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STAGE SPECIFIC LIFE TABLE OF INVASIVE PEST MEALYBUG, *PHENACOCCUS SOLENOPSIS* (TINSLEY) UNDER COTTON FIELD CONDITIONS

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ABSTRACT

The field study was conducted on at the experimental field of SALU – Khairpur during, 2016. Two hundred eggs were kept for each replication on cotton plants grown in large pots. When eggs hatched, the life table parameters such as; apparent mortality, survival fraction, mortality survivor ratio, indispensable mortality and k-value were studied. Natural enemies such as; *Chrysoperla carneae*, lady bird beetles, Spiders and *Anasius bambawallae* were found active on the potted and surrounding cotton plants in the field conditions. The total mortality in egg stage went to 19.00%. The mortality percentages of 1st instars due to natural enemies recorded was (18.73%) while, in 2nd instars (13.13%) mortality was recorded. The total combined mortality in 1st and 2nd instars was recorded (26.34%) and (15.64%), respectively. However, the mortality of 3rd instars and pupae due to parasitoids were recorded (7.28%) with the total mortality (10.26%) and the total mortality (54.83%) in cotton potted plants was recorded. Consequently, (45.17%) of adults survived with male and female ratio as ♂1:6.52♀, respectively. The highest apparent mortality was (26.34%), indispensable mortality (96.89) and k-value (0.13) recorded in 1st instar. The maximum survival fraction was recorded (0.90) in third instars/pupae with the total k-value generations (0.35). The study revealed that the predators and parasitoids should be encouraged in cotton field when mealybugs appear, because predators are highly voracious feeder of 1st and 2nd instars whereas; the parasitoid, *A. bambawallae* is known as main controlling natural enemy of cotton mealybug.

Contribution/ Originality: This study documents over the biological parameters of cotton mealybug to check its, egg laying, mortality, survivor ratio, total life span, fecundity, fertility, different life stages, predators activity and aboitic factors with the different equations about this vigorous pest under cotton field conditions.

1. INTRODUCTION

The cotton mealybug, *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) is an exotic mealybug also reported as *P. solani* Ferris by some workers due to identity opinions in India, is widely distributed on ornamentals, tobacco, and many other plants in the USA, Central America, Latin America, Africa, Hawaiian Islands, Italy, Pakistan and Israel [1-3]. During 2005, the sudden appearance of this pest in cotton in some parts of Pakistan destroyed the entire crop within a few days. Control of this pest is gradually becoming difficult with decrease in the

efficacy of insecticides and biological control appears to be a more suitable alternative. The honeydew exuded by developing mealybugs induces appearance of sooty mould near the affected region and cause necrosis of the affected parts [4, 5]. Sahito and Abro [6] studied the biology of cotton mealybug on okra and China rose under laboratory conditions. Sahito, et al. [7] also described the biological and morphological studies of *P. solenopsis* development under laboratory environment. Chong, et al. [8] described that *P. solenopsis* had longer developmental periods for the second instar over the other two instars under laboratory conditions, indicating the influence of weather conditions as well as host plants on its development.

In ecological study, life table is a most important analytical tool, which provides detailed information of population dynamics to generate simple but more informative statistics. It also gives a comprehensive description of the survivorship, development and expectation of life [9]. The collection of data on life-table at different temperature gives an important task for pest management in different environmental conditions [10]. Cohort life tables give comprehensive information on the mortality, survivorship, and development of a population and as such are fundamental to both theoretical and applied population ecology [11]. The expectancy of life exhibited a continuous decline with advancement of age. As far as stage specific life table is concerned, the developmental stages showed highest survivor fraction and lowest apparent mortality, mortality survival ratio, indispensable mortality and k-values with regard to temperature [12]. The present investigations were carried out to ascertain the mortality and survival percent and the factors responsible for mortality of cotton mealybug, a vigorous pest of cotton crop. The out put of the present investigations will be utilized for integrated pest manage.

