

Life tables of *Bracon hebetor* Say (Hymenoptera: Braconidae) and its Host; *Palpita unionalis* Hübner (Lepidoptera: Pyralidae)

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ABSTRACT

The reproductive performance of the ecto-larval parasitoid *Bracon hebetor* Say (Hymenoptera: Braconidae) as well as its host; the olive leaf moth *Palpita unionalis* Hübner (Lepidoptera: Pyralidae) was studied in the laboratory at 27 ± 2 °C. The *P. unionalis* is an important pest on olives, and also feeds on other host plants from the family Oleaceae. The estimated life table parameter was the net reproductive rate (R_0), the mean generation time (T), the intrinsic rate of natural increase (r_m) and the finite rate of increase (λ). This parameter was represented by 68.28, 20.01, 0.15, 1.17 for *B. hebetor* and 68.54, 32.09, 0.13 and 1.14 for *P. unionalis*, respectively. Females of the parasitoid lived for 21.8 ± 1.97 days. The average number of eggs oviposited by females was 365.6 ± 44.94 . Immature survival from egg to adult was 41%. Sex ratio of wasp progeny (females/total) was 0.46. *P. unionalis* females lived on average for 9.10 ± 0.35 days and deposited 179.98 ± 22.64 eggs/female. Survival rate for immature was 68%. Sex ratio of progeny was 0.55. The results concluded of this study can be used to improve mass rearing programs and support in oculative release applications of *B. hebetor* against the olive leaf moth.

Keywords: Olive, *Bracon hebetor*, *Palpita unionalis*, Life tables, Biological control

INTRODUCTION

Olive and fig orchards constitute the main agricultural domain at the Egyptian Northwestern Coastal (NWC) area. Olive tree through its developmental schedule face having more than one economic insect pest species. Olive leaf moth, *P. unionalis* is one of the highly devastating pests especially for nurseries. Larvae attack tender leaves, particularly those of terminal twigs. Newly hatched larvae usually feed on the parenchyma of the lower surface of the leaves, drying the upper epidermis, which becomes brown. Where, in nurseries, larvae may devour young leaves and apical buds, causing stunted growth of the plants. (Athanasios *et al.*, 2004; Kovanci and Kumral, 2004 and Kumral *et al.*, 2007).

Bracon hebetor is a hymenopteran member of Family Braconidae. Beyond the natural capability of its females to parasitize caterpillar larvae and lay its eggs on the larval body surface (ectoparasitoid, gregarious and Idiobiont species) (Eliopoulos and Stathas, 2008), a lot of biological control investigators at the last decades concerned this candidate through a series of studies to shed light on its biology (Yu *et al.*, 2003), on ecology (Eliopoulos and Stathas, 2008), on parasitization capacity (Cline and Press, 1990), on host species and density (Taylor, 1988; Gulel and Gunduz, 2004 and Yu *et al.*, 2003), investigation on effect of prevailing environmental conditions (Farghaly and Ragab, 1984 and Thanavendan and Jeyarani, 2010). The intended aim of their studies was to enroll *B. hebetor* in the proposed programs dedicated for combating caterpillar larvae. Through reviewing the previous studies it was worth to note that, although the shortage in the field data regarding the combating of pyralid larvae with *B. hebetor*, few of which concerned the life table of the wasp and its host (Cline and Press, 1990; Grieshop *et al.*, 2006, Eliopoulos and Stathas, 2008).

Life table study is often a simple way for keeping track of births, deaths and reproductive output in a

population of interest. Moreover, over the past few decades, life tables have become an indispensable tool for biological control workers, especially in evaluating a parasitoid against a host under various climate conditions and host habitats (Birch 1948, Jarvis and Copland 1996). In addition, demographic data could help to assess the potential of population increase on olive, and may help to explain why *P. unionalis* outbreaks occur in olive groves (Kumral *et al.*, 2007).

Bracon hebetor is one of the endemic (naturally occurring) larval parasitoid at the NWC olive orchards. Through her study, Mansour (2012) recorded this larval parasitoid in the olive orchards for the first time and a series of experimental trails had been done to explore its potential activity against olive leaf moth, *P. unionalis*.

