 35 °C, the lowest index rate of carbohydrate level was 1.70, 1.08, 3.50, and 4.21% (table 9 and figure 7).

Table 8: Carbohydrate content (mg/ml ± SD) of fifth instar nymph after treatment with LC_{50} of birational compounds at 4 levels of temperatures

Biorational insecticidees	**Carbohydrate content mg/ml of fifth Nymphal instar treated with LC_{50} of bioinsecticides at 4 temperature levels**			
	Temp. of 20ºC	**Temp. of 25ºC**	**Temp. of 30ºC**	**Temp. of 35ºC**
Sabadilla	44.21^{b}±3.23	41.12^{b}±0.12	37.12^{c}±0.10	35.13^{c}±0.08
Azadirachtin	47.32^{a}±2.14	44.16^{b}± 3.12	39.16^{b}±0.13	37.16^{b}±2.07
Rotenone	48.11^{a}± 2.11	46.13^{b}± 2.13	40.14^{b}±0.12	37.13^{b} ±2.11
Limonine	49.11^{a}±0.12	48.11^{a}± 2.13	41.12^{b}±0.14	38.21^{b} ± 2.09
Control	52.37^{a} ± 4.13	51.23^{a}± 3.22	48.36^{a}± 3.15	47.14^{a}± 2.16

Mean ± SD followed with the same letter (^{n}): is not significantly different (P>0.05)

Figure 6: Effect of temperature stress on heamolymph carbohydrate content (mg/ml ± SD) of *Sch.gregaria* after treatment of fifth instar nymphs with LC_{50} of biorational insecticides at constant temperature

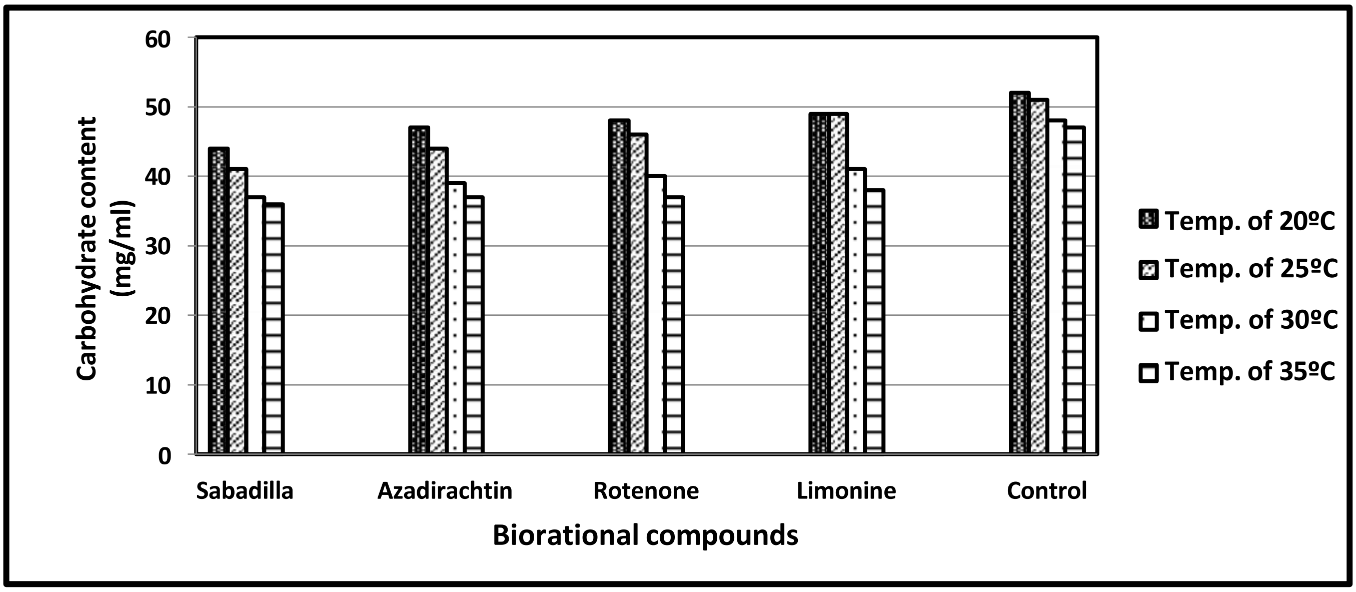
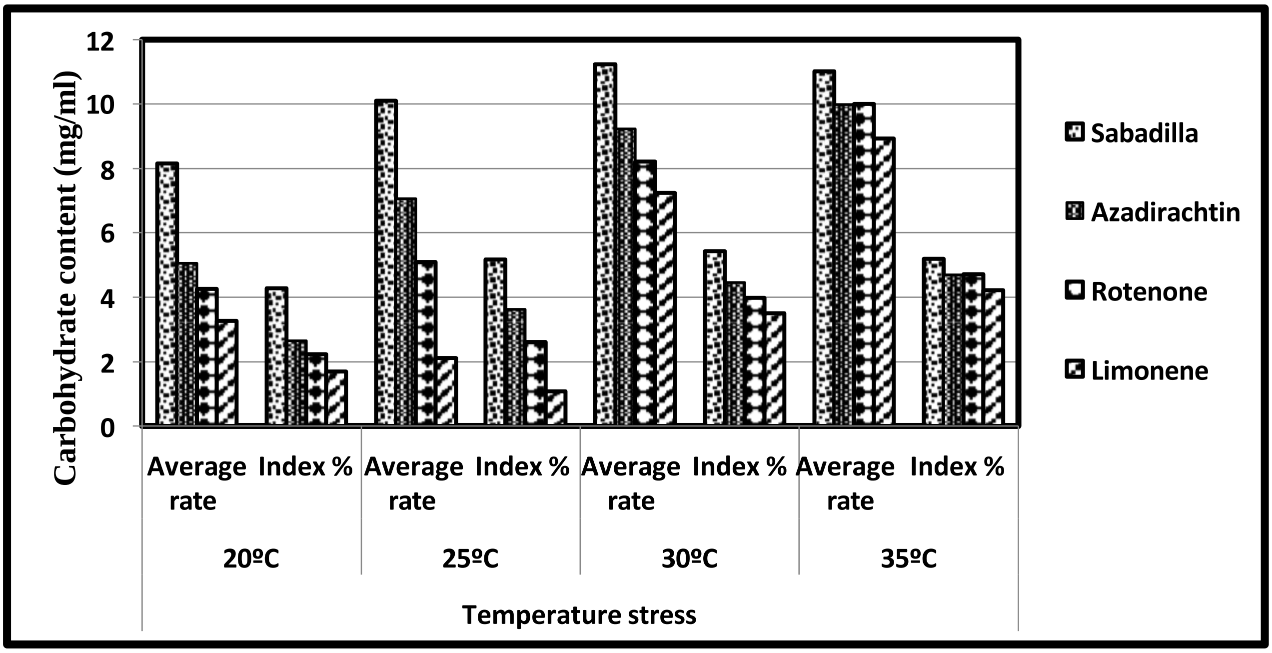


Table (10): Rate of change index of fifth nymphal carbohydrate at constant temperature

Bioinsecticides	Temperature stress and average of carbohydrate contents							
	20ºC		25ºC		30ºC		35ºC	
	Average rate	Index %	Average rate	Index %	Average rate	Index %	Average rate	Index %
Sabadilla	8.16	4.27	10.11	5.17	11.24	5.43	11.02	5.19
Azadirachtin	5.05	2.64	7.07	3.62	9.22	4.46	9.98	4.70
Rotenone	4.26	2.23	5.1	2.61	8.22	3.97	10.01	4.71
Limonene	3.26	1.70	2.12	1.08	7.24	3.50	8.93	4.21

Figure (7) Rate of change index of fifth nymphal carbohydrate at constant temperature



b. Effect on total protein of 5th nymphal haemolymph of *Schi. gregaria*

Data in Table (11) and Figure 8 show that total protein contents were significantly decreased in *Schi. gregaria* fifth nymphal instar post-treatment with sabadilla. This decrease was 64.04, 55.32, 54.22, and 48.12 mg/ml at temperature levels of 20, 25, 30, and 35 °C, respectively, compared to the untreated nymphs. The lowest decreasing of the total protein conets was obtained after nymphs were fed on treated clover leaves with limonene compounds (78.16, 63.26, 61.31, and 58.21 mg/ml) at temperatures of 20, 25, 30, and 35 °C, respectively, vs. control insects. Meanwhile, protein content decreased significantly after the nympha was treated with azadirachtin under temperature stress of 25, 30, and 35 °C (61.36, 65.27, and 57.17 mg/mL) compared to control protein nymphs, respectively. Whereas no significant decrease occurred in total protein after the nymph was fed on treated clover leaves with limonene. Protein content was 78.16, 63.26, 61.31, and 68.21 mg/mL as limonene was impacted by temperature stress at 20, 25, 30, and 35 °C, respectively (Table 11, figure 8). On the other hand, the rate of protein index of the fifth nymphal heamolymph increased with increasing temperature on the biorational components (table 10 and figure 9). The index rate of protein was 13.8, 11.5, 9.55, and 11.07 in the case of the sabadilla compound at temperatures of 20, 25, 30, and 30 °C, respectively. The least index rate of protein content level was 1.09, 5.83, 4.71, and 4.49% after nymphal treatment with limonene at temperatures of 20, 25, 30, and 35 °C (table 12 and figure 9).