2. MATERIAL AND METHODS

The experiment on "Age and stage specific life table studies of invasive pest mealybug, *Phenacocus solenopsis* (Tinsley) under cotton field conditions" was conducted at the experimental field Shah Abdul University, Khairpur - Sindh during, 2016. Three cotton plants were grown in large pots at experimental field the eggs of mealybug were collected from infested cotton field. Six hundred eggs were kept (200 for each replication) in cotton plant which grown in pots and replicated three times to ascertain the age and stage specific of life table cotton mealybug. The pots of cotton plants were regularly examined to observe hatching of the eggs. After hatching, the 1st instar nymphs/crawlers were regularly examined to observe the subsequent stages of cotton mealybug and also recorded the day's duration of various stages of cotton mealybug. For this purpose a (cv. Bt.) variety was grown in pots as well as surrounding of the pots whereas, one acre of the field was kept under observation. Those pots of cotton plant were put separate from each other and took distance about 10 feet. The pot of cotton plants were regular observed for presence of arthropods and non arthropods. The experimental field was kept under control plot in which the applications of pesticide were forbidden except the water wash and neem oil sprays were done to enhance the natural enemies. It was done in connection to reduce the chance to the test instars that they would not move to the adjacent or touching to other pot plants and even for easily viewing and counting the test instars for their mortality and survivorship.

Observations were made on alternate days for age and stage specific life table study of cotton mealybug, while counting of dead, missing and alive mealybug instars in potted plants. Activities of predators and parasitoids were also recorded around the instars on potted plants. The environmental factors i.e., temperature and relative humidity were also recorded during the study of research work.

Age specific life table: Observations on number of alive and dead instars out of replicated two hundreds eggs were recorded daily. The following assumptions were used in the construction of age specific life table of *P. solenopsis* therefore, the prescribed formula and equations are described as under:

Preparation of life table: Data on age and stage specific survival and mortality of eggs, 1st instar, 2nd instar, 3rd instar / pupae and adults of *P. solenopsis* were recorded. Following standard heads were used to complete stage specific life table.

x = Stage of the insect.

Lx = Number surviving at the beginning of the stage x.

dx = Mortality during the stage indicated in the column x.

The data calculated through above assumptions were used for computing various life parameters as given below:

Apparent mortality (100 qx): It gives the information on number dying as percentage of number entering that stage and was calculated by using the formula:

Apparent Mortality = [d x / l x] x 100

Survival fraction (Sx): Data obtained on apparent mortality was used for the calculation of the stage specific survival fraction (Sx) of each stage by using the equation:

Sx of particular stage = [Lx of subsequent stage / [Lx of particular stage].

Mortality survivor ratio (MSR): It is the increase in population that would have occurred if the mortality in the stage, in question had not occurred and was calculated as follows:

MSR of particular stage = [Mortality in particular stage] / [Lx of subsequent stage].

Indispensable mortality (IM): This type of mortality would not be there in case the factor (s) causing it is not allowed to operate. However, the subsequent mortality factors operate. The equation is solved under given formula:

IM = [Number of adults emerged] x [M.S.R. of particular stage].

K-values: It is the key factor, which is primarily responsible for increase or decrease in number from one generation to another and was computed as the difference between the successive values for "Log Lx". However, the total generation mortality was calculated by adding the k values of different development stages of the insect, which is designated/ indicated as "K" [13, 14].

k-values: K = k E + k L1+ k L2+ k L3 / k pp + kp.

Where, k E, k L1, k L2, k L3 / k pp and kp are the k-values at egg, first instar, second instar, third instar / pupae and adults stage of *P. solepnopsis.*

3. RESULTS

The field study was conducted on at the experimental field, SALU – Khaipur during, 2016. During the life table study of cotton mealybug, *P. solenopsis* the apparent mortality, survival fraction, survivor mortality ratio, indispensable mortality and k-value were ascertained. The results in table-1 indicated that the apparent mortality in eggs of *P. solenopsis* was (19.00%), while (15.64%) mortality was recorded in second instar. However, the highest mortality (26.64%) was noted in first instars and lowest apparent (10.26%) mortality was observed in third instars and in pupae of *P. solenopsis.*

The survival fraction of *P. solenopsis* in egg stage (0.81) was recorded and (0.84) in second instars. However, the maximum survival fraction was recorded (0.90) in third instars/pupae, while the minimum survival fraction was recorded as (0.74) in first instar.

