

Life Table Parameters of the Predatory Bug *Orius laevigatus* (Fieber) [Hemiptera: Anthocoridae] Preying upon the Tobacco Whitefly *Bemisia tabaci* (Gennadius) [Homoptera: Aleyrodidae] on Tomato Host Plant under Constant Conditions.

Abdul-Jalil Salem Hamdan*

ABSTRACT

The current study described the life table characteristics of the predatory bug *Orius laevigatus* preying upon the tobacco whitefly *Bemisia tabaci* infestation offered on tomato leaf discs under laboratory constant conditions of $26 \pm 1^\circ\text{C}$, $75 \pm 5\%$ R.H. and 16 L:8 D photoperiod regime. Average life table parameters of *O. laevigatus* were calculated for two successive generations as: intrinsic rate of increase (R_m): 0.12; gross reproductive rate (GRR): 46 insects/female/generation; net reproduction rate (R_0): 20 females/female/generation; finite rate of increase (λ): 1.12 females/female/day; mean generation time (T): 25.7 days; and doubling time (DT): 6 days. Those parameters indicated that *O. laevigatus* has the potential to be used as a predator against *B. tabaci* and that this predator would likely be able to overcome populations of *B. tabaci* on tomato plantation in greenhouses under the conditions similar to those used in this study. This is the first publication, recording the life table parameters of *O. laevigatus* when used as natural enemy against *B. tabaci* infestation of tomato.

Keywords: Life Table, *Orius laevigatus*, *Bemisia tabaci*, Tomato, Biological Control.

INTRODUCTION

Among the *Anthocoridae*, many species of the genus *Orius* are considered to be important beneficial insects for various agrosystems (Deligeorgidis, 2002; He'naut *et al.*, 2002; Yano *et al.*, 2002). Although they are polyphagous, *Orius* spp. show a preference for attacking larval and adult thrips (Kakimoto *et al.* 2006; Arno` *et al.* 2008; Xu and Enkegaard 2009) as well as the eggs and larva of whiteflies (Hamdan and Abu-Awad, 2007). In particular, *Orius laevigatus* (Fieber) [Hemiptera: Anthocoridae] is a species that has been widely employed in successful

biological control programs in Europe (Chambers *et al.* 1993; Sanchez and Lacasa 2002; Coll *et al.* 2007). Consequently, *O. laevigatus* is considered promising and effective as a biological control agent and has been used successfully in biological control programs in greenhouse and open-field cropping systems against various thysanopteran pests.

O. laevigatus (Fieber) is considered to be an effective predator of thrips and promising biocontrol agent against *B. tabaci* whiteflies (Chambers *et al.*, 1993; Dissevelt *et al.*, 1995; Van de Veire, 1995; Hamdan and Abu-Awad, 2007, 2008). Before using this predator in biological control or in integrated pest management, it is essential to study its biological characteristics including the life table parameters under experimental conditions. The intrinsic rate of increase (r_m) is a basic parameter which an ecologist may wish to establish for an insect population. Birch (1948) defined the intrinsic rate of increase as the

* Faculty of Agriculture, University of Hebron, Hebron, West Bank, Palestine.

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rate of increase per head under specified physical conditions, in an unlimited environments where the effect of increases in density do not need to be considered.

Jervis and Copland (1996) reviewed the use of life table analysis both by ecologists and by biological control workers. They indicated that, in a biological control program, when faced with a choice of candidate parasitoid species, in the absence of other criteria, the selection would be for the species with the greatest value for the intrinsic rate of natural increase.

MATERIALS AND METHODS

This study was conducted to assess the fertility life table parameters of *O. laevigatus* fed on *B. tabaci* stages offered on tomato leaf discs under standard conditions of $26 \pm 1^\circ\text{C}$, $75 \pm 5\%$ R.H. and 16:8 L:D photoperiod.

Insect Cultures: To establish a stock culture of *B. tabaci* to be used in this study, plant leaves infested with *B. tabaci* were collected from infested tomato plants from a nearby greenhouse during fall 2009, and placed on tomato transplants (*L. esculentum* L. cultivar: 16/84) kept in the wooden cages maintained in the greenhouse at Faculty of Agriculture, Hebron University, Hebron, Palestine.