Table 11: Protein content (mg/ml ± SD) of fifth instar nymph after treatment with LC_{50} of birational compounds under temperatures stress

Biorational insecticidees	**Protein content mg/ml of fifth Nymphal instar treated with LC_{50} of different bioinsecticides at constant temperatures**			
	Temp. of 20ºC	**Temp. of 25ºC**	**Temp. of 30ºC**	**Temp. of 35ºC**
Sabadilla	64.04^{b} ± 2.31	55.32^{b} ± 2.10	54.22^{b} ±0.13	48.12^{b} ± 2.13
Azadirachtin	75.58^{a} ± 2.05	61.36^{b} ± 4.11	65.27^{b} ±0.12	57.17^{b} ± 3.12
Rotenone	72.21^{a} ± 3.23	58.34^{b} ± 4.12	68.24^{a} ±0.15	54.14^{b} ± 2.15
Limonine	78.16^{a} ± 3.04	63.26^{b} ± 3.13	61.31^{a} ±0.12	58.21^{a} ± 3.12
Control	**80.33^{a} ± 5.11**	**71.42^{a} ± 2.24**	**68.22^{a} ±4.31**	**65.12^{a} ± 3.14**

Figure 8: Effect of temperature on protein content of fifth instar nymphs with LC_{50} of bioinecticides at constant temperature

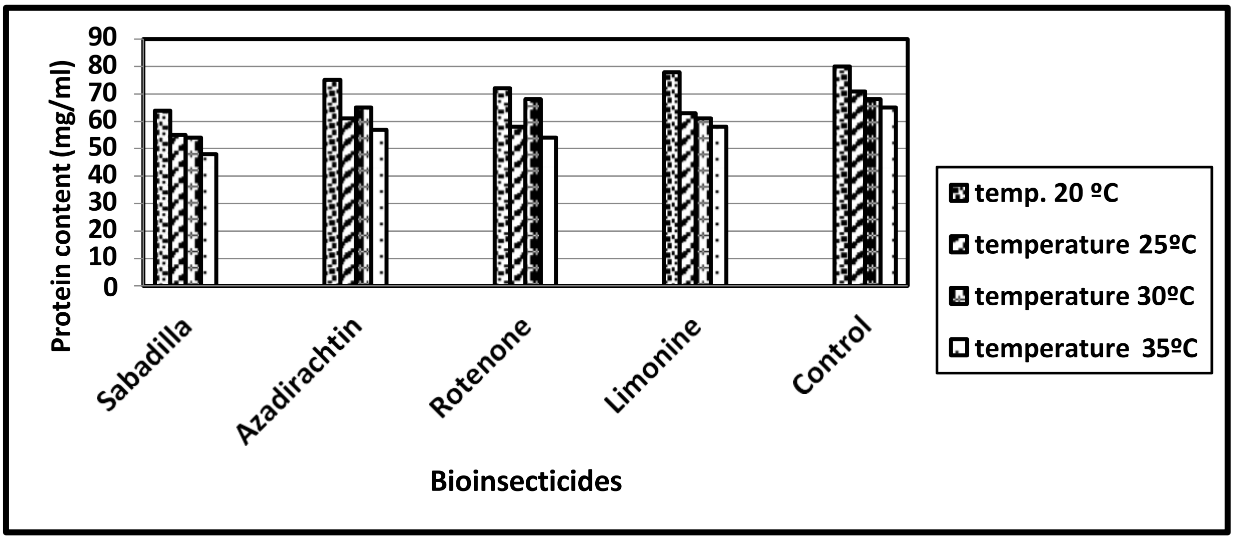
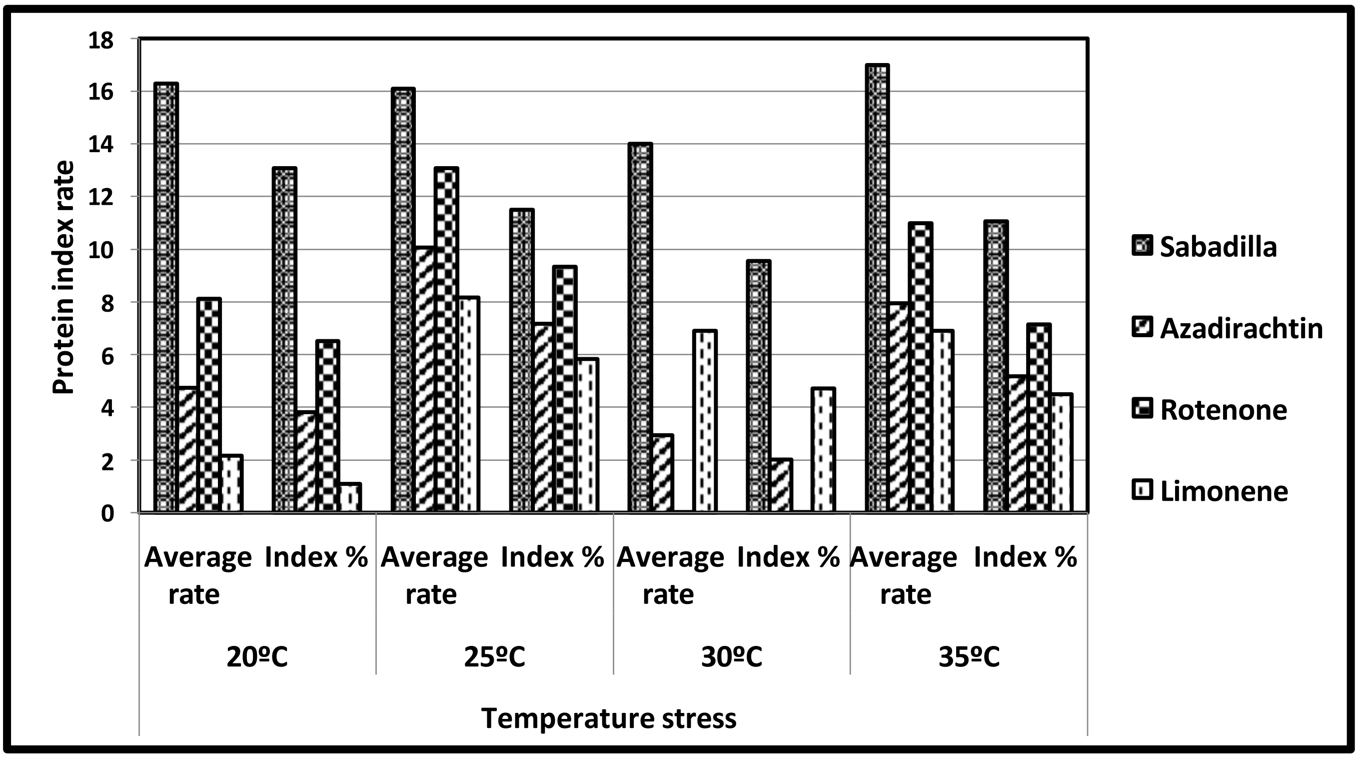


Table (12): Rate of change index of fifth nymphal protein at constant temperature

