© by PSP Volume 25 – No. 12/2016, pages 5365-5370 Fresenius Environmental Bulletin

MATERNAL AGE EFFECTS OF *ASPIDIOTUS NERII* BOUCHÉ BOUCHE (HEMIPTERA: DIASPIDIDAE) ON POTATO

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ABSTRACT

Aspidiotus nerii Bouché (Hemiptera: Diaspididae) is an excellent host for rearing biological control agents for the control of scale insects. In this study, we investigated the maternal effect on the reproduction and development of *A. nerii* crawlers transferred to separate clean potato tubers at the 1st, 15th and 30th days. After the crawlers settled, each potato was divided into 4 cm^2 cells surface area surrounded by 'stickem special' to prevent their escape. When all crawlers in the cell became adults, one female and all the males were left in the cells, and the rest of the females were removed. Experiments were done at 25°C, 16:8 hours and 65% relative humidity in a climate chamber. Cells were observed daily and crawlers were removed after counting. Variance analysis and Tukey's multiple range tests were applied for statistical analysis. Life table parameters were also calculated. Intrinsic rate of increase (r_m), net reproductive rate (R_o), and mean generation time (T_o) were 0.073, 0.072 and 0.034 females/female/day, 83.42, 27.95 and 5.47 females/female, 60.56, 46.11 and 49.56 days, respectively. The total crawler numbers were the 1st, 15th and 30th days age females were 208.57, 81.32 and 20.07 crawlers, respectively. These results clearly show that age does have a significant effect on crawler of females *A. nerii*.

KEYWORDS:
Aspidiotus nerii, age dependent life table, maternal age effect, potato

INTRODUCTION

As it is well known that most of the characters of the offspring in all living organisms were determined by the parents. Morphological and biological differences of offspring are realized environmentally and genetically conditions which have effect on maternal effects [1,2,3,4,5,6]. In researches, it was determined that offspring from older mother has longer life spans, higher death rate and lower reproductive performance according to offspring from young mother [1,7,8,9,10,11,12,13]. This subject is also very important for natural enemies are used in biological control studies [14,15,16]. The declining parasitoid fecundity as an age of mother may be due to the decreasing related to age, number of eggs laid and parasitization ability of females [17,18]. Female age dependent fecundity of *A. nerii* one of the best prey for the production of biological control agents of scale insects [19], was investigated in this study.

MATERIALS AND METHODS

Biparantel *Aspidiotus nerii* population grown on potato tubers in the insectarium of Plant Protection Department, Süleyman Demirel University, was used in this study. The potato tubers, containing *A. nerii* individuals in the same age, were placed on the top of the new clean potatoes when *A. nerii* individuals started to give new generations and kept 24 hours for the new generations passing to the clean potatoes. In this way, the 1st day crawlers of *A. nerii* were obtained. Fifteen days later, same method was used to transfer new generations from the potato tubers to the clean potatoes. Consequently, the 15th day crawlers of same aged *A. nerii* were obtained. The thirtieth day, again clean new potatoes were contacted to the potato tubers containing same aged *A. nerii* and kept for 24 hours to obtain the 30th day crawlers. Eventually, three different populations were constituted from same aged *A. nerii* giving birth at the 1st day, 15th day, and 30th day.

After the crawlers settled, each potato was divided into 4 cm^2 cells surface area surrounded by 'stickem special' to prevent their escape. When all crawlers in the cell became adults, one female and all the males were left in the cell and the rest of the females were removed. All males were removed after all of them become adult and mate with breeding female. Thus only one female left in each cells. Daily observations were made for each cell and crawlers were removed after counting. Experiments were done at 25°C, 16:8 hours and 65% relative humidity in a climate chamber (model KB 8400 F, Termax). Variance analysis and Tukey's multiple range tests were applied for statistical analysis [20]. Analysis were done by using CurveExpert pro (ver.1.6.7), SPSS, (ver.20.3), MS Excel (2010) softwares. Life table parameters were also calculated by using RmStat-3.2 [21]. These parameters;