Accordingly, the intended goal of the current work is dedicated for study the different biological parameters (the life table parameters) regarding both *B. hebetor* and its field host (*P. unionalis*), which include the net reproductive rate, the intrinsic rate of natural increase and the finite rate of increase. Such parameters are considered as crucial data that should be clarified to facilitate the engagement of such beneficial candidate in a scheduled augmentation program in order to combat larval stage of *P. unionalis*.

MATERIALS AND METHODS

To attain the intended objective, more than one step had been covered that include laboratory rearing of the greater wax moth, *Galleria mellonella* Linnaeus (as the factitious host for *B. hebetor*), *B. hebetor* and the field host, *P. unionalis*. All these insects had been subjected to scheduled rearing programs at the insectaries of Plant Protection Department, Desert Research Center at 27°C and 75% RH.

Insect cultures:

1-Olive leaf moth; *P. unionalis*

The initial source of the olive leaf moth, *P. unionalis*, has been collected from the infested young

olive trees at the olive orchard in El-Kasr district that locate at the western direction of Matrouh Governorate. Larvae were transferred to rearing jars (2 pounds plastic jars) in the laboratory and daily provided with tender olive leaves. Pupae were transferred to clean Petri dishes till adult emergence. Emerged moths were sexed and transferred with a ratio of 2 males: 5 females to new plastic jar that charged by small cotton piece saturated with 10% sugar solution for moth nourishment and olive tender branch as egg deposition sites. Moths were transferred to new jars as the eggs started to hatch. The emerged neonate larvae were frequently provided with tender olive till pupation.

2-Greater wax moth; *Galleria mellonella* Linnaeus

Artificial diet that previously described and published by Bhatnagar and Bareth (2004) were provided to *G. mellonella* larvae. Corrugated papers were added to the rearing jars as pupation sites. Pupae was collected and transferred to new plastic jars and left for adult emergence. Eggs are usually deposited on the rim of the jar that is covered with strip of paper. The cover of the jar where moths prefer to lay their eggs in between the double layer tissue paper is frequently replaced from time to other. Both strip papers and tissue papers are collected and transferred to new jars provided with artificial diet for larval feeding after egg hatchability.

3-The larval parasitoid; *B. hebetor*

The initial field collection of the wasp had been done from the olive groves at Matrouh Governorate (Mansour, 2012). Adult wasps are sexed and transferred to a clean Petri dish charged by small honey droplet for wasp nutrition and 1 full grown *G. mellonella* larvae for egg deposition. Each Petri dish had been tightly sealed with para-film. After egg deposition, each parasitoid couple had been transferred to a new Petri dish similar to that previously described for new egg deposition. Parasitoid eggs were left to hatch and their larvae feed on the host then pupation occurred in the near vicinity. Adults were collected as they emerge and transferred to new Petri dishes.

Experimental design:

Thirty seven *B. hebetor* females aged <1 day old had been individually separated in clean Petri dishes to act as replicates (i.e., 1 female/ 1 Petri dish). Each Petri dish had been supplied by newly emerged *Bracon* male for mating, small honey droplet for wasps' nourishment and one full grown *P. unionalis* larva as an egg deposition and larval feeding site. Each 24 hours, the parasitoid couple had been transferred to new Petri dish charged by new *P. unionalis* larva and small honey droplet. Such process had been repeated till the death of the parasitoid female. For each female, the daily number of its deposited eggs, the number of hatched larvae, the number of emerged progeny and their sex ratio had been recorded. In addition, fifty newly emerged *P. unionalis* females were daily observed for egg deposition till their death. Numbers of deposited eggs, hatched larvae, pupae and progeny emergence were recorded. Such obtained data had been formulated as an input data and entered in the 48 Basic computer program for

calculating the life table parameters (Birch, 1948 and Abo-Setta et al., 1986).