Bioinsecticides	Temperature stress and average of protein contents							
	20ºC		25ºC		30ºC		35ºC	
	Average rate	Index %	Average rate	Index %	Average rate	Index %	Average rate	Index %
Sabadilla	16.29	13.08	16.1	11.5	14.0	9.55	17.0	11.07
Azadirachtin	4.75	3.81	10.06	7.18	2.95	2.01	7.95	5.17
Rotenone	8.12	6.52	13.08	9.34	0.02	0.01	10.98	7.15
Limonene	2.17	1.09	8.16	5.83	6.91	4.71	6.91	4.49

Figure (9): Rate of change index of fifth nymphal protein at constant temperature



c. Effect on total lipid of nymphal haemolymph of *Schi. gregaria*

The data provided in Table (13) and Figure (10) demonstrated that the application of biorational chemicals to fifth instar nymphs under varying temperature stress levels did not significantly reduce the lipid content in their heamolymph. Furthermore, there was no basis for a decreased lipid content in relation to temperature. After limonene was applied to nymphs at 25°C, there was a greater decrease in total lipid (7.21 mg/ml) as compared to 9.23 mg/ml for the control group. When sabadilla, azadirachtin, rotenone, and limonene compounds were applied at a temperature stress of 35°C, the total lipid content was 8.22, 8.75, 8.66, and 8.82 mg/ml, respectively, as compared to 9.12 mg/ml in the control. Following nymphal treatment with sabadilla chemicals at 20, 25, 30, and 35ºC, respectively, the lipid levels were 7.56, 8.87, 8.15, and 8.22, respectively (Table 11 and Figure 10). On the other hand, the rate of lipid index of the fifth nymphal heamolymph decreased with increasing temperature on the biorational compounds (Table 14 and figure 11). The index rate of lipid was 0.08, 0.06, 0.05, and 0.04% in cases where the nymph was fed on treated clover leaves with sabadilla, azadirachtin, rotenone, and limonene at 20ºC degree of temperature respectively. While the same previous compounds produced 0.08, 0.03, 0.04, and 0.03 of index range at a temperature stress of 35ºC respectively, (Table 14 and Figure 11).

Table 13: Lipid content (mg/ml ± SD) of fifth instar nymph after treatment with LC50 of birational compounds at 4 level of temperatures

Biorational insecticidees	**Lipid content/ml of fifth Nymphal instar treated with LC50 of different bioinsecticides at 4 temperature levels**			
	Temp. of 20ºC	**Temp. of 25ºC**	**Temp. of 30ºC**	**Temp. of 35ºC**
Sabadill	7.56^{a} ± 0.13	8.87^{a}±0.14	8.15^{a}±0.12	8.22^{a}±0.08
Azadirachtin	7.86^{a}±0.12	8.77^{a}±0.09	7.62^{a}±0.07	8.75^{a} ±0.05
Rotenone	7.97^{a}±0.08	8.86^{a}±0.12	7.78^{a}±0.09	8.66^{a}±0.06
Limonene	8.12^{a}±0.07	7.21^{a}±0.08	8.13^{a}±0.06	8.82^{a}±0.06
Control	8.54^{a} ± 1.3	9.23^{a}±0.07	8.33^{a} ± 1.3	9.12^{a}±0.07

Mean ± SD followed with the same letter (^{a}): is not significantly different (P>0.05)

Figure 10: Effect of temperature on the lipid content of fifth instar nymphs with LC$_{50}$ of bioinecticides at constant temperature

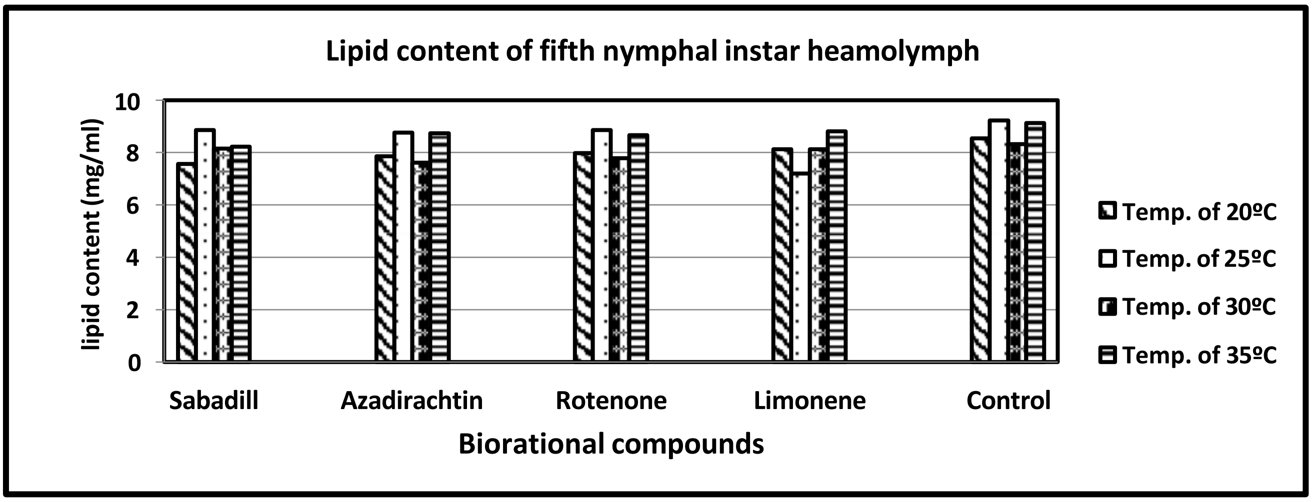
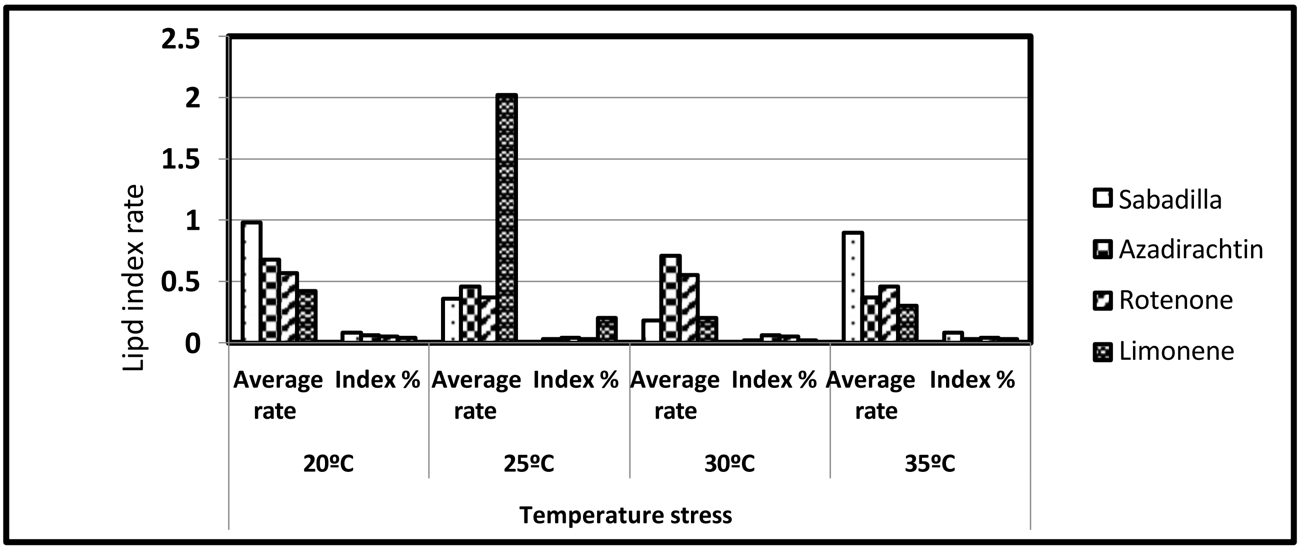


Table (14): Rate of change index of fifth nymphal lipid at constant temperature

Bioinsecticides	Temperature stress and average of lipid index contents							
	20ºC		25ºC		30ºC		35ºC	
	Average rate	Index %	Average rate	Index %	Average rate	Index %	Average rate	Index %
Sabadilla	0.98	0.08	0.36	0.03	0.18	0.02	0.90	0.08
Azadirachtin	0.68	0.06	0.46	0.04	0.71	0.06	0.37	0.03
Rotenone	0.57	0.05	0.37	0.03	0.55	0.05	0.46	0.04
Limonene	0.42	0.04	2.02	0.2	0.2	0.02	0.30	0.03

