Ecological studies on the pink bollworm pectinophora gossypiella (saunders) and its natural enemies

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V. SUMMARYExperiments were carried out to study the effects of constant temperatures on the pink bollworm, Pectinophora gossypiella (Saund.), its hymenopterous parasitoid Dibrachys cavus and the predaceous coccinellid Hippodamia tredecimpunctata. In addition, field studies were carried out through two cotton seasons 2002 and 2003 to study the seasonal fluctuation of pink bollworm under field conditions, cotton infestation by pink bollworm larvae, pink bollworm entrance in diapause & moths emergence at the next year, survey of the natural enemies associated with the pink bollworm diapaused larvae and the survey of common predators found in cotton fieldsand seasonal abundance of these predators. I. Laboratory studies:1. Effect of temperature on some biological aspects of pink bollworm, Pectinophora gossypiella (Saund.):1.1. Egg stage:The incubation period of eggs ranged between 12.40 -3.45 days when temperature ranged between 19-31 °C. The thermal heat units required for eggs to complete development were 78.62, 70.42, 69.72, 66.73 and 63.27 DD for 19, 22, 25, 28 and 31 °C, respectively. The lower and upper temperature thresholds for the incubation period of eggs were 13.88 and34.76°C, respectively.1.1.2. Hatchability percentages:The highest percentage of hatchability was 83.23 when eggs were kept at 28 °C and the lowest one was 57.9 % at 31 °C. 1.2. Larval stage:1.2.1. Durations and thermal heat units required:The durations of pink bollworm larvae were 25.32, 19.22, 15.31 and 13.27 days under the constant temperatures 22, 25, 28 and 31 °C. While at 19 °C, all larvae entered diapause. The means of thermal heat units required for larval developmental of the pink bollworm were 236.49, 237.17, 234.86 and 243.37 DD at 22, 25, 28 and 31 °C, respectively.1.2.2. Mortality:The mortality percentage when the larvae incubated at 19,22, 25, 28 and 31°C were 49.35, 35.6, 19.35 26.12 and 37.2%, respectively.1.3. Pre-pupaThe average durations of pre-pupae were 5.24, 4.02, 3.34 and 2.35 days at 22, 25, 28 and 31°C, respectively. The thermal heat units required for pre-pupa were 48.94, 49.61, 51.24 and 41.27 DD for 22, 25, 28 and 31 °C, respectively.1.4. Pupal stage:The period lasted 13.00, 9.34, 8.24 and 7.86 days on average at 22, 25, 28 and 31 °C, respectively. Pupa required 121.42, 115.26, 126.40 and 140.85 DD for its development at the same temperature, respectively.1.5. Female’s duration:1.5.1. Pre-oviposition period:All biological characters of P. gossypiella females were estimated when adults reared at 22, 25, 28 and 31 °C and fed on 10% bee honey solution. The pre- oviposition periods averaged 4.59. 3.38, 2.95 and 2.35 days at the mentioned temperatures, respectively. During this period, the female required 42.87, 41.71, 45.25 and 43.10 DD, respectively.1.5.2. Oviposition period:The egg laying periods averaged 9.32, 8.71, 6.15 and 4.88 days, respectively, during which the female required 87.05, 107.48, 94.34 and 89.50 DD, respectively.1.5.3. Post-OVipOSti011 period:At the same temperature degrees, female spent a post-ovipostion period of 7.605, 4.38, 2.14 and 1.75 days, respectively.1.5.4. Egg laying:The average in numbers of eggs deposited per femalewere 39.4, 117.67, 48.04 and 17.8 eggs, respectively. Thus indicating highest eggs’ reproductivity of P. gossypiella female at 25 °C.1.6. Adult male longevity:When P. gossypiella males were fed on 10% bee honeysolution at the same temperatures, the male lived 19.23, 15.60, 12.35 and 6.90 days, respectively. The rates of development for male were 5.20, 6.41, 8.10 & 14.51 and the thermal units190required for male moth

were 179.61, 192.50, 189.45 and 126.36 DD, respectively.1.7. Life-cycle:The period of P. gossypiella life-cycle (from eggs to deposition of the first egg of next generation) lasted 55.69, 41.61, 34.19 and 29 days at 22, 25, 28 and 31 °C, respectively. The thermal heat units required for pink bollworm, P. gossypiella, to complete one life-cycle at different constanttemperatures were 520.14, 513.47, 524.47 and 531.86 DD, respectively.2. Effect of temperature on some biological aspects of the parasitoid Dibrachys cavus Walker:Dibrachys cavus was surveyed as an active ectoparasitoid on P. gossypiella larvae.2.1. Egg stage2.1.1. Incubation period and thermal heat units required:The eggs hatched after a period of 2.89, 2.32, 1.82, 1.52 and 1.15 days when the parasitized larvae were incubated under 19, 22, 25, 28 and 31 °C, respectively. The