RESULTS AND DISCUSSION

Table (1) showed that *P. unionalis* moths have lived for 9.10±0.35 days. During their life time, 179.98±22.64 eggs were deposited. These data are coincided with Kumral et al. (2007) they recorded female longevity of the same insect to be 11.6, 9.9, 10.7 days when larvae reared on olive, ash and jasmine, respectively. They recorded average number of eggs oviposited by adults females as 390.3, 194.7, 321.8 eggs when reared on the same plant hosts, respectively. Data showed that survival rate of different immature averaged 0.68. Kumral et al. (2007) recorded survival percentage of immature stages reared on olive leaves as 73%. They added that immature mortality generally was high in larval stages and mortality was low among instars 3-6. After adult emergence, Data indicated that the sex ratio (female/total) was 0.55.

Average longevity of *B. hebetor* females was 21.8 ±1.97 days on the full grown larvae of *P. unionalis* (Table 1). In line with our data, Yu et al., (2003) recorded 20.88 ±0.97 days on *Plodia interpunctella* Hübner (Lepidoptera: Pyralidae). Results obtained in the present study showed high reproductive rate of *B. hebetor*. Where the average deposited eggs per female was 365.6 ±44.94. Hagstrum and Smittle (1977) stated that an average-size female that has encountered a host every day will have a lifetime fecundities of 250-350 eggs. Immature survival rate was 0.41 and the emerged progeny sex ratio was 0.46. Ghimire (2010) reported that a parasitoid survival to adult stage on *G. mellonella* was almost 50%. Many authors reported similar trends of the progeny sex ratio of the parasitoid. Reinert and King (1971) observed the sex ratio on *Plodia. interpunctella* to be around 52%. Noah and Dan (1973) and (Rotary and Gerling, 1973) found the sex ratio of *B. hebetor* at 25°C with *Ephestia kuehniella* Zeller (Lepidoptera: Pyralidae) as a host, to be 39 and 66%, respectively. Yu et al. (2003) stated that the overall progeny sex ratio was approximately 0.5. Parasitoid progeny sex ratios in other studies have been variable, ranging from a male bias to strongly female bias progeny (Ghimire and Phillips, 2010; Jamil et al., 2015; Alam et al., 2016).

Table 1. Biological parameters of olive leaf moth; *P. unionalis* and its larval parasitoid, *B. hebetor*.

Stages Insects	Female longevity (days)	Eggs/?	Larvae	Pupae	Progeny	Progeny sex ratio	Survival
<i>P. unionalis</i>	9.10 ±0.35	179.98 ±22.64	165.58 ±16.98	129.15 ±7.98	122.69 ±6.47	0.55	0.68
<i>B. hebetor</i>	21.8 ±1.97	365.6 ±44.94	204.29 ±25.11	161.28 ±19.83	150.53 ±18.51	0.46	0.41

Data illustrated in Table (2) gave clarified insights about the life table parameters that had been measured for the parasitoid and its field host. Upon shed

light on *P. unionalis*, Table (2) stated that its net reproductive rate (R_0) recorded about 68.54. As this parameter refers to the reproductive capability of the intended candidate (egg laying capacity), so the reproductive capacity of *P. unionalis* on olive plant is considered of moderate type. Where, through the field observations of the olive orchards under NWC conditions, it is easy to observe that the economic damage due to the olive leaf moth is of localized occurrence and mainly targeted olive seedlings and nurseries. In this field of study, Kumral *et al.* (2007) noticed that *P. unionalis* exhibited the highest R_0 value on olive comparing with both Ash and Jasmine. The second considered demographic parameter was the intrinsic rate of increase (r_m) that gave an impression about the mode of population increase (Birch 1948). The recorded r_m value for *P. unionalis* (about 0.13) indicated that the population increase of *P. unionalis* on olive leaves was of exponential mode ($r_m > 0$). Similar findings had been stated by Kumral *et al.* (2007) on *P. unionalis*, Greenberg *et al.* (2001) on *Spodoptera exigua* Hübner (Lepidoptera: Noctuidae) and Hansen *et al.* (2004) on *Sitotroga cerealella* Olivier (Lepidoptera: Gelechiidae).

