

Demographic Comparison of *Henosepilachna vigintioctopunctata* (F.) (Coleoptera: Coccinellidae) Reared on Three Cultivars of *Solanum melongena* L. and a Wild Hostplant *Solanum nigrum* L.

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Abstract

Henosepilachna vigintioctopunctata (F.) is a widespread pest found on many solanaceous vegetables. The development and fecundity of *H. vigintioctopunctata* were studied on three cultivars ('Zihong', 'Eyou', and 'Baijiao') of eggplant, *Solanum melongena* L., using the two-sex life table theory. These results were then compared with similar parameters from a wild alternate host, *Solanum nigrum*. Our results showed that there were no significant differences between the developmental times of the larval stages, pupae, oviposition period, adult longevity, and the fecundity of *H. vigintioctopunctata* reared on the three eggplant cultivars. The survival rates of *H. vigintioctopunctata* larvae reared on the three eggplant cultivars were higher than that on *S. nigrum*. The fecundity of *H. vigintioctopunctata* adults reared on *S. nigrum* (724.12 eggs), however, was significantly higher than on each of the three eggplant cultivars. The values for the intrinsic rate of increase (r), finite rate of increase (λ), and net reproductive rate (R_0) for *H. vigintioctopunctata* when reared on *S. nigrum* were 0.1225 d⁻¹, 1.1303 d⁻¹, and 299.6 offspring, respectively. Each of these was significantly higher than comparable values when reared on the cultivar Eyou and Baijiao but were not different from those reared on the Zihong. Our results indicated that *H. vigintioctopunctata* is well adapted to all tested host plant cultivars and that *S. nigrum* is an important alternate wild hostplant that may potentially contribute to future outbreaks of *H. vigintioctopunctata* if not taken into consideration when planning an integrated control strategy against the pest.

Key words: two-sex life table, population projection, fecundity, eggplant, black nightshade

Henosepilachna vigintioctopunctata (F.) (Coleoptera: Coccinellidae), commonly called 28-spotted potato lady beetle in China, is an important economical pest (Ghosh and Senapati 2001) feeding on solanaceous crops, such as tomato, potato, and eggplant, in China (Zhou et al. 2015), Japan (Nakamura 1976, Shinogi et al. 2005), and India (Venkatesha 2006). The larvae and adults feed on the leaves by scraping the leaf cuticle, reducing the leaf surface by skeletonizing the surface area, resulting in russet browning of the leaves. The feeding effects cause significant losses in crop growth, decrease in fruit production, and, eventually, sizable income loss to the growers (Sharma et al. 2012, Kawazu 2014).

The continuous presence of potential crop and weed host plant species within the migration range of an oligophagous pest is a major contributing factor in the dispersal as well as outbreaks of the

pest species and suggests that weed control be considered as a factor in successful management of the pest (Lu and Xu 1997, Liu et al. 2004). Eggplant, *Solanum melongena* L., is an important vegetable crop commonly grown in many regions of the Jiangnan Plain, in central China. The black nightshade, *Solanum nigrum* L., a wild host of *H. vigintioctopunctata*, is often found in many nearby wooded areas, as well as fallow fields near areas where eggplants are grown. Huang (2005) reported the outbreak of *H. vigintioctopunctata* on *S. nigrum* in Taiwan and determined *S. nigrum* was an important wild host for *H. vigintioctopunctata*. Zhou et al. (2015) found that population densities of *H. vigintioctopunctata* were higher on *S. nigrum* and eggplants than they were on potatoes and tomatoes. It is possible that weed management, particularly of black nightshade, is an important factor in suppressing *H. vigintioctopunctata*

populations. The contribution of this weed species to outbreaks of this pest needs to be determined and incorporated into planning of an integrated pest management program.

'Zihong', 'Eyou', and 'Baijiao' are the three major eggplant cultivars grown throughout the Jiangnan Plain. To date, only a few studies have been conducted on the development and reproduction of *H. vigintioctopunctata* on different eggplant cultivars (Gui et al. 1995, Wang 2001, Wang et al. 2015). Assessing and selecting eggplant cultivars resistant to *H. vigintioctopunctata* will allow growers to reduce their dependence on pesticides. Life table studies are an effective and comprehensive tool that can be used to summarize the survival and reproductive potential of a population on different host plants (Farhadi et al. 2011). By compiling and analyzing life tables from different hosts, the growth potential of *H. vigintioctopunctata* on various eggplant cultivars can be accurately evaluated, while simultaneously comparing the resistance of the eggplant cultivars to the beetle.

In order to evaluate the effect of eggplant cultivars on the development and reproduction of *H. vigintioctopunctata* and to determine the role of the alternative wild host, *S. nigrum*, in outbreaks of *H. vigintioctopunctata*, we collected the data on the development, survival, and fecundity of *H. vigintioctopunctata* reared on the above three eggplant cultivars and on the wild hostplant, *S. nigrum*. We then analyzed and compared the results using the age-stage, two-sex life table, and predicted the growth of *H. vigintioctopunctata* using population projections for three eggplant cultivars and *S. nigrum*.