To obtain tomato transplants freshly infested with *B. tabaci*, healthy tomato transplants (*L. esculentum* L. cultivar: 16/84) were inserted in between the heavily infested plants that were kept in the wooden cages. After 48 hours, those freshly infested transplants were transferred to the Perspex cages and kept under ambient conditions in the laboratory to be used as a source of leaf discs freshly infested with eggs and larvae of *B. tabaci* used in bioassays.

The predator bug, *O. laevigatus* obtained from Bio-Bee Company, were provided in a package with two bottles; each containing 250 bugs. About 80% of the bugs were newly emerged adults and the rest were at 5th nymphal instars mixed with Vermiculite carrier for

ventilation.

Rearing Cages: Woody cages, Perspex cages and Petri-dish cages that used for rearing insects were constructed as follow:

Two woody cages (1m length x1m width x1m height) were constructed with woody firms and covered with 50 mesh screen from all sides. One cage was used to keep healthy transplants of tomato; the other cage was used to keep the culture of *B. tabaci* on tomato plants.

Perspex cages were made from transparent Perspex material (50 cm width x 70 cm depth x 50 cm height). To allow ventilation, a door of 50 mesh cloth (30 cm width x 40 cm high) was provided on the front of the cage. A ten cm diameter hole covered with 50 mesh net was provided in the rear side. The Perspex cages were placed on a metallic tray on laboratory bench with approximately 90 cm high under ambient conditions. Those cages were used to maintain the freshly infested tomato transplants to be used as a daily resource for the infested leaf discs provided to the bioassays.

Each Petri-dish cage (5 cm diameter x 1.5 cm height) had hole of 2 cm diameter in the middle of the lid, which was covered by 50 mesh cloth to provide ventilation. These cages were used for rearing the predators on infested leaf discs in an incubator (Sanyo Growth Cabinet Model MLR-350HT) under the experimental conditions of $26 \pm 1^\circ\text{C}$, $75 \pm 5\%$ R.H. and 16:8 L:D photoperiod. Agar layer of 2 mm thick was used in Petri-dish cages as a source of nutrients as well as a source of moisture for the leaf-discs

Fertilized Agar medium was prepared by adding Agar at rate of 15 g/liter to plant growth fertilizer (20N:20P:20K) diluted in a distilled water at a rate of 2 g/liter. The mixture was heated with a magnetic stirrer for 25 min on hot-plate for homogenizing and dissolving of Agar and then autoclaved for 40 minutes at temperature of 120°C under (1.4 bar) atmospheric pressure. After cooling to $45\text{-}50^\circ\text{C}$, a fungicide solution

prepared by dissolving 0.3 g of Benlate® (50% Benomyl) in 7 ml of ethanol 95% was then added to 3 ml of distilled water, was added to the Agar medium at rate of 1 ml/liter of fertilized Agar. The Benomyl was used to prevent the growth of mould on the agar layer.

Life Table Bioassay: Bioassays were carried out during fall 2009 in the laboratories of Hebron University, Palestine as part of a research project funded by the deanship of academic research in Hebron University. All tests were done in an incubator under standard conditions of $26\pm 1^{\circ}\text{C}$, $75\pm 5\%$ R.H and 16 L: 8 D photoperiod regime.

The experiment was conducted for two successive generations. The 1st generation started on 10th September, 2009 and included twenty replicates. Each replication consisting of couple of female + male of newly emerged adults of *O. laevigatus* obtained from Bio-Bee Company. Adult females of *O. laevigatus* were distinguished from males by observing the presence of ovipositor of female under binocular dissecting microscope at 40X. Those adults which were mass reared on *Ephestia* eggs during their developmental stages in the insectaries of the Bio-Bee company but, were fed on *B. tabaci* stages during their adult longevity in Hebron University laboratory under the standard conditions. The 2nd generation included fifteen replicates obtained from the offspring of the 1st generation that were completely reared on *B. tabaci* stages in Hebron University laboratory under the standard conditions.

Each replication consisted of couple of newly emerged adults of *O. laevigatus* reared in 5cm diameter Petri dish cage and offered tomato leaf disc heavily infested with *B. tabaci* eggs and larvae. The predators were provided with infested leaf-discs placed underside upwards on 2mm-thick Agar medium. A filter paper was used as a layer between the leaf-disc and the Agar medium enabling the free movement of the insects and

decreasing the possibility of their sticking to the Agar.

