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COMPARATIVE LIFE TABLE PARAMETERS OF THE CABBAGE WHITE BUTTERFLY *PIERIS RAPAE* FEEDING ON CABBAGE PLANTS INFESTED WITH SUCKING INSECTS BY CONSTRUCTING AGE- STAGE, TWO SEX LIFE TABLE

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ABSTRACT

Brassicaceae family produce a specific secondary metabolites, so called glucosinolates which are known to mediate interactions between Brassicaceae and their associated insect herbivores. They have been recognized as a class of natural pesticides since they exhibit toxic or repellent effects. They establish a significant defence mechanism to protect Brassica plants against pests and diseases. The glucosinolate concentration can increase in response to herbivore feeding, and this high level of glucosinolates can affect both generalist and specialist herbivores. This study evaluate some biological aspects of Cabbage white butterfly when fed its larvae on cabbage seedling infested with Cabbage aphid *Brevicoryne brassica* by constructing age- stage, two sex life table. The results showed that the survival rates off eggs, larvae, pupae, females and males were 1, 1; 0.78, 0.42; 0.64, 0.42; 0.04, 0.06; and 0.02; 0.04 when fed its larvae non infested and infested plants respectively. Life expectancy were 24.04, 17.94; 20.04, 14.54; 7.38, 6.76; 12.8, 9.4 and 4.33, 2.67 respectively too. The reproduction rate of female was 164.66 and 99.87eggs/females,whereas the mortality rates 0.06 at age 7 for larvae fed on health Cabbage plants, while the highest death rate was 0.22 at age 10 when fed on infested plants, and for pupae 0.64 at age 25 and 0.50 at age 26, respectively. The population growth parameters showed that the intrinsic rate of increase (rm) was 0.07, 0.10 individuals/day, finite rate of increase (ƛ) 1.1077 1.0772, net reproductive rate (R0) 24.64, 11.16 female/female/generation, Groos reproduction rate (Grr) 225.96, 136.95 eggs/female. A difference was also found in the periods required for the doubling time (DT) of the population depending on the insect's feeding, as the minimum period was 6.77 days when feeding on healthy plants, while the highest period was 9.31 days when feeding on plants infested with nymphs of Cabbage Aphid.It was also found that the mean generation time (T) decreased when feed on healthy plants, as it reached 31.31 days, while that period reached 32.42 days when feed infested plants. It is evident from the above results that plants infested with Cabbage Aphid had affected the life aspects of Cabbage white butterfly. The feeding of aphids on Cabbage plants has stimulated its to produce or increase the concentration of some secondary compounds that had an obvious effect on the life of the Cabbage white butterfly.

Keywords : Glucosinolates, Secondary compounds, *Brevicoryne brassica, Pieris rapae*

Introduction

Brassicaceae family (Cruciferae) is one of the largest families, which is also known as the Mustard family, as it includes about 338-500 genera and more than 2000-3000 species (Al-Musawi, 1986, Rollin, 1993, Al-Shehbaz, 2004). In Iraq, it has 80 genera and more than 177 species (Towsend and Guest, 1980). The crops of this family are infested by many insect pests, the most important of which are Cabbage white butterfly *Pieris rapae* (L.), Cabbage caterpillar *Pieris brassicae*(L.),Cabbage stalk borer *(Capnodis) Hellulaundalis* sp (Fabriciu), and Diamond back moth *Plutell axylostella* (L.), Cabbage leaf worm (inch worm) *Trichoplusia ni* (Hubner), Cabbage Aphid *Brevicoryne brassicae* (L.), whitefly *Aleyrodes brassicae* (L.), And Cabbage flea Beetle *Phyllotreta sp*. (Spinola).

The Cabbage white butterfly *Pieris rapae* (L.) is an important insect pest, causing a yield loss of more than 40% per year (Pajmon, 1999). It is a specialized pest on Brassicaceae plants and has been used as a model species in insect pest biology (Smallegange *et al*., 2007). The Cabbage white butterfly is active in temperate regions, as it is a global species spread throughout Europe, Asia and North America (Hern and others, 1996, Capinera, 2004). Brassicaceae family is production a specific secondary metabolites, so called glucosinolates which are known to mediate interactions between Brassicaceae and their associated insect herbivores. They have been recognized as a class of natural pesticides since they exhibit toxic or repellent effects. They establish a significant defence mechanism to protect Brassica plants against pests and diseases. The glucosinolate concentration can increase in response to herbivore feeding, and this high level of glucosinolates can affect both generalist and specialist herbivores. Brassicaceae plants own a defense system known as glucosinolates-myrosinase against insect pests and plant diseases (Talekar and Shelton, 1993, Bartlet *et al*. 1999, Hennigens-Janssen, 2014). The crops of the Brassicaceae family, during the various metabolism