Figure (11): Rate of change index of fifth nymphal lipid at constant temperature



6- Malformation effect of precocenII on fifth nymphal inatar of *Schi.gregaria*

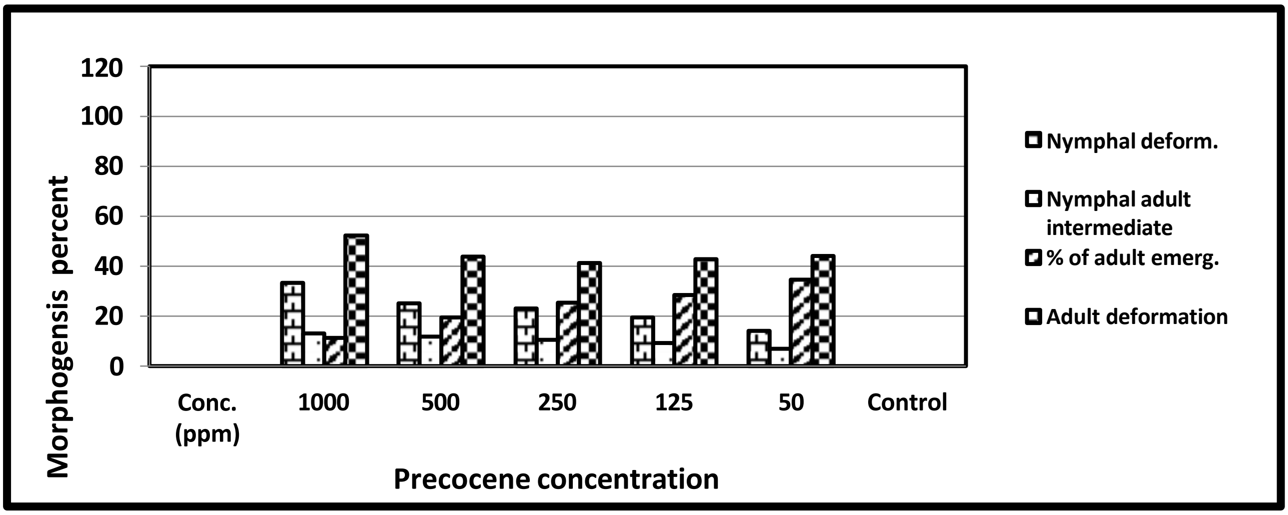
Several aspects of nymphal and adult performance were influenced after fifth-instar nymphs were treated with different concentrations of ant-juvenoid, PrecocenII (Tabel 15 and Figure 12). The supernumerary extramoulted nymphs of Schi. gregaria increased with increasing concentrations of precocenII. The blocking adult emergence was increased proportionally to the ascending concentration; however, the lowest emergence was observed at the highest concentration (table 13 and figure 12). PrecocenII pronouncedly affected the nymphal malformations, which were recorded in two extremes: the strongest deformation was 33.3% at the highest concentration of 1000 ppm, and the lower nymphal deformation was 14.2% at the lowest concentration level of 50 ppm. Several features or symptoms of such impaired adult morphogenesis are observed. PrecocenII seriously affected nymphal growth and resulted in nymphal-adult intermediate, which recorded 13.2 at concentration level 1000 ppm and 7.0% at concentration 50 ppm of precoceneII. After treatment of the fifth instar nymphs, it was observed that growth inhibition substantiated such results since it increased with increasing concentration. As a result, nymphs spent an extended period before metamorphosing into adults. On the other hand, the blocking action of precocene II on the adult deformation resulting from the treated fifth nymphal instar increased as the concentration increased. Hagiest and lowest adult malformations resulted in 52.2% and 41.1% of the treated fifth instar nymph at concentrations of 1000 ppm and 250 ppm of precocene II, respectively (table 13 and figure 12). The percent of adult emergence after nymphal treatment with precoceneII, however, varied between 34.7% at 50 ppm and 11.3% at 1000 ppm of precoceneII compared to control. Moreover, the emerged adults survived only a shortened lifespan, which could be attributed to the death-accelerating action of PrecocenII. The adult survived for a short time and eventually perished without mating. The deformed fifth nymphal instar of

Schi. gregaria, by effect of precocene II, exhaustedly perished as blackish yellow-colored. Almost all nymphal and adult malformations were represented as adult curled wings and twisted wings. Also, old cuticles were connected with the results of adults in different positions. Nymphs were unable to moult into a complete adult stage and died without completing the moulting process. Various degrees of different malformations were obtained in the form of nymphal-adult intermediate stages at all concentrations. The majority of such malformations appeared as severely or slightly curled bodies, with some cases of antennal or leg deformities observed. The reason for this deformity was either the nymphs failing to molt into the following nymphal instar or attaining adult stages that were deformed. These deformations could be seen in the following ways: a) the nymph failed to shed the last nymphal exuvia entirely because it was still attached to its body; b) it resembled an adult with curled legs and incompletely developed short wings; and c) the nymphal-adult intermediate stage appeared.

Table (15) Morphogenic effect of precocenII on fifth instar nymphs of *Schi. gregaria*

PrecoceneII Conc. (ppm)	Nymphal deform.	Nymphal adult intermediate	% of adult emerg.	Adult deformation
1000.0	33.3	13.2	11.3	52.2
500.0	25.0	11.8	19.4	43.8
250.0	23.0	10.5	25.3	41.2
125.0	19.5	9.3	28.5	42.7
50.00	14.2	7.0	34.7	44.1
Control	00.0	00.0	00.0	00.0

Figure (12) Morphogenic effect of precocenII on fifth instar nymphs of *Schi. gregaria*



V- Discussion

Toxicity Effect of Biorational Insecticides on *Schistocerca gregaria*

The results of this study showed that the toxicity value of the biorational botanical insecticides sabadilla, rotenone, azadirachtin, and limonene against *Schi. gregaria* could be attributed to the active ingredients of their chemical components. Many authors have studied the effects of biorational natural compounds and natural bioactive compounds against locusts, grasshoppers, and other insects. Nassar and Ghazawy (2018) mentioned that *Azadirachta indica* had a toxicity effect on the desert locust Schi. *gregaria*; Nasseh et al. (1993); Wilps et al. (1990) revealed that the neem products were affected by the locust; and Al-Maroug et al. (2022) concluded that some biorational compounds were toxic and inhibited the growth rate of *Schi. gregaria.* The obtained results are also in agreement with those found by Soliman *et al*. (2019), who found that when applying chlorantraniliprole, spinosad and fipronil were affected against the fifth nymphal instars and adult stages of the desert Locust *Schistocerca gregaria*.Furthermore, the current findings are in agreement with Abdel-Fattah and Ammar (2005 and 2012) in the field against the nymphal instars of *Schi.*

gregaria. The mortality of *Schi. gregaria*, like many other insects, depends basically on the mode of action of many botanical extracts (Nassar et al., 2000; El-Shazly and Nassar, 2005). In insects, biologically meaningful plant chemicals primarily have delayed effects, particularly those caused by neem oil (Schmutterer, 1990). According to Stark and Rangus (1994), Neem acts slowly against the pea aphid. Consistent with the current results, Ibrahim et al. (2001) found that limonen achieved insecticidal, repellent, and antimicrobial activity and pointed out the phytotoxicity of its essential oils against insect pests. Many biorational botanical pesticides are attributed to the fact that they include bioactive ingredients, such as saponin components, which may have an impact on cell membranes as they reduce digestion and absorption (Bogumil and Wieslaw, 2006; De Bogumil and Wieslaw, 2006; De Geyter et al., 2012). The degree of harm caused by biorational botanical pesticides in the current study may vary based on the tissues' sensitivity to the effects of certain compounds. Certain substances damage the insect lipid layers of membranes, which causes water loss and the formation of vacuoles, which destroys the permeability of the insect plasma membrane (Sharaby et al., 2012). Also, Keamy et al. (1994) submitted that the anti-feeding activity of *Azadirachta indica* against the desert locust *Schi. gregaria* has been very effective. And Schmutterer and Freres (1990) reported the activity varied in *A. indica*, *Jatropha curcas*, and *Solenostemma argel* against the desert locust with a significant mortality of 43.39%, 40.54%, and 20.70%, respectively. Sh.Hk (2013) deduced that when *Nigella sativa* extracts were compared with those of *A. indica*, the *N. sativa* caused a decrease in body weight but no mortality. On the other hand, Abbassi et al. (2003) showed that the effects of *Calotropis procera*, *Zygophyllum gaetulum,* and *Peganum harmala* on the survival, feeding, and reproduction of the desert locust showed that all the alkaloids extracted from these plants have reduced food intake, increased weight loss, and a significant mortality.