Materials and Methods

Plants

The three eggplant cultivars that were used in the experiments, Zihong, Eyou, and Baijiao, were planted in the Yangtze University Botanical Garden from April 2015 to November 2015. Field-collected specimens of the alternative wild host, *S. nigrum*, was transplanted to the botanical garden and grown in an appropriate shaded environment. Host plants were planted in plastic pots (20 cm in diameter and 16 in height, filled with sandy loam) with no pesticides being used during the experiments.

Life table study

H. vigintioctopunctata adults were collected from potato plants in Jingzhou city and were fed with the three eggplant cultivars and *S. nigrum* in the laboratory (25 ± 1°C, 75% ± 10% RH, 12:12 [L:D] h) for a full generation prior to being used in the study. In the life table study, eggs obtained from 10 pairs of adults within a 24-h period were randomly selected and placed in an environmental chamber (GZX-400BS-III, Shanghai Xin-Miao Medical Equipment Manufacturing Co., Ltd, China) set at 25 ± 1°C, 75% ± 10% RH, and a photoperiod of 16:8 (L:D) h. A total of 60, 59, 58, and 58 eggs were used for the Zihong, Eyou, Baijiao, and *S. nigrum* studies, respectively. Newly hatched larvae were individually transferred to a plastic dish (9-cm diameter, 1.8-cm deep) containing a filter paper disc and a moistened cotton ball to maintain humidity. Fresh leaves of each host plant were provided daily and the filter paper replaced every 3 d. The newly emerged adults were paired and provided with fresh leaves daily.

Developmental data for each stage, survival data, and female fecundity were recorded daily until the death of all test individuals. The raw life table data for *H. vigintioctopunctata* were analyzed using the age-stage, two-sex life table procedure developed by Chi and Liu (1985) and Chi (1988). The life history parameters, including the age-stage survival rate (s_{xy} , where x = age, y = stage), the age-specific survival rate (l_x), age-specific fecundity (m_x), and the

population parameters (R_0 , net reproductive; r , intrinsic rate of increase; λ , finite rate of increase; T , mean generation time) were calculated using the computer program, TWSEX-MSChart (Chi 2016b) (available at: <http://140.120.197.173/Ecology/Download/TWSEX-MSChart.rar>). The bootstrap technique (Efron and Tibshirani 1993, Huang and Chi 2012) with 100,000 resampling was used to calculate the variances and standard errors of the population parameters and life history parameters, including developmental time, adult longevity, adult preoviposition period (APOP), total preoviposition period (TPOP), and fecundity. The age-specific survival rate (l_x), which is the probability that a newly laid egg will survive to age x , was calculated as

$$l_x = \sum_{j=1}^k s_{xj} \quad (1)$$

where k is the number of stages. The age-specific fecundity of the population (m_x) was calculated as

$$m_x = \frac{\sum_{j=1}^k s_{xj} f_{xj}}{\sum_{j=1}^k s_{xj}} \quad (2)$$

The net reproductive rate (R_0), which represents the mean number of offspring that an individual can produce during its lifetime and is the cumulative summation of $l_x m_x$ from birth to death, was calculated as

$$R_0 = \sum_{x=0}^{\infty} l_x m_x \quad (3)$$

The intrinsic rate of increase was calculated by using the iterative bisection method from the Euler-Lotka formula (Goodman 1982) with age indexed from 0:

$$\sum_{x=0}^{\infty} e^{-r(x+1)} l_x m_x = 1 \quad (4)$$

The finite rate of increase (λ) was calculated as $\lambda = e^r$. The mean generation time (T), which is defined as the length of time that a population needs to increase to R_0 -fold of its size (i.e., $e^r = R_0$ or $\lambda^T = R_0$) at the stable age-stage distribution, was calculated as

$$T = \frac{\ln R_0}{r} \quad (5)$$

Life expectancy is a statistical measure of the average time that a member of a population is expected to live (Shryock et al. 1973). Based on the age-stage, two-sex life table theory, individuals of the same age may have different life expectancies; hence, the age-stage-specific life expectancy (e_{xy}) is defined as the length of time that an individual of age x and stage y is expected to live to and was calculated by assuming that $s'_{xy} = 1$, through the Chi and Su (2006) equation:

$$e_{xy} = \sum_{i=x}^{\infty} \sum_{j=y}^k s'_{ij} \quad (6)$$

Fisher (1930) first defined the reproductive value as a concept in demography and population genetics that represents the contribution of an individual of age x and stage j to the future population. In the age-stage, two-sex life table, the reproductive value (v_{xy}) describes

the contribution of an individual of age x and j to the future population and was calculated according to Tuan et al. (2014) and Huang and Chi (2011) as

$$v_{xj} = \frac{e^{r(x+1)}}{s_{xj}} \sum_{i=x}^{\infty} e^{-r(i+1)} \sum_{y=j}^k s'_{iy} f_{iy} \quad (7)$$

Population projection

Based on data from the age-stage, two-sex life table, we projected the population growth of *H. vigintioctopunctata* to simulate the population size and stage structure by assuming an unlimited growth from an initial population of 10 eggs (Chi 1990). The computer program TIMING-MSChart (Chi 2016a) was used in the projections.