Each couple was transferred to freshly prepared cages every day and the previous leaf discs from each cage were kept in the incubator under the standardized conditions during incubation period of eggs and then observed for egg hatching. A solution of 0.5 ml/liter of Merpan® (50% Captan) was sprayed on the leaf discs to prevent the growth of mould on the leaf surface. The following parameters of *O. laevigatus* adults were observed for each replication:

1. The survival of adult female at 24 h intervals.
2. Daily observation was done on the presence of eggs of *O. laevigatus* in leaf discs where females reared.
3. Fertility of *O. laevigatus* females reared in each replication by daily observation and counting the number of nymphs hatched from cages where the *O. laevigatus* females were reared. Due to the difficulty of counting the eggs laid per female, the fecundity was considered as the number of newly hatched nymphs from eggs oviposited per every female and referred to as fertility

To obtain adult *O. laevigatus* that were used for life table bioassay in the 2nd generation, 50 newly hatched nymphs were collected from Petri dish cages where the adult couples of the 1st generation reared. Each nymph was separately reared in a 5 cm Petri dish cage on heavy infestation of *B. tabaci* offered on tomato leaf discs. These nymphs were daily transferred to a freshly prepared Petri dish cage by a fine paint brush while checking them under a binocular microscope (40X). Duration of development from egg to adult, mortality and survival of each bug, and the sex ratio of adults were assessed by daily checking of each nymphal stage.

Each couple reared in a 5 cm diameter Petri dish was followed individually till the death of all individual members of the cohort. The surviving adults were maintained and monitored individually to collect necessary data for constructing the life tables. The age of each female (x), the probability that a new individual is

alive at age x (Lx) and the number of female offspring produced by a female with attributed x (mx) were also recorded.

Data Analysis: Life-table analyses for the study were

undertaken using QBASIC computer program (Jervis and Copland, 1996). These analyses were done on the basis of a cohort female proportion of 50%, survival rate to adults of 60% and average duration of development from egg to adult of 16.5 days (Table 1).

Table 1: Duration of development, survival to adult and sex ratio of *O. laevigatus* nymphs fed on *B. tabaci* infestation offered on tomato leaf discs under constant conditions

	Duration of Development Egg-Adult Mean \pm SD	Nymph Survival To Adult Stage (%)	Sex Ratio (Female %)
Value	16.46 \pm 0.51 days	60%	50%

In addition to rm , the other main fertility life table parameters including net reproductive rate, generation time, doubling time, and finite rate of increase were calculated. Once the value of Lx (survival) and mx (fecundity) were tabulated, the following population parameters can be calculated (Messenger, 1964):

a) Gross reproductive rate (GRR) is the mean total number of eggs produced by a female over its life-time, ($GRR = \sum mx$) measured in females/female/generation.

b) The net reproductive rate (or basic reproductive rate) (Ro) is the number of times a population will multiply per generation, ($Ro = \sum Lx mx$) measured in females/ female/ generation.

c) The intrinsic rate of increase (rm) can be measured in females/female/day. The precise value of the intrinsic rate of increase (rm) was obtained by solving the Euler equation (Andrewartha and Birch, 1954): $\sum L_x m_x e^{-rx} = 1$

In this equation, y is the oldest age class, Lx is the survival of a newborn female to the midpoint of an age interval, and x is the age of each female at each age interval.

d) The capacity for increase (rc) is an approximation for rm . $rc = \log_e Ro/Tc$.

e) The finite capacity for increase (λ) is the number of times the population will multiply itself per unit of time, ($\lambda = e^{rm}$) measured in females/ female/day.

f) The cohort generation time (Tc) defined as the mean

age of maternal parents in the cohort at birth of the female offspring. $Tc = \sum Lx mx/Ro$.

g) The mean generation time (T). The comparison of two or more populations by means of their net reproductive rates may be quite misleading unless the mean length of the generation is the same. $T = \sum x Lx mx / \sum Lx mx$.

h) The doubling time (DT) is the time required for a given population to double its numbers, ($DT = \log_e 2/rm$) measured in days.