- Age-specific survivor rate (l_x) and fecundity rate (m_x), [22],
- Net reproductive rate, $R_0 = \quad l_x.m_x$ [22],
- Intrinsic rate of increase (r_m), $e^{(\quad r_m.x)}.l_x.m_x = 1$ [22],
- Mean generation time (day), $T_0 = \frac{\ln .R_0}{r_m}$ [22],
- Gross reproduction rate, $GRR = \quad m_x$ [22],
- Finite rate of increase, $\quad = e^{r_m}$ [22],
- Doubling time (day), $T_2 = \frac{\ln 2}{r_m}$ [23],
- Reproductive value, $V_x = \frac{\sum_{y=x} (e^{r_m \cdot y}.l_y.m_y)}{l_x.e^{-r_m.x}}$ [24],
- Life expectancy, $E_x = \frac{\sum_{y=x} \frac{l_y + l_{y+1}}{2}}{l_x}$ [25,26],
- Stable age distribution, $C_x = \frac{l_x.e^{-r_m.x}}{\sum_{x=0} (l_x.e^{-r_m.x})}$ [22],
- Age-dependent reproduction was calculated with the equation of Enkegaard [27,28].

$F_{(x)} = a.x.e^{(-b.x)}$ [27,28],

Where; F(x), daily age specific fecundity rate (egg/female/day); x, female adult age (day), a and b empirical constant. In the equation, first day is the female's first day as adult. The model was fitted to the data by nonlinear square technique; JMP (version 5.0.1), MS Excel 2010 and SPSS, (ver. 20.3) softwares.

RESULTS AND DISCUSSION

Effect of mother age on growth and reproduction of *Aspidiotus nerii* was determined and life table parameters were given in Table 1. Total development periods of crawlers in the 1st, 15th and 30th days age females were observed 47.00, 37.00 and 45.00 days, oviposition periods 29.93, 22.14 and 7.87 days, respectively ($P<0.05$). Preoviposition period, life span and total life time decreased depending on age of mother. Omkar and Mishra [29] determined as 0- and 10-day-old females of *Propylea dissecta* (Mulsant) (Coleoptera: Coccinellidae) preoviposition period were found statistically different. Priest et al., [30] reported that *Drosophila melanogaster* Meigen (Diptera: Drosophilidae) offspring from older mother shorter life than did offspring from young mother.

TABLE 1
Development and fecundity of in the 1st, 15th and 30 th days age females of *Aspidiotus nerii* (*)

	n	1st Age	n	15th Age	n	30th Age
Total development time	28	47.00±0.00	22	37.00±0.00	30	45.00±0.00
Preoviposition	28	1.00±0.00	22	0.73±0.12	30	0.00±0.00
Oviposition	28	29.93±0.73 a	22	22.14±1.71 b	30	7.87±0.98 c
Postoviposition	28	1.00±0.00	22	0.55±0.21	30	1.27±0.19
Generation time	28	49.00±0.00	22	38.73±0.12	30	46.00±0.00
Life span	28	31.93±0.70	22	23.41±1.76	30	8.70±0.74
Total life time	35	69.14±3.40	32	44.66±4.46	55	40.96±2.88
Daily number of crawlers	28	6.50±0.15	22	3.64±0.36	30	1.70±0.21
Total number of crawlers	28	208.57±7.84 a	22	81.32±8.19 b	30	20.07±2.45 c

*Means within a same row followed by the same letter do not differ significantly in Tukey test (P<0.05).

TABLE 2
Life table parameters of in the 1st, 15th and 30 th days age females of *Aspidiotus nerii* (*)

Life Table parameters	1stAge	15th Age	30th Age
Intrinsic rate of increase, r_{m^*}	0.073 a	0.072 a	0.034 b
Net reproduction rate, R_o	83.42	27.95	5.47
Mean generation time, T_o	60.56	46.11	49.56
Gross reproductive rate, *GRR*	110.39	51.28	12.84
Doubling time, T_2	9.48	9.59	20.21
Finite rate of increase, λ	1.08	1.07	1.03
n	35	32	55

*Means within a same row followed by the same letter do not differ significantly in Tukey test ($P<0.05$).