The mortality survivor ratio (0.23) was noted in the egg stage while, mortality survivor ratio (0.19) was recorded in second instars. The highest mortality survivor ratio (0.36) was noted in first instars and minimum (0.11) was recorded in third instars/ pupae.

The indispensable mortality (63.57) was observed in egg stage *P. solenopsis* while, (50.25) was recorded in second instars. The maximum indispensable mortality (96.89) was recorded in first instars and minimum (31.00) was recorded in third instars/ pupae. Similarly, the k-value in egg stage was recorded (0.09). The k-values at (0.07) and (0.05) was recorded in second and third instars/pupae. However, the maximum k-value (0.13) was observed in first instars. However; the total generation of cotton mealybug mortality 'K' was recorded (0.35).

Table-1. Life table of cotton mealybug on cotton potted plants under field conditions

Stage x	Number surviving at the beginning of stage (Lx)	Number dying in each stage (dx)	Apparent mortality (100qx)	Survival fraction (Sx)	Mortality survivor ratio (MSR)	Indispensable mortality (IM)	Log (Lx)	K-value
Eggs	600	114	19.00	0.81	0.23	63.57	2.78	0.09
1st Instar	486	128	26.34	0.74	0.36	96.89	2.69	0.13
2nd Instar	358	56	15.64	0.84	0.19	50.25	2.55	0.07
3rd Instar/ pupae	302	31	10.26	0.90	0.11	31.00	2.48	0.05
Adult	271	271	100.00				2.43	0.35

3.1. Stage-Specific Mortality of *P. solenopsis*

The data in table- 2 depicts the stage wise dx and dxf. The dxf in egg stage were failure of hatching due to unknown reasons, and mortality was recorded (12.00%) however, some of the eggs were seen abnormal (Squeezed, shrunken, discolored etc.). The percent of such abnormal eggs was observed (7.00%) with the total mortality in egg stage (19.00%).

The first and second instars of cotton mealybug are known as crawlers; they were seen moving almost on potted plants. This behavior made them vulnerable to be attacked by natural enemies such as; *Chrysoperla carnae*, lady brid beetle, spider and *Aenasius bambawallae* etc. were found active on or around the cotton potted plants. However, the remaining body parts of cotton mealybugs instars were seen on the cotton potted plants, which were considered as invaded or eaten by the predator and the mummies of parasitoids of *P. solenopsis* were also observed there. Hence, the mortality percentage of 1st instars due to predator and parasitoids was recorded (18.73%) and missing crawlers (7.61%). While, in 2nd instars due to predator and parasitoids (13.13%) were recorded however, the missing crawlers (2.98%) were recorded. The total mortality in 1st and 2nd instars recorded up to (26.34%) and (15.64%), respectively.

Table-2. Stage specific life table of *P. solenopsis* on cotton potted plants during, 2016

X	Lx	DXF	Dx	100qx
Egg	600	Not hatched due to unknown reason	72	12.00
		Seen abnormal	42	7.00
		Total	114	19.00
1st Instar	486	Predators/ Parasitoids	91	18.73
		Missing	37	7.61
		Total	128	26.34
2nd Instar	358	Predators/ Parasitoids	47	13.13
		Missing	09	2.51
		Total	56	15.64
3rd Instar / pupae	302	Predators/ Parasitoids	22	7.28
		Missing	09	2.98
		Total	31	10.26
Adult	271			
	♂1:6.52♀			
		Total Mortality	329	
		Mortality %	54.83%	
		Survivorship %	45.17	

However, the mortality percentage of 3rd instars and pupae due to predator and parasitoids (7.28%) and missing (2.98%) was recorded while the total mortality was recorded (10.26%) in 3rd instars and pupae. The total mortality percentage (54.83%) in cotton potted plants was also recorded. Consequently, (45.17%) of adults survived with male and female ratio as ♂1:6.52♀, respectively.