thermal heat units required for the completeness of embryological development were 22.98, 25.40, 25.39, 25.76 and 22.94 DD, respectively. The rates of development at the above mentioned temperatures were 34.60, 43.10, 54.95, 65.79 and 86.96, respectively.2.1.2. Hatchability percentage:1The highest percentage of hatchability was 96 % at 19 °C, while the lowest one was 86% at 31 °C. The hatchability percentage of D. cavus eggs Was found to be decreased as the temperature was increased.2.2. Larval stage:2.2.1.Duration and thermal heat units required:Larval durations of D. cavus were 10.46, 7.96, 6.56, 5.30 and 4.22 days when the larvae were reared on P. gossypiella full grown larvae at 19, 22, 25, 28 and 31 °C, respectively. The means of thermal heat units required throughout the larval duration were 83.16, 87.16, 91.51, 89.84 and 84.19 DD at 19,22, 25, 28 and 31 °C, respectively. The lower and upper temperature thresholds for development were 11.13 and 38.67°C.2.2.2. Larval mortality:Among the reared D. cavus larvae, mortalities ranged between 4-10% , when temperature increased from 19 to 28 °C. The highest mortality percentage (26.8%) was recorded when the parasitoid was reared at 31°C.2.3. Pupal stage:At constant temperatures of 19, 22, 25, 28 and 31 °C, thepupal duration of the parasitoid D. cavus lasted 14.26, 10.52, 8.45, 6.89 and 5.11 days, respectively. The thermal heat units required, at these temperatures, for pupal durations were 113.37, 115.19, 117.88, 116.79 and 101.94 DD, respectively.12.4. Adult stage:-2.4.1. Sex ratio:The sex ratio (male : female) of emerged adults resulted from the larval of D. cavils reared on pink bollworm full grown larvae were 1:1.63, 1:3, 1:5.25, 1:6.69 and 1:6.14 male: female at19, 22, 25, 28 and 31°C. Highest percentage of females resulted by rearing at 28 °C.2.4.2. Female's duration:The averages of female longevity were 23.88, 18.91, 13.95, 12.03 and 8.22 day by rearing on 19, 22, 25, 28 and 31 °C, respectively. The rates of development of the parasitoid female increased from 4.19-12.17 as temperature was increased from 19-31 °C. The lower and upper temperature thresholds for female were 13.26 and 37.09 °C, respectively. All the biological processes were estimated at constant temperaturedegrees ranging from 19-31°C and offering bee honey for adults' nutrition.2.4.2.1. Pre- oviposition period:The pre ovipostion periods lasted 2.25, 2.19, 2.10, 1.96 and 1.60 days at 19, 22, 25, 28 and 31 °C, respectively.2.4.2.2. Oviposition period:At the same constant temperature degrees, the oviposition period averaged 19.33, 14.97, 10.40, 8.86 and 5.35 and the thermal heat units required throughout this period were 152.88, 152.97, 159.17, 150.35 and 118.90 DD, respectively.2.4.2.3. Post-oviposition period:The shortest post-oviposition period was (1.2 days) recorded when females were reared at 31 °C. While, the longest period was 2.3 days at 19 °C.2.4.3 Male longevity:The male longevity of the parasitoid D. cavus averaged 20.25, 14.89, 11.78, 9.02 and 5.85 days, and the thermal heat units required were 160.99, 163.05, 164.33, 152.89 and 116.71 at 19, 22, 25, 28 and 31 °C, respectively.2.5. Life-cycle:The mean duration of life-cycle averaged 29.86, 22.99, 18.93, 15.67 and 12.08 days by rearing at the mentioned temperature degrees, respectively. Throughout this period, the female required 237.37, 251.74, 264.07, 265.61 and 241.00 DD, respectively.3. Effect of temperature on some biological aspects of the predator, Hippodamia tredecimpunctata, fed on pink bollworm, Pectinophora gossypiella eggs:3.1. Egg stage:The incubation period of H. tredecimpunctata eggs averaged 3.48 and 2.71 days at 25 and 31 °C, respectively.3.2. Larval stage3.2.1. larval duration:The durations of the four larval instars were 3.56, 3.43, 4.20 and 5.20 days for the 1st , 2nd , 3rd and 4th instar larvae, respectively when reared at 25 °C. opposed to 2.34, 2.10, 3.20 and 3.85 days by rearing on 31 °C .3.2.2. Larval mortality:Among H. tredecimpunctata larvae that were reared onP. gossypiella eggs larval mortalities were 93 and 94 % at 25 and 31 °C, respectively.3.3. Pre-pupal period:The pre-pupal period was 2.5 and 1.66 days, when thelarvae fed on the pink