It was recorded that generation times were 49.00, 38.73 and 46.00 days, crawlers number laid daily were 6.50, 3.64 and 1.70 crawlers and total crawlers number were 208.57, 81.32 and 20.07 crawlers, respectively. Yuztas et al., [13] determined in a study investigated the survival rate of bean aphid, *Aphis fabae* (Hemiptera: Aphididae) four different populations generated at the 1st, 6th, 11th and 16th days old mother, the highest nymph number was recorded 19.59 nymph in 6 day-old-mother, while in other groups as 7.25-14.14 nymph. Gunduz and Gulel [11] found that the mean numbers of total progeny per female *Bracon hebetor* (Hymenoptera: Braconidae) changed with the females age, between 1 day old and 5 day old females were not statistically significant; however, in the 10 day old females offspring production significantly decreased.

According to the life table, intrinsic rate of increase (r_m) of in the 1st and 15th day age females were statistically in the same group while in the 30th day age females were in the different group ($P<0.05$). The mean generation time (T_0), calculated from the time during which crawlers were constituted 24.50% (60.56 days), 26.55% (46.11 days) and 27.07% (49.56 days), respectively. At the end of the oviposition period, in the 1st, 15th and 30th day age females, gross reproductive rate (*GRR*) were 110.39, 51.28 and 12.84 females/female, net reproductive rate (R_0) were 83.42, 27.95 and 5.47 females/female, respectively (Table 2).

Nymphal mortalities were 0.20, 0.28 and 0.27 in the 1st, 15th and 30th day age females, respectively. Yüztaş et al., [13] identified that death rate increased depend on age of mother in survival rate of bean aphid, *A. fabae* four different populations generated by 1, 6, 11 and 16 days old mother. Fox et al., [9] reported that offspring from older parents often had shorter adult lifespan than offspring of younger parents in the seed beetle, *Callosobruchus maculatus* (Coleoptera:Chrysomelidae).

At the beginning of oviposition period, the reproductive rate (m_x) in the 1st, 15th and 30th days age females increased and at the 11th days (5.29 crawlers), at the 9th days (2.86 crawlers) and at the 2th days (1.30 crawlers) with reached maximum value, respectively. The oviposition period ended at the 36th, 37 th day and 18th day in the 1st ,15th and 30th days age females, respectively (Figure 1).

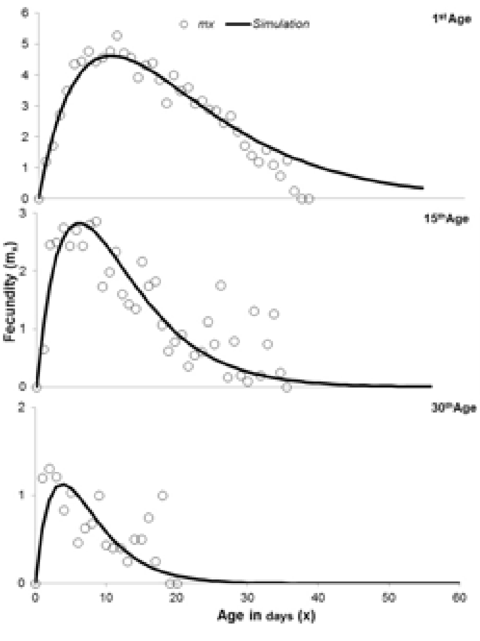

FIGURE 1
Effect of female age on fecundity (m_x) of *A. nerii* in the 1st day age females (Parameters: *a*=1.391±0.058, *b*=0.106±0.002, R^2=0.934), in the 15th day age females (*a*=0.192±0.128, *b*=0.155±0.009, R^2=0.712) and in the 30th day age females (*a*=0.798±0.186, *b*=0.261±0.035, R^2=0.313).

The numbers of crawlers increased on the first days of the oviposition period and decreased regularly. Crawlers of young patterns were reflected in an increase in the daily number of crawlers laid per female. Another important indicator was to high numbers of crawlers produced by their first days of young females. Also oviposition period of females of young parents took longer than occurs in the elderly parents. This relation was determined with the Enkegaard equation and calculated parameters. Parameters were attained; in the 1st day age females a=1.391±0.058, b=0.106±0.002, R^2=0.934, in the 15th day age females a=0.192±0.128, b=0.155±0.009, R^2=0.712 and in the 30th day age females a=0.798±0.186, b=0.261±0.035, R^2=0.313.