3.2. Age Specific Life Table Parameter of Female and male of *P. solenopsis*

During research study, it was observed that the first instar of cotton mealybug took (3.82) days with the second instar (7.64), third instar (5.78) and an adult stage (17.56) thus, the overall days consumed by the female of mealybug (34.80) (Fig. 1). Whereas; the male of cotton mealybug first instar stage took (5.54), pre-pupae (3.64), pupae (5.23) and an adult (4.56) with the overall days (18.97), respectively (Fig. 2). The analysis of the varrience showed the significant difference among the all stages of female and male of cotton mealybug at ($P<0.05$).

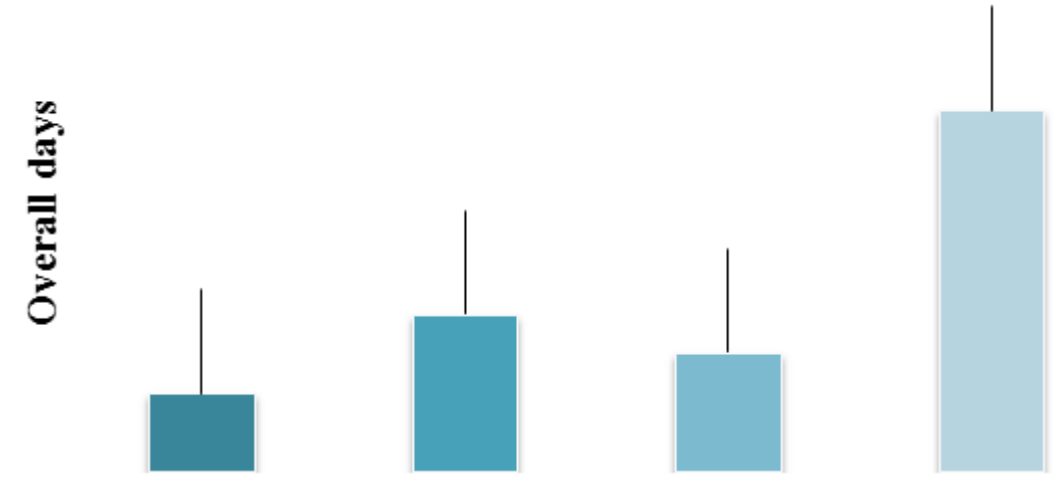

Figure-1. Age specifie life table of cotton female mealybug.