processes, produce many chemical compounds, as more than 120 glucocainolites belong to three main chemical groups, which are indole and glucosinolite, which constitute 10%, and vatica, glucosinolite, which is 50%, and finally, aromatic, glucosinolite, which forms 10% of the proportion of glucosinolite. Mithen (2001), Bekaert and others (2012), mentioned that Glucosinolate is considered one of the means of chemical defenses used by plants against many insect pests and plant diseases (Ahuja *et al*., 2010). This study aimed to shed light on some of the life aspects of cabbage white butterfly *Pieris rapae* (L.) feeding on infested plants with Cabbage aphid through constructing age- stage, two sex life table in order to use the results of the study in the integrated management programs for this insect in fields.

Materials and Methods

Preparation of Seedling

GREEN GLOBE F1 (*Brassica oleracea*) variety was chosen, the seeds were planted in nursery after preparing the cultivation medium (peat moss). After 40 days of planting agricultural medium was prepared which consists of a mixture of cambium and peat moss in a ratio of 1:2 v/v. Plastic pots with a weight of 1 kg were used. The pots were planted with seedlings of Cabbage, and 100 of this were but in 5 wooden box with dimensions of 1*1 m and a height of 60 cm covered with boredom in order to avoid infestation with insects. When the Cabbage plants growth to 4-5 leaves they were isolated individually by confining each plant by means of transparent plastic paper strips that were folded in the form of a tube, the top of tubes was blocked by a piece of dull cloth and tied with a rubber band, while the second end fitted to the mixture of pots.

Laboratory Colony of Cabbage white butterfly:

The laboratory colony of Cabbage white butterfly was initiated with adults collected from Cabbage fields, by using sweeping net, then transferred to box breeding with dimensions 60 * 60 cm and a height of 80 cm, which contains pots planted with seedlings of Cabbage and free from insect infestation.

Life table study

In order to obtain eggs with the same age, 15 pairs of reared moths were kept inside an plastic container (10 cm diameter and 19 cm height), which was sealed at the top with a 50 mesh cloth net. After 12 hours, the eggs were collected from the container. A total of 100 eggs were isolated individually in plastic Petri dishes (8 cm diameter and 1 cm depth) with a hole on the lid being covered by a fine mesh net, and egg hatching was recorded every day. In this time 50 plants was infested with nymphs and adults of Cabbage aphid (*Brevicoryne brassica*) collected from the cultivated fields of Cabbage by transfer 50 Aphids to each plants. After three days of infestation with aphids, each plants (50 infested and 50 non infested), were infested with one day old larvae of cabbage white butterfly by means of the brush. As each of them was divided into 5 replicates, each duplicate contains 10 plants. The periods of development, survival, number of females and males, and the number of eggs laid daily by each female, were recorded by reserving both sexes in wooden cages prepared for this purpose until their death. The data were analyzed using age-stage two sex life tables according to (Chi and Liu, 1985, and Chi, 1988), and the life table parameters were calculated using the Two Sex - MS Chart Programmer 2019. As follows :-

Age-stage specific survival rate (Sxj):

Calculated through the following equation:

$$Ix = \sum_{j=1}^{\infty} Sxj$$

As:

Ix = average number of surviving individuals.

Sxj = number of surviving individuals in age x and stage j.

x = age.

j = Stage.

Age-stage life expectancy (exj):

Use the model suggested by Chi and Su (2006)

$$exj = \sum_{i=x}^{n}\sum_{j=y}^{m} Sij$$

As:

n = number of individuals.

x = age.

j = Stage.

i = the age at which you go to Stage j.

Age - stag mortality rate (qxj)

It is the probability that individuals will die after a period of time in age x and stage j.

The values were extracted by the following equation:

$$Qx = D(j)/I(j)$$

As:

Q = mortality rate.

D = dead individuals in stage j.

x = age.

j = Stage.

I = the age at which you travel to stage j.

Net reproductive rate:

Calculate from the sum of mx * Ix from birth to death and through the following equation:

$$Ro = \sum Ix \cdot mx$$

Ro = the number of females replacing the female in the next generation.

x = age in days.

Ix = the number of surviving individuals at age x.

mx = the average number of eggs a female lays in age x.

Intrinsic rate of increase:

Calculated by the following equation:

$$rm = \frac{LinRo}{T}$$

Finite rate of increase

Calculated by the following equation:

$$\lambda = e^{rm}$$

Since e represents the antilog against the natural logarithm of the raised power to the exponent of 2.718, and rm represents the rate of internal increase of the population.