The finite rate of increase (λ) behaved similar trend of r_m value. Where, the calculated value of Lambda (λ) (about 1.14 *i.e.*, $\lambda > 1$) referred to an increment in *P. unionalis* population. Accordingly, the last two parameters should be considered by the field monitors to schedule or track a precise monitoring system for the olive leaf moth population in order to be ready for any population outbreak. Where, the field monitoring of its population through the last two years under the Egyptian NWC olive orchard conditions and due to the warmer winter seasons during this period than the previous ones, the monitoring team succeeded to record *P. unionalis* caterpillars attacking olive tender leaves and seedlings till December month (unpublished data). The last measured demographic parameter was the mean generation time (T). According to the current findings, *P. unionalis* is able to build up one generation at about 32.1 days. Our results regarding T value was similar to that stated by Kumral *et al.* (2007) who calculated T values for *P. unionalis* as 35.3, 32.99 and 36.16 days on olive, ash and jasmine hosts, respectively. Khaghaninia and Pourabad (2009) estimated the mean developmental time from the egg to the adult of the same pest at 27°C to be 34.9 days.

Table 2. Demographic parameters of olive leaf moth; *P. unionalis* and its larval parasitoid, *B. hebetor*.

Parameters	<i>P. unionalis</i>	<i>B. hebetor</i>
Net Reproductive Rate (R_0)	68.5364	68.2824
Mean Generation Time (T)	32.0910	20.0147
Intrinsic Rate of Increase (r_m)	0.1317	0.1541
Finite Rate of Increase (λ)	1.1408	1.1666

The second part of Table (2) concerned with the demographic parameters of the larval parasitoid *B. hebetor* that had been reared on its field host, *P. unionalis*. The net reproductive rate (R_0) and the intrinsic rate of increase (r_m) of our intended parasitoid

were about 68.28 and 0.15, respectively. Through exploring such values on other pyralid hosts, Seung-Hun *et al.* (1999) stated that, both R_0 and r_m values of *B. hebetor* on *Plodia interpunctella* recorded about 136.2 and 0.29, respectively. Although the value of r_m in the present study is lower than others, Huffaker *et al.* (1977) stated that, the natural enemy should have an r_m high enough to offset that part of the pest's r_m that is not negated by parasitism. Moreover, the other two parameters as shown in Table (2) were the finite rate of *B. hebetor* population increase λ and the mean generation time (T). The calculated values for both parameters were about 1.17 and 20.01, respectively that referred to the effective role that could be played by the parasitoid to induce successful parasitization and turn down the population of olive leaf moth. One of the very supportive issues for that conclusion was the shorter mean generation time of *B. hebetor* than that of its host (*P. unionalis*) by about 10 days that gave the priority for the parasitoid for producing about one generation and half at the same time that required for its host to attain one generation. Eliopoulos and Stathas (2008) recorded the mean generation time for *B. hebetor* to be 20.14 and λ to be 1.13 when reared on *Plodia interpunctella*. This was graphically illustrated in Figs. 1 & 2.

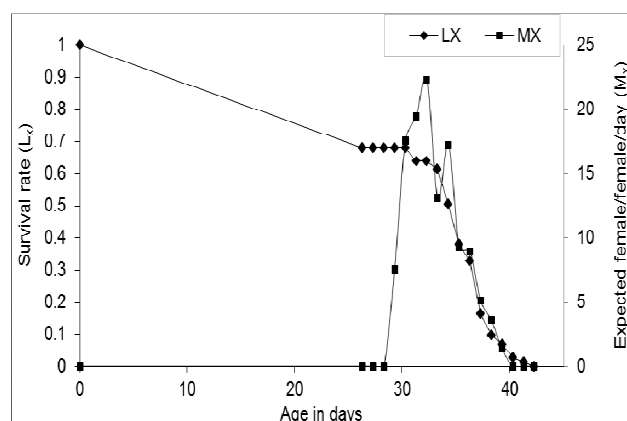


Fig 1. Expected female/female/day (M_x) and survival rate (L_x) of *P. unionalis*.