Messgo-Moumene et al. (2015) observed a similar result and postulated that the alkaloids of *C. procera, Schouwia purpurea*, and *Zizyphus lotus* had a similar effect on the desert locust. They observed morphological changes, inhibition of molting, and anti-feeding effects. On day five after treatments, they observed a notable death rate ranging from 45% to 53%.

On the other hand, the biorational alkaloids of sabadill reduced the feeding behavior of *Diaprepes abbreviates,* weevils, and deterrence. Sabadilla alkaloids appear to be similar to pyrethrins in that they work on voltage-sensitive sodium channels (Stephen *et al.,* 2010). Sabadilla caused a significant reduction in the feeding behavior of the grasshopper, *Sch. americana,* which has similar properties to azadirachtin, against different orders of insects, including Orthoptera (Aerts and Mordue 1997; Capinera and Froeba 2007). Toxicity by sabadilla triterpenoid on *Schistocerca gregaria* could be attributed to blockage of the neurons that detect phagostimulatory compounds such as carbohydrates (Winstanley and Blaney, 1978). The current investigation concluded that the bioactivity of the biorational compounds against the fourth and fifth nymphal instars of *Schi. gregaria* may suggest that it contains many bioactive chemical components. In an attempt to compensate, the plants produce chemicals known as 'allelochemicals' that make them suitable for utilization by phytophagous insects and other herbivores by imparting repellency, toxicity, biochemical, and physiological functions (Baerson et al. 2005). Also, these compounds inhibited JH-biosynthesis in the corpora allata (CA) of adult females of the cricket *Gryllus maculates in vitro* (Muthukrishnan *et al*., 1999). Similar to this finding, Adfa *et al*. (2010) and (2011) isolated Scopoletin (7-hydroxy-6- methoxycoumarin) from *Protium javanicum* (Burseraceae) and synthesized some derivatives that are structurally similar to the anti-juvenoid effect. Many scientific academic institutions have been engaged in great efforts to use natural compounds from plant origin that may have toxic, repellent, antifeedant, or anti- hormonal characteristics (Bagari *et al.,* 2015). The mortality of *Schi. gregaria,* like many other insects, depends basically on the mode of action and the type of biorational compounds (Nassar 2000; El-Shazly & Nassar 2005). The results obtained in the present study revealed that azadirachtin and rotenone were the most potent, followed by sabadilla and limonene insecticides. This could be attributed to their mode of action. Similar to this finding, rotenone is a mitochondrial poison that blocks the electron transport chain and prevents energy production (Andres 2009; Isman 2006; Rosell *et al.,* 2008). Moreover, it is now well established that the activity of many plants, including *Azadirachta indica,* is attributed to the presence of saponin components that perhaps affect cell membranes as well as reduce digestion and absorption (Bogumil and Wieslaw, 2006; and De Geyter et al., 2012). Ghazawy et al. (2007) reported that LC_{50} within 24 hours on the 2nd nymphal instars of *Schi. gregaria* and the 4th, fifth, and 6th nymphal instars of *Heteracris littoralis* were dose-dependent, and the insects died at the time of ecdysis. Asiri (2015) showed that the methylene chloride extract of *A. indica* is the most potent extract against *Schi. gregaria*. A greater extent of injury by biorational botanical insecticides may occur depending on the susceptibility of tissues to particular poisons. Some poisons have an effect on the lipid layers of cell membranes, resulting in the destruction of the permeability of the plasma membrane due to water loss and the appearance of vacuoles (Sharaby *et al.,* 2012). Despite the plenty of literature about the bioactivity of biorational botanical insecticides and other plant extracts against several insect species, they caused toxicity at higher concentrations. The oils are pressed from the seeds of *Azadirachta. indica, which* achieved mortality rates of 65–100% in *Schi. gregaria* (Schmutterer and Freres, 1990; Nicol and Schmutterer, 1991). Also, the high mortality of *Schi. gregaria,* red locust *Nomadacris septemfasciata,* and variegated grasshopper *Zonocerus variegates* was caused by the neem oil (Schmutterer et al. 1993). Azadirachtin, rotenone, sabadilla, and limonene had potent toxic and antifeedant effects on *Schi. gregaria*. Similar to the present results, the toxicity occurred on a large number of insects, including Orthopterans insects by El-Shazly et al. (2008) and Sharaby et al. (2012) on *Heteracris littoralis*. Sabadilla is approved for use in the USA as an organic insecticide, as well as for other uses, by the Organic Materials Review Institute (OMRI). Sabadilla also caused a significant reduction in the feeding behavior of the grasshopper, *Schi. americana*, which has similar properties to azadirachtin against different orders of insects (Capinera and Froeba 2007). The findings in this study revealed that rotenone was effective as a biologically toxic insecticide on *Schi. gregaria*. These results agree with the finding obtained by Andres (2009), who reported that rotenone sabadilla, azadirachtin, and ryanodine effectively deter *Schi. Americana*. Whereas rotenone, sabadilla, and ryanodine reduced the feeding activity of *D. abbreviatus* under field conditions. To a greater extent, rotenone showed a strong antifeedant effect against adults and larvae of the wheat weevil, *Sitophilus granarius* L., adults of the confused flour beetle, *Tribolium confusum,* and larvae of the khapra beetle, *Trogoderma granarium* Everts (Nawrot *et al.,* 1989). Rotenone is one of several isoflavonoid compounds produced in the roots of the tropical legumes *Derris, Lonchocarpus,* and Tephrosia (Leguminosae). Rotenone can act as a feeding deterrent against stored-product insect pests (Nawrot *et al.,* 1989) and polyphagous noctuid species (Wheeler *et al.,* 2001). Furthermore, in the current investigation, it was observed that biorational limonene insecticides caused a significant reduction in the nymphal survival of *Schi. gregaria*. Mortality may be associated with the failure of the nymphs to moult, and the nymphs died. In harmony with these results, D-limonene had higher mortality rates than control fleas and did not lay any eggs. D-limonene-treated fleas also produced fewer feces and probably fed less while on their hosts (Collart and Hink, 1986). Limonene is a naturally occurring monoterpene found in citrus and other fruits. The toxicity and neurotoxic effects of limonene are discussed by Coats *et al.* (1991), and the suitability of limonene for the control of insect pests has been reviewed by

Ibrahim *et al.* (2001). Several reports mention using limonene for the control of plant pests (Tiberi et al., 1999; Hollingsworth, 2005). The limonene mode of action in insects may cause an increase in the spontaneous activity of sensory nerves; this high activity sends serious information to motor nerves and results in twitching and a lake of coordination (Weinzierl and Henn 1994). Limonene also causes convulsions; the central nervous system may also be affected, resulting in additional stimulation of motor nerves, which may lead to rapid knockdown paralysis (Weinzierl and Henn 1994). Moreover, limonene is a monoterpene usually found in many plant species, against *Tribolium confusum* du Val (Antonino *et al.,* 2016). On the other hand, limonene has broad application prospects in antibacterial and food preservation due to its broad- spectrum bactericidal activity, safety, and low mammalian toxicity (Young *et al.,* 2013). The biorational botanical insecticides rotenone, sabadilla, azadirachtin, and limonene have potency toxic, repellent, convulsion, development, and growth inhibitory effects against *Schi. gregaria* instars, making them a future potential tool for the integrated management of grasshoppers.