Female longevity was shorter in the 30th day age individuals. Daily fecundity was affected by maternal age. The fecundity was the highest for *A. nerii* reared from 1st day age females. They reproduce at the same time but decrease in daily fecundity as maternal age increases was observed. Similarly, reproductive value (*Vx*) reached the highest level in the 1st day age females at 52th day, in the 15th day age females at 39th day and in the 30th day age females at 46th day, respectively. This value decreased quickly in following days with increasing death rate (Figure 2).

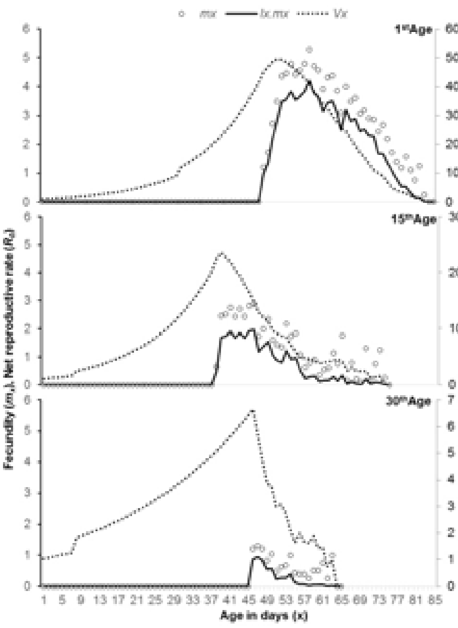

FIGURE 2
Fecundity (m_x), Net reproductive rate (R_0) and Reproductive value (*Vx*) of in the 1st, 15th and 30 th days age females of *Aspidiotus nerii*.

Life expectancy (*Ex*) in the beginning of nymph stage in the 1st, 15th and 30th days age females were calculated as 68.64, 44.16 and 40.46 days, but survival days 85, 75 and 64 days, respectively. Stable age distribution (C_x) reached to 0.1 value in the 1st day age females at 63th day, in the 15th and in the 30th day age females at 43th day. It was reached to value of 1 depend on survival rate (*lx*) at the 85th, 75th and 64th days respectively (Figure 3).

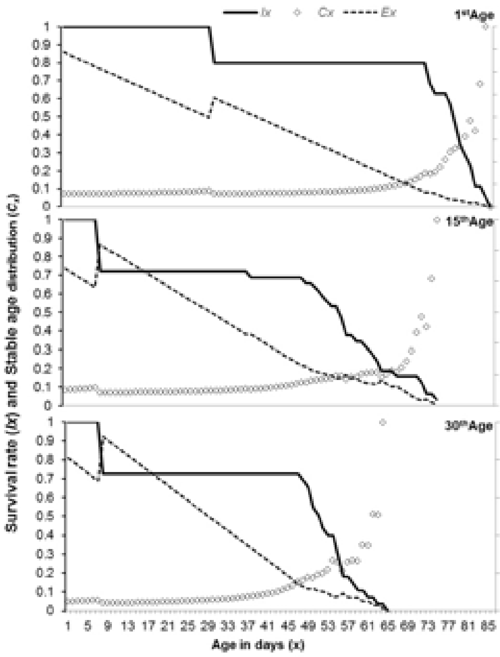

FIGURE 3
Survival rate (l_x), Stable age distribution (*Cx*) and Life expectancy (*Ex*) of in the 1st, 15th and 30 th days age females of *Aspidiotus nerii*.

CONCLUSIONS

The use of biological control agents has been increasing worldwide for the control of insect pests. However, quality control is required for the production and use of these natural enemies. In our study, we showed importance of using crawler of young females to produce the organisms used in biological control agents. These results clearly show that age of mother has a significant effect on the bioecology of crawlers. Reproduction was found to be dependent on adult age and decreased with maternal age.

ACKNOWLEDGEMENTS

This study was presented as a poster presentation on the IV. Plant Protection Congress, which was held on 28-30 June 2011 in Kahramanmaraş, Turkey.

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Received: **16.02.2016**
Accepted: **18.09.2016**

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