Mean generation time (T):

It is defined as the length of time that the population needs to multiply from the hatching of the egg to the first egg laid by the adult female, calculated through the following equation:

$$T = \frac{lnRo}{rm}$$

Doubling time (DT):

It was calculated by the following equation:

$$DT = \frac{Ln2}{rm}$$

Gross reproduction rate (Grr):

Calculate through the equation:

$$Grr = \sum mx$$

Results and Discussion

Age-stage specific survival rate (Sxj)

Figures (1) and (2) show the survival rates of groups and age stages of a Cabbage white butterfly when fed on non infested and infested Cabbage plants. The results showed that the survival rates off eggs, larvae, pupae, females and males were 1, 1; 0.78, 0.42; 0.64, 0.42; 0.04, 0.06; and 0.02; 0.04 when fed its larvae on non infested and infested plants respectively. This indicates that the survival rates were equal in the egg stage, while in larvae and pupae were higher when feeding the larvae on non infested plants, while their survival rates decreased when fed on infested plants, and this indicates the effect of the secondary compounds that stimulated or increased its concentration when cabbage infested with cabbage aphids.

Age-stage life expectancy (ex)

Life expectancy (ex) is the period of time which the individual is expected to survive at age x and stage j alive. Figures (3) and (4) show the life expectancy of the stages of Cabbage white butterfly under the effect of feeding its larvae on non infested and infested plants. The life expectancy for the new surviving individuals of the egg stage was 24.04, 17.94; larvae 20.04, 14.54; pupae 7.38, 6.76; females 12.8, 9.4 and males 4.33, 2.67 when feeding its larvae on non infested and infested cabbage plants, respectively. The conclusion from this data that the life expectancy of individuals of a Cabbage white fly was decreased when fed its larvae on infested plants,, and this indicates the affect of secondary compounds in infested plants, which stimulated by feeding of Cabbage Aphids on its.

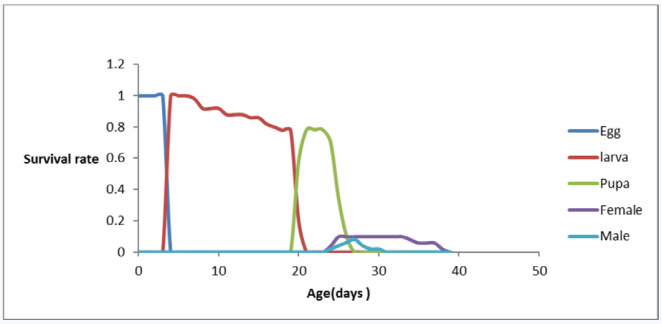

Fig. 1 : The age-stage survival rates for each stage and the survival rate of total cohort (lx) of Cabbage white butterfly fed on non infested plants.

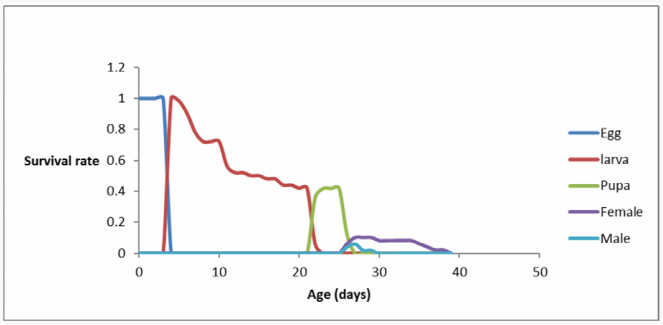

Fig. 2 : The age-stage survival rates for each stage and the survival rate of total cohort (lx) of Cabbage white butterfly fed on infested plants.

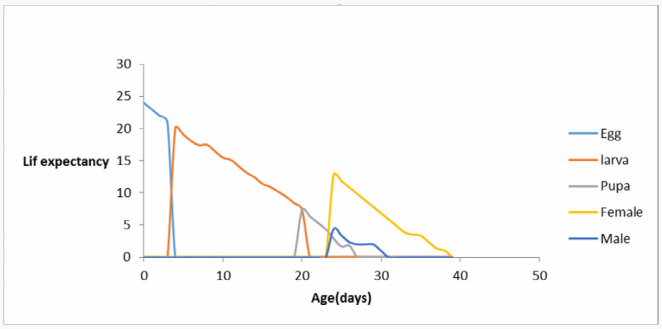

Fig. 3 : Life expectancy for life stage of the Cabbage white butterfly when fed on non infested plants.