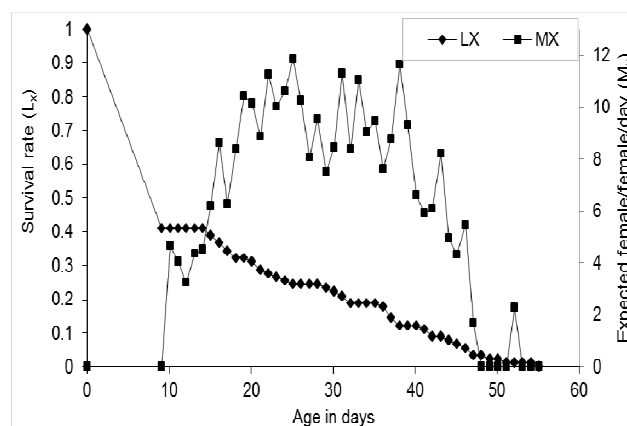


Fig 2. Expected female/female/day (M_x) and survival rate (L_x) of *B. hebetor*.

Expected female/female/day (M_x) and survival rate (L_x) for the parasitoid and its host are presented in Figs. 1 & 2. It is obvious that survival curve of the pest

followed type I of survival (where most of the population reaches maturity and death occur following oviposition). On the other hand, type III was followed in the case of parasitoid survival. Where, parasitoid survival as adults was the dominant.

In conclusion, the present study indicated that demographic parameters are useful for the assessment of *B. hebetor* suitability to combat the olive leaf moth. Therefore, an effort should be made for the application of field releases of the parasitoid in olive orchards because they not only live long but also produce more progeny that can play a significant role in olive groves.

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جداول الحياة لبراكون هيباتور ساي (غشائية الأجنحة: براكونيدي) و عائلته؛ دودة أوراق الزيتون الخضراء (حرشفية الأجنحة: الفراشات ذات الخرطوم)

أماني نبيه منصور^١ ، أحمد إبراهيم إمام^١ ، ولاء جميل إبراهيم^٢ ، عبدالرحمن جمال الدين عبدالرحمن^١ ، عصام عبدالمجيد عجمي^٣ و حسن فرج ضاحي^٢

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تم دراسة كفاءة كل من طفيل اليرقات الخارجي براكون هيباتور ساي (غشائية الأجنحة: براكونيدي) و عائلته؛ دودة أوراق الزيتون الخضراء (حرشفية الأجنحة: الفراشات ذات الخرطوم) على التكاثر تحت الظروف المعملية عند درجة حرارة ٢٧ درجة مئوية. تعد دودة أوراق الزيتون الخضراء من أخطر الآفات التي تصيب الزيتون بالإضافة إلى قدرتها على مهاجمة النباتات الأخرى التي تنتمي للعائلة الزيتونية. من خلال دراسة جداول الحياة لكل من الطفيل و عائلته، تم حساب المدلولات التالية؛ صافي معدل التزايد الحقيقي (R_0)، متوسط مدة الجيل الواحد (T)، المعدل الحقيقي لتزايد المجموع (r_m)، معدل الزيادة النهائية (λ). وقد مثلتها القيم التالية على التوالي؛ ٦٨.٢٨، ٢٠.٠١، ٠.١٥، ١.١٧ للطفيل و ٦٨.٥٤، ٣٢.٠٩، ٠.١٣ و ١.١٤ للعائل. و قد عاشت إناث الطفيل في المتوسط 21.8 ± 1.97 يوماً. وكان متوسط عدد البيض الذي وضعته تلك الإناث 365.6 ± 44.94 . بيضة لكل انثى و قد بلغ متوسط النسب المئوية لبقاء الأطوار الغير كاملة من الطفيل من البيض وصولاً إلى الأطوار الكاملة ٤١٪. كما بلغت النسبة الجنسية للجيل الأول (الإناث / المجموع الكلي) 0.46 . عاشت إناث دودة أوراق الزيتون الخضراء في المتوسط 9.10 ± 0.35 يوماً و قد وضعت خلال تلك الفترة 179.98 ± 22.64 بيضة في المتوسط. كان معدل البقاء على قيد الحياة للأطوار الغير كاملة 68٪. كما بلغت النسبة الجنسية للذرية الناتجة ٥٥. يمكن إستخدام نتائج هذه الدراسة لتحسين برامج التربية الكمية ودعم عمليات إطلاق الطفيل لمكافحة دودة أوراق الزيتون الخضراء في بساتين الزيتون.

الكلمات الافتتاحية: الزيتون ، براكون هيباتور ، دودة أوراق الزيتون الخضراء ، جداول الحياة ، مكافحة البيولوجية .