Effect of the biorational botanical insecticides on the Nymphal Weight of *Schistocerca gregaria*:

According to Armbruster and Hutchinson (2002), one useful indicator for assessing insect growth is body weight loss, which leads to weight gain. In the current study, the somatic weight growth was lower than that of the control nymphs following treatment of the fourth nymphal instars of *Schi. gregaria* with rotenone, limonene, sabadilla, and azadirachtin. These results are, however, in accordance with several results using the many botanical insecticides against insects. Growth inhibition was recorded for the migratory locust *L. migratoria* after treatment with a compound from the neem tree, *Azidrachta indica* (Sieber and Rembold, 1983). The increased developmental duration led to a decrease in nymphal weight, which was observed in offspring nymphs of *Schi. gregaria* treated with biorational pesticides, while a reduction in adult longevity was also detected (Waqas *et al.*, 2022). These data could be confirmed by Schmidt *et al.* (1997) and Schmidt (1999). The findings published for several plant species, such as *M. volkensii* on *Culex pipiens* (Al-Sharook et al., 1991) and Jojoba oil on *M. domestica* (Amer et al., 2004), did not agree with the study's conclusions. In the present study, after feeding the fourth nymphal instars of *Schi. gregaria* on treated clover leaves with azadirachtin, rotenone, sabadilla, and limonene, nymphal weight gain was less with a variable range compared to control nymphs. Similar results have been obtained for the migratory locust *L. migratoria* after treatment with the active compound of *A. indica* (Rembold and Annadurai, 1993). However, no significant effect was observed due to the effect of neem extract on the body weight gain of some other insects, *Pieris brassicae* larvae (Osman, 2009). Concerning the growth inhibition in the present study at different concentrations, it was observed that biorational botanical insecticides on the fourth instar nymphs of *Schi. gregaria* resulted in suppressed body weight gain, particularly at higher concentrations. These results agree with several reported results for other insect species using plant extracts. The essential oils of garlic significantly suppressed the growth rate of the coleopterans *Sitophilus zeamais* and *Tribolium castaneum* (Huang et al., 2000). Acetonic and ethanolic extracts from *tubercula* and various compounds of *Aristolochia pubescensi* inhibited the larval growth of *T. castaneum* (Nascimento et al., 2004). A methanolic extract from the roots and aerial parts of *Myrtillocactus geometrizans* (Cactaceae) disturbed the growth of *Spodoptera frugiperda* and *Tenebrio molitor* at higher concentrations (Cespedes et al., 2005). The growth inhibition seen in *Schi. gregaria* due to the use of biorational insecticides in this investigation might be attributed to growth hormone blockage. The blocking of growth peptides causes alteration in ecdysteroid and juvenoid titers, as suggested by Sieber and Rembold (1983), Barnby and Klocke

(1990), and Linton et al. (1997). Also, the effect of biorational insecticides in the present study may be similar to the effect of azadirachtin on the tissues and cells involved in the mitosis of *Schi. gregaria* (Nasiruddin and Mordue, 1994). Successful control of desert locusts will require the development of an integrated pest management program using a variety of products that can be applied with a range of appropriate techniques in different habitats and circumstances (Magor *et al.,* 2008). This must be associated with reduced pesticide application, economic costs, environmental risks, and the duration and extent of the locust threat (Showler 2002).

Effect of biorational botanical insecticides on nymphal duration after treatment of fourthnymphal instars of *Schi. gregaria*

In the present study, the treatment of penultimate instar nymphs of *Schi. gregaria* with the biorational botanical insecticides sabadilla, rotenone, limonene, and azadirachtin suppressed the nymphal duration. These resulted in retarded development since the developmental duration was prolonged and the developmental rate was regressed parallelly to the concentration level. Biorational botanical insecticides prolonged the nymphal duration so that nymphs were unable to reach the adult stage, particularly at higher concentrations. Prolonged developmental duration was more or less a good indicator of the inhibited development of the migratory locust *L. migratoria* after treatment with azadirachtin (Urishalom et al., 1988). The desert locust *Schi. gregaria,* after treatment with the seed oil from *Az. Indica*, exhibited prolonged development and nymphal duration, which was a good indicator of inhibited development (Nicol and Schmutterer, 1991). On the contrary, a shortened developmental duration indicating an induced development was not observed for *Schi. gregaria* after treatment of the nymphs with Neemazal, while Jojoba exhibited only a slight effect on both fecundity and fertility in *M. domestica* (Amer et al., 2004). In harmony with the present result, many authors studied the effect of botanical extract on the developmental duration of different insect species. Extracts from *M. volkensii* caused a conspicuous prolongation of larval development in *Schi. gregaria* and the mosquito *Aedes aegypti* (Mwangi and Rembold, 1988; Wilps et al., 1993). Also, Amr et al. (1995) observed a significant prolongation in the larval duration of *Spodoptera littoralis* by the ethanolic extract from *Nerium oleander*, which also caused a similar prolongation in the developmental duration of *Muscina stabulans* (El-Shazly et al., 1996). The present study is in agreement with similar enhancing effects of different plant species like *Annona squamosa* against the mosquito *An. stephensi* (Saxena et al., 1993), *Ajuga reptans reptans* against the sarcophagid *Neobellieria bullata* (Darvas et al., 1996), *Launaea arborescens* (Asteraceae), *Pteridium aquilinum* (Polypodiaceae) against the coleopteran *T. castaneum* (Jbilou et al., 2008), and Jojoba oil against the coleopteran *Rh. ferrugineus* (Abdel-Ghaffar et al., 2008). Furthermore, no effect on the developmental duration was reported for some plant species on different insects, such as *M. volkensii* (Meliaceae) on the mosquito *Culex pipiens* (Al-Sharook et al., 1991), Jojoba oil on the muscidae *M. domestica* (Amer et al., 2004), and *Solanum dubium* extracts on the false stable fly *Muscina stabulans* (Nassar et al., 1995). The delay effects of the biorational botanical chemicals on the ecdysis and transformation can be related to the extension of the developmental phases and, consequently, to the postponed development of *Schi. gregaria* (Quadri and Narsalah, 1978; Linton et al., 1997). On the other hand, the prolongation of nymphal durations by the present biorational botanical compounds may be attributed to a specific physiological elasticity in the insect body for overcoming the adverse conditions during the time interval during which the insect would be more tolerant. Such results were obtained by Roger (2005), who reported that biorational botanical insecticides can induce various modes of action, including physiology, repellence, growth inhibition, and modifications in their structure.

Insect growth regulators also have an effect on insect morphogenesis in terms of physiology, biochemistry, and pharmacology (Retnakaran et al., 1985).

Effect of temperature stress on biorational toxicity against *Schi. gregaria* at variable times

The present study revealed that the toxicity of biorational insecticides, sabadilla, azadirachtin, rotenone, and limonene, was positively correlated with the tested temperature stress range. An insecticide with a positive temperature coefficient becomes more toxic with an increase in temperature. Whereas, those with a negative temperature coefficient become more toxic at lower temperatures (Glunt et al. 2013). Assessing the impact of temperature on the toxicity of different insecticides against a target insect pest is critical in implementing chemical-based management strategies with reference to environmental conditions in a given locality (Boina et al. 2009). As stated above, *Schi. gregaria* occurs throughout the year with fluctuations depending upon the different environmental conditions, including temperature and the seasonal abundance of desert locusts, while their control results in the decline of such outbreaks. In the present study, based on LC_{50} values, the toxicity increased significantly as the stress of temperatures and the time of exposure increased when compared with the control fifth nymphal instar of *Schi. gregaria*. The obtained results agree with the results of Hinks (1985), who suggested the temperature positively affected the toxicity of the second instar of the orthopteran grasshopper, *Melanoplus sanguinipes* nymphs, to deltamethrin. Similar to these findings was the result obtained by pyrethroid toxicity by Brown (1987), who found that the LD_{50} of tobacco budworm treated with fenvalerate, flucythrinate, and permethrin at 26°C was 27, 140, and 13 times the LD_{50} at 16°C; Ewen et al. (1984) reported that a field rate of 15 g/ha cypermethrin provided an effective mortality rate of 85, 90, 92, 95, and 97%

after 1, 2, 3, 4, and 5 days, respectively. Also, they concluded that high temperatures increased the toxicity of cypermethrin against the nymphs of the migratory grasshopper, *Melanoplus sanguinipes* (Orthoptera: Acrididae).