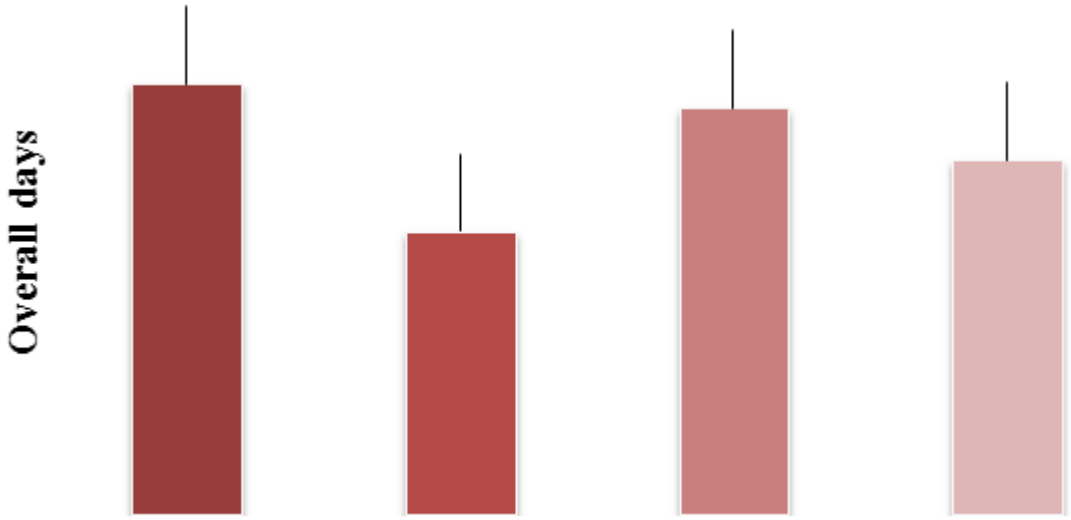

Figure-2. Age specifie life table of cotton male mealybug.

4. DISCUSSION

The life table indicated that the stage specific mortalities were recorded in all life stages of cotton mealybug kept in potted plants. The factors influence the survival were: hatching failure and abnormal egg in egg stage; predators and parasitoids invasion also recorded and missing in subsequent first, second and third/pupae cotton mealybug stage also noted. However, the number of cotton mealybugs was found missing from the cotton potted plants. *Chrysoperla carnea* lady beetle and cotton mealybug parasitoid *Aenasius bambawallae* were recorded most

active predators and parasitoid around the cotton potted plants. The finding are in agreement with those of Agounke, et al. [15] who mentioned that the coccinellids; *Chilocorus nigrita* Exochomus and *E. troberti* and the lycaenids, *Spalgis* spp. as the most important among the predators on cotton mealybugs in Togo.

The findings on stage specific life-tables also revealed that the mortality parameters *viz*., apparent mortality, mortality survival ratio, indispensable mortality and k-value of cotton mealybug [16] who have reported that the high mortality magnitude at the all subsequent stages of mealybug. The high magnitude of apparent mortality, mortality survival ratio, indispensable mortality and k-value were recorded at first instars stage followed by subsequent stages to last nymphal/pupal stage. Our findings almost similar to [17, 18] when pre-pupal and pupal stages were examined, the respective highest MSR figures were evaluated as 0.04 and 0.06 and lowest (0.01) observations on the mortality performance of above coccinellid species. The k-value was recorded almost in all stages, similarly, Omkar and Pervez [19] reported that the total generation mortality 'K' was recorded maximum (0.2676) and minimum (0.1079) *Propylea dissecta*. Schulthess, et al. [20] mentioned that the mealybugs reared on leaves of different ages showed little differences in r_m, and the higher occurrence of *P. manihoti* on plant tips and oldest leaves could not be explained with better nutritive value of these plant parts alone. Awmack and Leather [21] mentioned that host plant quality affects the fecundity of herbivorous insects at both the individual and the population scale. Plant nutrition greatly influences insect survival, development, and fecundity [22]. The survival, body size and development rate of the species were adversely affected on nutrient-deficient host plants. Whereas, the findings of Sandra [23] also endorsed to the Huberty [24] that herbivore population dynamics can be influenced significantly by heterogeneity in plant quality. Birth and death rates of herbivores are influenced by plant-induced changes in parameters such as; growth, survival and fecundity. Similarly, Ali and Rizvi [25] and Rizvi, et al. [26] recorded high mortality on Indian mustard followed by yellow sarson, gobhi sarson and cauliflower in all life stages of *P. brassicae* due to difference in nutritional values of host plants. The maximum survival fractions were recorded at later stage of development on cabbage as compared to other cole crops [27].

5. CONCLUSION

It is concluded that more apparent mortality, mortality survivor ratio, indispensable mortality and higher K-value were recorded 1st instars of cotton mealybugs on potted plants. The 1st and 2nd instars were found vulnerable to be attacked by *Chrysoperla carneae*, lady bird beetle, spiders, and maximum parasitoids ratio was recorded in third instars. Significantly mean mortality was recorded in 1st instars as compared with other life stages of *P. solenopsis*.

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