bollworm eggs' at 25 and 31 °C, respectively.3.4. Pupal period:Pupae of H. tredecimpunctata emerged after 5.64 and 4.10 days, when reared on the pink bollworm eggs under constant temperatures of 25 and 31 °C, respectively.3.5. Adult's emergence:Data obtained from rearing H. tredecimpunctataconfirmed that P. gossypiella eggs are not the suitable prey for successful development of this predator. Only 5 and 2 % of the reared individuals succeed to develop to the adult stage.3.6. Feeding capacity of H. tredecimpunctata :A H. tredecimpunctata larva was able to feed upon 76.85, 132.42, 215.87 and 256.87 P. gossypiella eggs during the1st 2nd 3rd and 4thinstar, respectively. when reared under 25 °C, while at 31 °C the mean consumed were 64.28, 119.58, 225.63 and 239.57 at 1St , 2nd 3rd and 4th instar, respectively. The total eggs consumed was 682.00 and 649.1 when the larvae of H. tredecimpunctata reared under 25 and 31 °C, respectively.3.6.1. Adult stage:The adult male lived for 45.20 days , while the female lived for 54.60 days when reared under 25 °C, in case of 31 °C the adult male lived for 39.46 days , while the female longevity was 41.53 days. The adult male of H. tredecimpunctata consumed a total number of 1981.33 from pink bollworm eggs, while the female consumed a total number of 2512.133 eggs when reared on 25 °C. The average daily was 43.83 and 46.00 eggs for male and female, respectively. In case of 31 °C, the adult male of H. tredecimpunctata consumed 1930.8 of pink bollworm eggs, while the female consumed 2108.26 eggs of pinkbollworm. The average daily consumed was 48.92 and 50.76eggs for male and female, respectively.II. Field studies:1. Seasonal fluctuation of pink bollworm, Pectinophora gossypiella, male moths:The pink bollworm male moths catch recorded five peaks during 2002 and 2003 years. The accumulated numbers of moths catch were 3256 at the first year 2002 while the second year 2003 was 3505 male moths. The number of male moths differed from year to another and during the same season. This may be due to the moths emergence from larval diapause which wasaffected by weather factors and crop rotation.1.2. Fruiting structure of cotton variety Giza 85 and seasonal fluctuation of pink bollworm adult males:The cotton buds initiate about 644 and 427 DD to appear from the plantation date during the first and second season, respectively. The buds appear after 55 and 48 days from planting date during the first and second seasons, respectively. The first peak of male moths' catch in pheromone started to be detectedafter one and two weeks after the first appear of squares during the first and second seasons, respectively.The first appearance of cotton flowers started at the 3rd week of June with 0.08 and 0.44 flower / plant during 2002 and 2003 cotton seasons; i.e., 76 days after sowing. This indicated that flowers required 920 DD to first appear. While, green cotton bolls initiation to appear required bout 1020 DD from the date of sowing, as those started to appear after 83 days from sowing with 0.64 and 0.44 bolls/plant during the first and second seasons, respectively. It could be concluded from the obtained results that the first generation of P. gossypiella coincided withsquares and flowers of cotton, while the 2'd & 3rd generations coincided with presence of green cotton bolls.1.3. Effect of climatic factors on the population density of P. gossypiella:1.3.1. Maximum temperature:The population density of P. gossypiella was highly significantly & positively correlated with maximum temperature during the two years of study. The simple correlation coefficient "r" values were 0.489 and 0.699 in 2002 and 2003, respectively. 1.3.2. Minimum temperature:The simple correlation "r" values between Minimum temperature and number of male moths caught in pheromone traps were 0.536 and 0.726 in the two seasons, showing significant & positive correlation.1.3.3. Relative humidity:In contrast to the effect of temperature, relative humidity,negatively, affected the population of P. gossypiella moths. The "r" values were -0.0007 and —0.057 at 2002 and 2003, respectively, being insignificant during the two seasons.1.3.4. Interaction of the three climatic factors:The combined effect of the three weather factors (explained variance E.V.) was significant during the two successive years (32.21% and 52.15%, respectively).1.4. Number of generations:Male moths accumulative counts captured to pheromonetraps indicated the presence of 6 generations in 2002 and 5 generations in 2003. from the two years data, it was clear that the fifth generation of season 2002 was the highest (47.94%), while the first one of the same season was the lowest (0.62%).1.5. Relationship between number of pink bollworm malemoth and accumulated heat units:Correlation coefficient values for the accumulated pink bollworm male moth catches versus to the accumulated degree days were 0.94 and 0.97 during 2002 and 2003 years, respectively, being highly significant during the two years.