On the other hand, the disruptive effects of biorational compounds on the main body metabolites in the fifth nymphal instar of *Schi. gregaria* in the current work may also be explained by the intervention of certain chemical constituents of each biorational compound in the hormonal regulation of metabolite mobilization. Also in the present finding, the stress of different temperature levels increased the toxicity of the bioinsecticides due to disturbance of the biological activity of the nymphal instar of *Schi. gregaria*. Meanwhile, the main metabolites of *Schi. gregaria* were disturbed by these biorational compounds because of their ability to modify the synthesis of some metabolites at low temperatures and concentrations. These alternative compounds should be characterized by a shorter half-life than conventional insecticides, as well as being effective at low concentrations at a certain temperature (Gade and Goldsworthy, 2003). In agreement with these results, at low temperatures, the toxicity of organophosphate insecticides decreased due to a decrease in biological processes called biotransformation (Harwood et al. 2009). The results are in accordance with what has already been reported on the impact of temperature on pyrethroid toxicity in different insect species (Li, 2006). Moreover, rotation of insecticides in summer and winter temperatures will also reduce selection pressure on insects and ultimately delay the development of insecticide resistance (Khan et al. 2014). These findings may be useful in developing biorational compound-based management strategies that are successful in managing *Schi. gregaria* across several seasons. In addition to having a shorter half-life than traditional insecticides, the alternative chemicals ought to work effectively at low temperatures and concentrations (Gade and Goldsworthy, 2003). Furthermore, they biodegrade into innocuous chemicals that have little effect when present in small amounts (Tiryaki and Temur, 2010; Walkowiak et al., 2015; Li et al., 2017).

Morphogentic effect of precocene II against desert locust *Schi. gregaria*

The present study revealed different deformative effects of *Schi. gregaria* nymph and adult stages due to the effect of Precocene II on fifth nymphal instars, which exhibted disturbed metamorphoses and did not transform to the next typical form. Regardless of the treatment period or concentration level, some nymphal-adult intermediates were formed due to Precocene II interacting with the metamorphosis program. The formation of nymphal-adult intermediates of *Schi. gregaria* in the present study possibly indicated the disturbance of the normal ecdysone or ecdysteroid titer, which is usually needed for the perfect metamorphosis. The chemical allatectomy can be performed by applying suitable chromenes (Precocene II) that selectively target and inactivate the nymphal corpora allata (Bowers et al., 1976). Precocenes undergo oxidative bioactivation in the target tissue of the treated insects (Pratt et al., 1980); this causes insitu-cellular necrosis, thereby preventing further production of JH and truncating the normal sequence of nymphal stages (Aboulafia-Baginsky et al., 1984), so that the following molt results in precocious adultoids. The present results were, to a great extent, in agreement with those reported results of precocious metamorphosis in several insects of various orders by different IGR's compounds. Ghoneim and Ismail (1994) reported that *Schistocerca gregaria* was subjected to five doses of pyriproxyfen, which caused increasing mortality and many abnormalities of the nymphal and adult instars. Within Orthoptera, exposure of fifth instar nymphs of the desert locust *Schistocerca gregaria* to Precocene II (15 μg/cm**2**) induced precocious adultoids (Salem et al. 1982). Also, the precoceneII compound inhibited the JH-biosynthesis in the corpora allata (CA) of adult females of cricket *Gryllus maculates* in vitro (Muthukrishnan *et al*., 1999). Sehnal (1983) suggested that the inhibited adult emergence may be attributed not to the function and growth of insect cells but to the prevention of adult differentiation.

With regard to adult differentiation and morphogenesis**,** different abnormalities have been caused by several IGRs, and some of these were produced in *Blatella germanica* (Kramer *et al.*, 1989) by hydroprene; *Anopheles farauti* (Suzuki *et al.*, 1989); *Muscina stabulans* (Ghoneim *et al.*, 1992; Nassar, 1995); and *Corcyra cephalonica* (Bhargava and DevrajUrs, 1992) by fenoxycarb. Several works on locusts showed similar morphogenic disorders by various juvenoids, such as PrecocenII in *Locusta migratoria (De* Kort and Koopmanschap, 1991; Edwards et al., 1993) *and Schi. gregaria* (Ghoneim and Ismail, 1995a,b). On the other hand, many authors recorded an inhibitory action of disturbance of *Schi. gregria* performance due to the modification of the ecdysteroid titer, which in turn leads to changes in lysosomal enzyme activity causing overt morphological abnormalities (Josephrajkumar *et al.*, 1999). To a great extent, similar results had been obtained by azadirachtin on *Bombyx mori* (Koul *et al.*, 1987), *Spodoptera litura* (Mittal *et al.*, 1995), Naqvi (1986), *M. domestica* (Wilps, 1989), and some other botanicals in *M. stabulans* (Nassar et al., 1995, and El- Shazly *et al.*, 1996).

Metabolic heamolymph change with relation to temperature stress on the fifth instar nymph after it was treated with biorational compounds

The current investigation revealed that temperature stress caused a disruption effect on heamolymph, protein, carbohydrate, and lipid contents after the fifth nymphal instars of *Schistocerca gregaria* were treated with LC_{50}s of limonene, rotenone, azadirachtin, and sabadilla. This suggested a reduction in activity of the fifth nymphal instars under different temperature stress. Insect haemolymph is influenced at least on the level of its physical properties, such as volume, density, and pH, or on its biochemical composition, by several factors, among them diet, temperature, and disease (Carrel *et al.,* 1990), the physiological condition of the insect (Chapman, 1973), and insect development (Jones, 1977). Total hemocyte counts (THCs) and differential hemocyte counts (DHCs) in different insect species have also received considerable attention. Much work has been done on changes in the hemocyte picture following injury and hemorrhage in insects attacked by parasites, particularly during metamorphosis ecdysis (Salt, 1970). These counts have great significance in insect immunity due to their share in defense reactions. Heamolymph protein, carbohydrate, and lipid contents reflect the balance between the synthesis, storage, transport, and degradation of structural and functional nutrients during metamorphosis, as well as a response, particularly to physiological conditions. Similar to this finding, Shakoori and Salem (1991) reported that the increased protein content in the hemolymph or fat body of some insect species may occur after insecticidal treatments in order to synthesize proteins needed for insecticide detoxification. The current results are in harmony with the finding obtained by Said (2014), as spinosad bioinsecticide caused a reduction of hemolymph total protein in the fifth nymphal instar of *Schi. gregaria* 2, 4, and 6 days post-treatment. Also, Rashwan (2013) found that coragen caused a significant decrease in the total lipids of the fifth larval instar of *Spodoptera littoralis* after 24 hours of treatment. In another study by Upadhyay *et al.* (2010), who reported that fipronil caused a significant decrease in lipid levels after 8 and 4 hours of treatment with 40% and 80% of LD_{50} in the Indian white termite *Odontotermes obesus,* Similar to the present study of some bioinsecticides with different insects on the haemolymph contents, Rhodojaponin III, extracted from *Camellia sinensis,* affected the protein content in the diamondback moth, *Plutella xyllostella* (Xiaolin *et al*., 2013); extracts from *Ricinus communis* resulted in a significant increment of protein content in the haemolymph of *Spodoptera littoralis larvae* (Khatter and Abuldahb, 2010). However, the decreasing protein content in certain developmental stages of *Schi. gregaria in* the present study may be attributed to the increased biochemical activity as a tool of detoxification. Wilkinson (1976) explained that proteins help to synthesize microsomal detoxifying enzymes that assist in detoxification. On the other hand, remarkably, the decreased protein content in the hemolymph and fat bodies of fifth instar nymphs and the newly emerged adults of *Schi. gregaria* after treatment with biorational compounds in the present study could be explained by the decreasing of enzymes. A similar finding was obtained by Wilkinson (1976), who reported that the proteins help insects synthesize the microsomal detoxifying enzymes. Therefore, the decrease in proteins may reflect the decrease in the activity of these enzymes (Kyung & Kim, 1990). On the other hand, the present results suggest that different temperature stresses on the insect can inhibit the total protein in the hemolymph. This could be due to the breakdown of proteins into amino acids; with the entrance of these amino acids to the TCA cycle as a kito acid, they will help to supply energy for the insect (Etebari &Matindoost, 2004 a, b). These results, to a certain extent, are in accordance with the increasing carbohydrates in the hemolymph and fat bodies of *Spodoptera littoralis* larvae after treatment with oils extracted from *R. communis* and *Brassica nigra (Khatter & Abduldahb,* 2010). Another point of interest is the carbohydrate, lipid, and protein depletion in the hemolymph of *Schi. gregaria, which* in the current work may be attributed to the major mobilization of metabolites as well as a reduction in their synthesis. Several findings have been reported for some insects by different biorational compounds. A considerable reduction in the carbohydrate content in the hemolymph of *Agrotis ipsilon* (Abo El-Ghar *et al*., 1995) and *Sp. littoralis* (Chitra and Reddy, 2000) was caused by extracts from *Ammi majus, Apium graveolens, Melia azedarach,* and *Vinca rosea*. A similar reducing effect was achieved on the greater wax moth larvae of *Galleria mellonella* by the volatile oils from *Lantana camara* and Vitexagnus castus (Shoukry& Hussein, 1998). A great reduction in protein content and biological parameters was determined after treatment of *Schi. gregaria* with different plant extracts and IGR's (Bakr *et al.*, 2008 &2009).