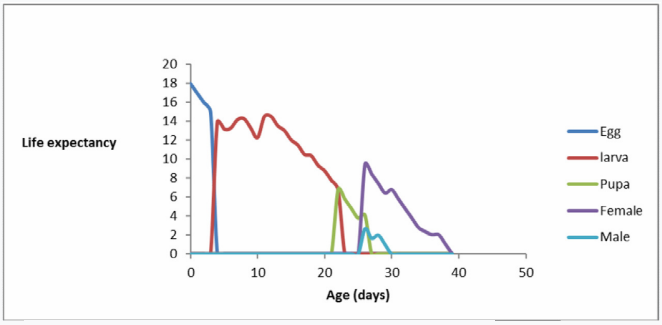

Fig. 4 : Life expectancy for the life stages of the Cabbage white butterfly when fed on infested plants.

Age – stag mortality rate (qxj):

The Q (x, j) is the probability that individuals of age x and stage j will die after 1 time unit. Figures (5) and (6) show the mortality rates for the age stages under the effect of feeding on non infested and infested plants. The highest death rate in larvae stage was 0.06 at age 7 days and 0.22 at age 10 day, pupa stage was 0.64 at age 25 days, 0.50 at age 26; female 1,1 at age 38, 38 days, and in male 1, 1 at age 29, 29 days when fed its larvae on non infested and infested plants .

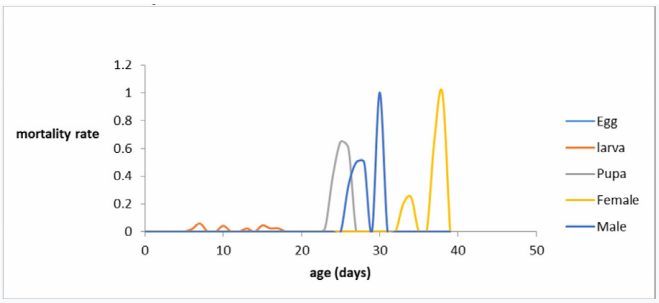

Fig. 5 : Age - stage mortality rates of the Cabbage white butterfly when fed on non infested plants.

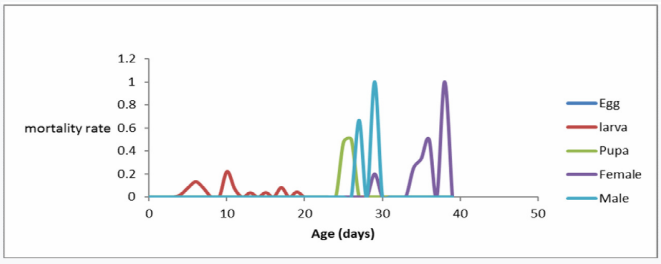

Fig. 6 : Age - stage mortality rates of the Cabbage white butterfly when fed on infested plants.

Life table parameters indicated that the net reproductive values (Ro) of *P. rapa* fed on non infested and infested plants was 24.64, 11.60 female/female/generation, and the intrinsic rate of natural increase (rm) was 0.10, 0.07 female/female/day respectively. The Ro and rm are the two key demographic parameters used to compare fitness of populations across diverse climatic and food- related conditions (Kingsolver & Huey, 2008).

According to this results, there were significant differences in values of Ro and rm among non infested and infested plants. The finite rate of increase (λ) which represents the females added to the population (female/female for each time unit) was significantly different among non infested and infested plants. It was variation from 1.10 to 1.07 day^{-1} respectively.

The gross reproduction rate (Grr) were 225.96 eggs/female when fed its larvae on non infested plants, while it decreased to 136.95 eggs/female when fed on infested plants with Cabbage Aphid. Also, a difference was found in the periods required for the doubling of the population (DT), depending on the insect's feeding, as the minimum period was 6.77 days when feeding on non infested plants, while the highest period was 9.31 days when feeding on plants infested with Cabbage aphid. It was also found that the average generation time (T) decreased when fed on non infested plants, as it reached 31.31 days, and reached 32.4253 days when fed on plants infested with nymphs of Cabbage Aphid.

Table 1 : Population growth parameters for the Cabbage white butterfly feeding on Cabbage plants infested with Cabbage aphids.

Life table parameter	Non infested plant	Infested plant
The rate of natural increase (rm)	0.10	0.07
Net reproductive rate (R0)	24.64	11.07
The rate of specific increase (λ)	1.10	1.07
Gross reproduction rate (Grr)	225.96	136.95
doubling time of generation (DT)	6.77	9.31
generation duration (T)	31.31	32.42

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