The coefficients of determination (R2) for simple regression were0.99 and 0.991. explained variance values were 99 and 99.1% during 2002 and 2003 years, respectively.Generally, the accumulated trap catch and accumulated degree days may be a useful tool for predicting the number ofpink bollworm male catch and as an indicator of the seasonal population increase.2. Percentage of infestation by P. gossypiella to fruiting structures of cotton plants:2.1. Infestation in squares:The overall mean percentages of infested squares by pink bollworm larvae during the whole season in the untreated cotton field were 6.95 and 4.82%, opposed to 5.49 and 3.97 % in thetreated one during 2002 and 2003 cotton seasons, respectively. 2.2. Infestation in flowers:The overall mean percentages in cotton flowers during the two seasons were (21.08 and 22.30 %) and (13.22 and 8.85 %) in the untreated and treated cotton fields, respectively.2.3. Infestation in green bolls:The infestation of green cotton bolls by pink bollworm started at the 2nd week of July during 2002 and 2003 cotton seasons. The mean percentages of infestation in bolls were 59.7 and 48.87 % in untreated cotton field during, while those were23.02 and 14.09% during 2002 and 2003 cotton seasons, respectively.2.4. Pink bollworm larval counts in green bolls:The seasonal mean numbers of pink bollworm larvae ranged between 0.04 -2.34 and 0.02 -1.64 larvae/ boll during2002 and 2003, respectively, in untreated cotton field. In case of treated cotton fields, those ranged between 0.027-1.17 and 0.02-0.73 larvae /boll, respectively. It was clear that infestation rates in green bolls were higher in untreated than treated cotton field. 2.5. Relationship between the captured numbers of pinkbollworm moths and infestation percentages in greencotton bolls:The correlation values between infestation rates in greenbolls and captured moths were positively significant in 2002 and insignificant during 2003 in untreated field, while in the treated cotton, correlation values were were positively insignificant during the two seasons.3. Pink bollworm, Pectinophora gossypiella, larvae enteringdiapause:Diapause of pink bollworm larvae started at the end ofAugust by 0.80 and 0.79% of total larvae during 2002 and 2003 cotton seasons, respectively. The percent of pink bollworm larvae that entered diapause increased gradually from the first week of September to reach the highest percentages (95.1 and 96.08%) at the second week of November in both seasons.3.1. Relationship between climatic factors and pink bollwormlarvae entering diapause stage:3.1.1. Temperature:-Maximum temperature:Simple correlation coefficient values (r) weresignificantly negative correlation in the two seasons (-0.87 and -0.81, respectively). The simple regression (b) was highly significant. It was clear percentage of pink bollworm larvaeentering diapause increased by the decrease in maximum temperature.-Minimum temperature:Highly significant negative correlation values (-0.88 and - 0.88) were detected, indicating increase in percentage of pink bollworm larvae entering diapause towards the end of cotton season when the temperature decreased.3.1.2. Effect of relative humidity:The simple correlation coefficient ”r” values between RH % and percentage of larval diapause were insignificant in 2002 and significant in 2003 cotton season (0.12 and 0.76). Therelative humidity play certain role as a factor inducing diapause. 3.1.3. Effect of photoperiod:The simple correlation ”r” values were negative and significant (-0.90 and -0.84 during 2002 and 2003 cotton seasons). The simple regression values ”b” were significant during the two cotton seasons. It was clear that when thephotoperiod decreased the percentage of pink bollworm larvae entering diapause increased.3.1.4. Joint effect of the three weather factors:The joint effect ” R2 ” values were highly significant during the two cotton seasons (0.8918 and 0.8843, respectively). The explained variance percentages (E.V.%) indicating effect of the three combined weather factors were 89.18 and 88.43% during 2002 and 2003 seasons, respectively.3.2. Larval diapause duration:The diapausing period of P. gossypiella larvae was foundto be shorter when larvae entered diapause early (4th week of August) and those entered diapause late at first week of November during the two seasons. While, the longest periods were 202.5 and 205.23 for larvae that entered diapause during the 2nd and 3rd weeks of September in 2002 and 2003 seasons, respectively.3.3. Pupal period after larval diapause:The duration of pupal stage after larval diapause rangedbetween 30-19.87 days in the first season, and between 32 to 18.50 days in the second season. It was found that this period was affected by the time of pupation.4. Emergence of P. gossypiella moths during the subsequentseason:In general, the pink bollworm larvae that entered diapauseearliest in the fall, led to adults that emerged earliest with overlapping in the times of moth emergence from larvae that entered diapause in different times. The beginning and end of moths