The disruptive effects of the biorational compounds sabadilla, rotenone, azdirachtin, and limonene on the main body metabolites in *Schi. gregaria* in the present work may be explained by the intervention of certain chemical constituents' ingredients in these biorational compounds' mortality and metabolite mobilization. A considerable reduction in the carbohydrate content in the hemolymph of *Agrotis ipsilon* (Abo El-Ghar *et al.*, 1995) and *Sp. littoralis* (Chitra and Reddy, 2000) was caused by extracts from *Ammi majus, Apium graveolens, Melia azedarach,* and *Vinca rosea*. Also, recorded disturbances in the main metabolites due to temperature stress in *Schi. gregaria* by these biorational compounds can be understood in light of their ability to modify the synthesis of some metabolites, disrupt the heamolymph content toxicity, as well as deformation abnormalities in *Schi. gregaria* (Al-Maroug et al., 2022).

VI- Recommendations and future prospective

The use of synthetic pesticides poses a continuing risk to human health, wildlife, and the environment. It's critical to keep in mind and discuss the use of natural pesticides. The usefulness of botanicals in managing crop pests has to be reevaluated in light of their regenerative character, contribution to environmental and human protection, and efficacy. The effects of botanical pesticides on insects are demonstrated by their chemical properties, which include growth retardants, feeding dissuasive agents, repellents, and toxicants. Consequently, we promoted the use of botanical insecticides, which have been approved, and efforts are being made to find new sources of these pesticides. The current study showed that the biorational compounds' capacity to alter the synthesis of certain metabolites disrupts the heamolymph contents, toxicity, and deformation abnormalities in *Sch. gregaria.*

The prevention and control strategies of desert locusts must consider: (1) the broad nature of many locusts and their infestations, which necessitates an appropriate and thorough plan by nations and governmental entities. International collaboration may be started and maintained as needed. (3) According to a cost-benefit ratio analysis, there has been a growing shift in perspective from crop protection to preventative management as a result of damage identification. (3) The use of preventive techniques is growing as the most sensible, practical, and affordable means of controlling workable control strategies. Therefore, epidemics are now more effectively contained and frequently have shorter durations and smaller geographic scopes. (4) Increasing the use of biological products, improving monitoring and control methods, and advanced technology like satellite images and geographic information systems are all necessary for locust management. (5) The steady, enduring, and noteworthy advancement of locust control toward environmental sustainability, effectiveness, and accuracy can function as a template for crop protection generally. (6) Desert locusts have been repeatedly disturbed in recent years, and it is thought that climate change is the primary cause of their demise. Therefore, the influence of climatic and meteorological elements on the desert locust population from an ecosystem viewpoint should be analyzed, and research on the dynamic development law of the population induced by climate change should be strengthened. (7) In addition, we should expedite the development of a novel and effective technical system for controlling desert locusts and screen chemicals and application techniques appropriate for specific places based on the damage caused by desert locusts in those regions. We plan to expedite the creation of many novel and effective locust control agents, including fungi, bacteria, and viruses. (8) Implement hierarchical and zonal preventive and control techniques to achieve long-term control over desert locust populations. The influence of climatic and meteorological elements on the desert locust population from an ecosystem viewpoint should thus be analyzed, and research on the dynamic development law of the population induced by climate change should be strengthened. (7) In addition, we should expedite the development of a novel and effective technical system for controlling desert locusts and screen chemicals and application techniques appropriate for specific places based on the damage caused by desert locusts in those regions. We plan to expedite the creation of many novel and effective locust control agents, including fungi, bacteria, and viruses. (8) Implement hierarchical and zonal preventive and control techniques to achieve long-term control over desert locust populations.

It was very important to speed up the establishment of international cooperation and communication mechanisms to jointly deal with locust disasters because the desert locust disaster affects many countries and regions. It can be suggested that the application of these biorational compounds during the IPM system against *Schi. gregaria* is recommended. Future research needs to explore biorational insecticides with other control agents, including chemical insecticides, as a means of integrated pest management for desert locusts.

VII- Summary

The desert locust, *Schistocerca gregaria* (Forskål), sometimes known as the desert locust, is a significant insect problem on a global scale. This study examines the responses of nations and international organizations to intricate ecological and toxicological issues that are out of proportion to the management capabilities of the desert locust, Schistocerca gregaria. The work focuses on efforts to control population dynamics under temperature stress in relation to the desert locust, Schistocerca gegaria, by employing biologically- based bioinsecticides. Periodically, desert locusts intrude into pastures and crops, causing extensive damage to the food security and agricultural output.

The alternative to chemical pesticides, which are thought to be more effective, safer, and less expensive, is to utilize natural insecticides with biocidal properties that work against a variety of insects, including desert locusts. Promising non-conventional insecticides against harmful pests for crops and health are made from natural products such as pathogens, predators, parasites, IGRs, fungi, and animal venoms. These include biorational insecticides. In this study, the clover leaves were treated with LC50s of the biorational compounds of azadirachtin, rotenone, sabadilla, and limonene in order to feed the fourth and fifth instar nymphs of *Schi. gregaria*.

This study evaluated the effect of temperature stress on biorational insecticides against *Sch. gregaria*. Newly moulted fourth and fifth instar nymphs of the desert locust were fed on the treated clover leaves with LC_{50} of Azadirachtin, Rotenone, Sabadilla, and Limonene. Also, the fifth nymphal instar was treated with an anti-juvenoid, precocene II, to study the morphogenic effect of *Schi. gregaria*. The obtained results revealed that the nymphal instar was more sensitive to azadirachtin, followed by rotenone, sabadill, and finally limonene bioinsecticides, than the fifth nymphal instar. The recorded LC_{50} values of the fourth instar nymph were 3.4, 3.7, 3.8, and 4.2% due to the effects of azadirachtin, rotenone, sabadilla, and limonene, respectively. While LC_{90} was 15.2, 18.7, 26.3, and 28.1% of the same previous compounds, respectively. In the case of the fifth nymphal instar, the higher LC_{50} was 4% after treatment with azadirachtin, and the lower LC_{50} was 5.2% with the limonene compound. Meanwhile, the LC_{90} of the fifth nymphal instar was 22, 27, 34, and 36 after treatment with azadieachtin, rotenone, sabadilla, and limonene, respectively. The fourth nymphal instar suffered weight loss after treatment with all tested biorational compounds, particularly at higher concentrations, and then died. The higher and lower decreases in fourth nymphal weight were 238.4 mg and 338.7mg due to the effects of rotenone at a 20% concentration and limonene at a 5% concentration, respectively. The fourth nymphal duration was prolonged by 17.6 days by the effect of azadirachtin at 15% concentration, while limonene increased duration by 10.5 days at 5% concentration, compared with 10.2 days in control.

However, 81.12% of rotenone at 35°C and 58.1% of sabadilla at 30°C showed greater and lesser effects of temperature stress on toxicity against the fifth nymphal instar treated with LC_{50} after 96 hours of treatment.

Moreover, under various temperature stress conditions, the fifth nyphal haemolymph contents of protein, lipid, and carbohydrate decreased in response to the biorational insecticides of limonene, sabadilla, rotenone, and azadirachtin. After application the ant-juvenoid Precocene II against the fifth nymphal instar, extramoulded nymphs were seen. Adult deformation was 52.2% at higher precocene II doses of 1000 ppm and 14.2% at lower precocene II values of 50 ppm. In the meanwhile, the precocene II concentration of 1000 ppm was found for the nymphal adult intermediate at 13% and 7%, respectively. According to these findings, the biorational chemicals may be able to interfere with the heamolymph's metabolites, toxicity, and aberrant deformations in *Schistocerca gregaria* nymphs and adults stages

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