RESULTS AND DISCUSSION

Life-table analyses were undertaken using QBASIC computer program (Jervis and Copland, 1996) (see Appendices 2 & 3). These analyses were done on the basis of a cohort female proportion of 50%, survival rate to adults of 60% and average duration of development from egg to adult of 16.5 days (Table 1). In addition, the daily fertility of *O. laevigatus* was recorded by counting the nymphs which emerged from the eggs laid in each day of the oviposition period.

Results of the present study described the life table characteristics of *O. laevigatus* that fed on eggs and larvae of *B. tabaci* offered on tomato leaf-discs for two generations under laboratory conditions of 25°C, 75% r.h. and 16:8 L:D. The life table parameters for the 2nd generation that were completely reared on *B. tabaci* stages

were with higher values than that of the 1st generation which were mass reared during developmental stages on *Ephestia* eggs but fed on *B. tabaci* only during adult longevity (Table 2).

Results show that the net reproductive rate, the capacity for increase, intrinsic rate of increase and the finite capacity for increase of *O. laevigatus* during the 2nd generation were higher than that of the 1st generation. Moreover, the cohort generation time, the generation time, and the doubling time of the 2nd generation were shorter than that of the 1st generation. The life table parameters of *O. laevigatus* fed throughout its lifetime on *B. tabaci* were with higher values than those which mass reared during developmental stages on *Ephestia* eggs (in Bio-Bee Company) but fed during adult longevity on *B. tabaci* (in Hebron University Laboratory). However, *Ephestia* eggs

are considered the most preferred food that currently used for mass rearing of predatory bugs in company insectaries.

Thus, *B. tabaci* proved to be with higher nutritional values for feeding *O. laevigatus* and therefore, *O. laevigatus* might be a promising bio-control agent for suppressing populations of *B. tabaci* infesting tomato under greenhouse conditions similar to the standard conditions of this study.

Furthermore, the mean calculated life table parameters of *O. laevigatus* for the two generations were as follow: gross reproductive rate of 46 insects/ female/ lifespan, net reproductive rate of 20 females/ female/ generation, intrinsic rate of increase of 0.12 females/ female/ day, a generation time of 26 days, and doubling time of 6 days (Table 2).

Table 2: Life-table parameters of *O. laevigatus* fed on *B. tabaci* stages offered on tomato leaf discs under constant conditions

LIFE TABLE PARAMETER		1 ST GENERATION	2 ND GENERATION	MEAN ± SD
Gross reproductive rate	GRR	52.05	39.94	45.99 ± 8.56
Net reproductive rate	Ro	18.60	21.37	19.985 ± 1.95
Capacity for increase	Rc	0.0975	0.1154	0.10645 ± 0.012
Intrinsic rate of increase	Rm	0.1101	0.1228	0.11645 ± 0.0089
Cohort generation time	Tc	29.9749	26.53	28.2525 ± 2.2436
Generation time	T	26.5349	24.9225	25.7287 ± 1.140
Finite capacity for increase	λ	1.1165	1.1307	1.1236 ± 0.010
Doubling time	DT	6.29	5.64	5.965 ± 0.459

Anthocorids are predatory bugs in the family Anthocoridae. They are all generally predaceous on aphids, mites, thrips, scales and other arthropods and their eggs and larvae (Henry, 1988). Hodgson and Aveling (1988) reviewed the importance of anthocorids as biological control agents of pests. They concluded that *Anthocoris* and *Orius* (Anthocorinae) are the two genera most important as aphid predators. Both genera

are widely distributed in the Northern Hemisphere, where they are important components in biological control programs.

The intrinsic rate of increase is a basic parameter which an ecologist may wish to establish for an insect population. Birch (1948) defined the intrinsic rate of increase as the rate of increase per head under specified physical conditions, in an unlimited environment where the effect

of increases in density do not need to be considered. Lewontin (1965) indicated that studies on the effect of changing various aspects of the life cycle on the intrinsic rate of increase of a species was important. He considered even the effect of small changes in such life cycle phenomena as fecundity, longevity, length of developmental period etc., on the rate of increase.