emergence differed according the time in which larvae entered diapause. The peaks of moths emergence from all dates of starting diapause were detected during the 2nd and 3rd weeks of May in 2003 and 2004, respectively.4.1. Accumulated heat units in relation to emergence of pinkbollworm moth:Cumulative moth emergence rates and heat units weresignificantly correlated. Values of simple correlation coefficient"r" were 0.893 and 0.901 in 2003 and 2004, respectively, The explained variance values of accumulated heat units on theaccumulative number of moths emergence were 95.73 and 93.34 %, respectively.5. The parasitism on pink bollworm diapausing larvae: 5.1. Pink bollworm larval mortality:The pink bollworm larval mortality during diapause stage recorded two peaks during each of two seasons. The larval mortality was higher during December and April of the firstseason (2002) and during December and March of the second season (2003).5.2. Number of pink bollworm parasitized larvae:Parasitized larvae were detected from the 2nd week ofNovember (3 and 4 larvae /100 dry cotton bolls) and increased until end of December in both seasons. Then, the countednumbers fluctuated until the end of March . Mean percentage ofparasitism were 10.28 and 10.47 % on the diapausing larvae during the first and second seasons, respectively.5.3. Number of pink bollworm larvae parasitized by different parasitoids:Rates of parasitism were higher during December and January than other months. The parasitic species of mite, P.herfsi was the dominant during the period from March till the first week of May during the two seasons.5.4. Emergence of adult parasitoids:The total numbers of adult parasitoids that emerged afterparasitism on diapaused P. gossypiella 420 and 428 adults during the first and second seasons, respectively. The peak of adult counts were (69 and 65 adults) were recorded during 2nd and 3rd weeks of December during the two seasons, respectively. 6. Seasonal abundance of arthropod predators in cottonfields:6.1. The sweep net method:6.1.1. Abundance of total predators:-The total population of insect predators were, generally,higher in pesticide free cotton field compared with sprayed one. Also, in the untreated cotton field, the population was higher during 2003 (644 individuals) than 2002 season (565 individuals). As for the weekly counts of predators on cotton plants, predators were, generally, in high population during June and August throughout the two seasons. Also, data revealed that the population decreased gradually throughout July and returned to increased towards the end of season.6.1.2. Abundance of different predators:Insect predators belonging to nine genera in four familiesand three orders were surveyed in this study. Those included six coleopterous, Coccinella septempunctata, Coccinellaundecimpunctata, Cydonia spp., Hippodamia tredecimpunctata, Scymnus spp. (Coccinellidae) and Paederus alfierii (Staphylinidae), a hemipteran, Orius spp. (Anthocoridae)and a neuropteran, Chrysoperla cornea (Chrysopidae). The true spiders were also counted.6.2. Direct count technique:6.2.1. Abundance of total predators:The populations of insect predators were, generally,higher in 2003 than in 2002 cotton season in both treated anduntreated cotton fields. During the two seasons (2002 and 2003), the total population of predaceous arthropods showed four andthree peaks of abundance on the 2nd week of June , third week of July , fourth week of August and first week of September during 2002 season and on the second week of June, second week of July and fourth week of August throughout 2003 season in untreated cotton field. Also, in treated cotton field the population of predators showed four and three peaks of abundance durinthe two cotton seasons. g