Jervis and Copland (1996) reviewed the use of life table analysis both by ecologists and by biological control workers. They indicated that, in a biological control programme, when faced with a choice of candidate parasitoid species, in the absence of other criteria the selection would be for the species with the greatest value for the intrinsic rate of natural increase.

However, van den Bosch *et al.* (1973) stated that the life-table for cohorts or populations are merely schedules of births or deaths caused by various factors and that the intrinsic birth and death rates of a population may be determined in the laboratory under various conditions of food quality, temperature, humidity, and photoperiod.

It is important to note that no study was found containing the life table parameters *O. laevigatus* when fed on related whiteflies, and the current study might be the first research that recorded the life table parameters of *O. laevigatus* when used as natural enemy against *B. tabaci* infestation on tomato plantation. However, previous studies (Hamdan, 1997; Hamdan, 2006) reported records of the life table parameters of a mired predatory bug (*Macrolophus caliginosus*) when fed on a related whitefly (*Trialeurodes vaporariorum*) offered on tomato leaf discs

under similar laboratory conditions. Meanwhile, *M. caliginosus* is currently recommended as a biocontrol agent against the greenhouse whitefly *T. vaporariorum* in most European and Mediterranean countries (Lucas and Alomar 2002; Bonato *et al.*, 2006; Rasdi *et al.* 2009).

Therefore, comparing the life table parameters of *O. laevigatus* (preying on *B. tabaci* in the present study) and that of *M. caliginosus* preying on the greenhouse whiteflies, *T. vaporariorum* (Hamdan, 1997; Hamdan, 2006), showed that the intrinsic rate of increase of *O. laevigatus* (0.12) was three times higher than that of *M. caliginosus* (0.04), the gross reproductive rate of *O. laevigatus* (46) was four times higher than that of *M. caliginosus* (11.3), and the doubling time of *O. laevigatus* (about one week) is half that of *M. caliginosus* (two weeks).

In conclusion, results of the present study suggest that the *B. tabaci* infestation is a satisfactory diet for establishing and maintenance of *O. laevigatus*, and *O. laevigatus* proved to have the potential to be used as predator against *B. tabaci*, and this predator would probably be able to overcome populations of *B. tabaci* on tomato plantation in greenhouses under the conditions similar to those used in this study.

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جدول الحياة للبق المفترس *Orius laevigatus* (Fieber) [Hemiptera: Anthocoridae] في حالة تغذيته على آفة ذبابة التبغ البيضاء *Bemisia tabaci* (Gennadius) [Homoptera: Aleyrodidae] على نبات البندورة تحت ظروف ثابتة

عبد الجليل سالم حمدان¹

ملخص

تشتمل الدراسة الحالية على وصف لمعايير جدول الحياة للبق المفترس *O. laevigatus* عند تغذيته على ذبابة التبغ البيضاء مقدمة على أوراق البندورة تحت الظروف المخبرية ($26 \pm 1^\circ\text{C}$, $75 \pm 5\%$ R.H. and 16 L: 8) (D). وجد أن معدلات معايير جدول الحياة للبق المفترس ولجيلين متتاليين كانت: معدل الزيادة الجوهرية (0.12)، معدل التكاثر الإجمالي (46) حشرة/أنثى/جيل، معدل التكاثر الصافي (20) أنثى/أنثى/جيل، معدل الزيادة المحدود (1.12) أنثى/أنثى/يوم، معدل الجيل (25.7) يوم، معدل زمن التضاعف (6) يوم. وعليه يمكن الاستنتاج بأن البق المفترس *O. laevigatus* لديه الإمكانية لاستعماله كحشرة مفترسة للسيطرة على تعداد ذبابة التبغ البيضاء على نباتات البندورة في الزراعة المحمية تحت ظروف مناخية مشابهة لظروف البحث الحالي. ومن المهم ملاحظة أن هذه الدراسة تكون الدراسة الأولى التي تسجل جدول حياة *O. laevigatus* عند استعمالها كعدو حيوي ضد آفة *B. tabaci* على نباتات البندورة.

الكلمات الدالة: جدول الحياة، *Orius laevigatus*، *Bemisia tabaci*، بندورة، مكافحة حيوية.

(1) كلية الزراعة، جامعة الخليل، الضفة الغربية، فلسطين.
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