Results

All *H. vigintioctopunctata* eggs hatched on the fourth day. The mean developmental times for each of the larval stages, the total larval period, as well as the preadult survival rates (%) of *H. vigintioctopunctata* reared on the three eggplant cultivars, plus *S. nigrum*, are shown in Table 1. The larval and pupal developmental times were not significantly different between the three eggplant cultivars. Although the duration of the total larval developmental stages of *H. vigintioctopunctata* reared on *S. nigrum* was significantly shorter than that on the three eggplant cultivars, significant differences were

not found in the length of the preadult period on the different host plants. The highest preadult survival rate, 89.8% on Eyou, was significantly higher than that on Zihong (75%) and *S. nigrum* (72.5%) but was not significantly different than on Baijiao (81%).

Although values for the APOP, TPOP, oviposition period, female fecundity (number of eggs), and male and female longevities were not significantly different between the three eggplant cultivars (Table 2), the TPOP value for individuals reared on *S. nigrum* (30.26 d) was significantly less than that on any of the three eggplant cultivars. No significant differences were found in the male and female longevities between those reared on the eggplant cultivars and on *S. nigrum*. The oviposition period (the length of time from the first to last oviposition day), the total oviposition days (the number of days an insect actively laid eggs), and the mean fecundity values for *H. vigintioctopunctata* reared on *S. nigrum* were 79.53 d, 30.26 d, and 724.12 eggs per female, respectively, all of which were significantly longer/higher than the corresponding values for those reared on the three eggplant cultivars.

The overlaps seen in the age-stage-specific survival rate curves (s_{xj}) (Fig. 1) clearly show the variable developmental rate that is found among individuals. The highest s_{xj} values for the adult (female + male) curve were 75, 85.8, 79.3, and 70.7% for Zihong, Eyou, Baijiao, and *S. nigrum*, respectively. The proportions of female:male: *N*-type (those dying in the preadult stage) were 26:19:15, 26:27:6, 17: 30:11, and 24:18:16, for Zihong, Eyou, Baijiao, and *S. nigrum*, respectively. The female-to-male sex ratios were then 1:0.73, 1:1.04, 1:1.77, and

Table 1. Mean (\pm SE) of developmental time (d) and survival rate (%) of *H. vigintioctopunctata* reared on three eggplant varieties and *S. nigrum*

Stage	Host plant			
	Zihong	Eyou	Baijiao	<i>S. nigrum</i>
L1 (d)	3.71 \pm 0.07a	3.68 \pm 0.06a	3.83 \pm 0.05a	3.71 \pm 0.06a
L2 (d)	3.04 \pm 0.10a	2.91 \pm 0.07a	2.90 \pm 0.09a	2.41 \pm 0.08b
L3 (d)	3.28 \pm 0.09a	3.17 \pm 0.08ab	3.23 \pm 0.06a	2.89 \pm 0.09b
L4 (d)	5.26 \pm 0.08a	5.32 \pm 0.10a	5.26 \pm 0.07a	5.21 \pm 0.06a
Pupa (d)	3.98 \pm 0.04a	4.11 \pm 0.04a	4.06 \pm 0.04a	4.05 \pm 0.07a
Total larval stage (d)	15.30 \pm 0.14a	15.06 \pm 0.12a	15.19 \pm 0.10a	14.14 \pm 0.17b
Preadult (d)	23.27 \pm 0.14a	23.17 \pm 0.13a	23.26 \pm 0.11a	22.19 \pm 0.19a
Preadult survival rate (%)	75.0 \pm 5.6b	89.8 \pm 3.9a	81.0 \pm 5.1ab	72.5 \pm 5.9b

The standard errors were calculated using the bootstrap procedure with 100,000 resampling. The means followed by different letters in the same row are significantly different between cultivars using the paired bootstrap test at 5% significance level.

L1 (the first instar); L2 (the second instar); L3 (the third instar), and L4 (the fourth instar).

Table 2. Means \pm SE of the APOP (the time interval from female adult emergence to its first oviposition day), TPOP (the time interval from the birth of a female individual to the first oviposition day), fecundity, and female and male longevity of *H. vigintioctopunctata* adult reared on three eggplant varieties and *S. nigrum*

Stages	Host plant			
	Zihong	Eyou	Baijiao	<i>S. nigrum</i>
APOP (d)	10.67 \pm 0.96a	15.13 \pm 2.57a	13.50 \pm 3.07ab	8.27 \pm 0.51b
TPOP (d)	33.88 \pm 1.04a	38.50 \pm 2.56a	37.06 \pm 3.15a	30.26 \pm 0.67b
Oviposition period (d)	48.33 \pm 5.06a	44.13 \pm 5.04a	49.00 \pm 7.38a	79.53 \pm 8.07b
Oviposition days (d)	12.78 \pm 1.25b	8.75 \pm 1.22c	11.37 \pm 1.80bc	37.67 \pm 4.32a
Female adult (d)	86.50 \pm 5.82a	85.77 \pm 4.20a	82.71 \pm 8.42a	59.92 \pm 10.08a
Male adult (d)	86.37 \pm 5.15a	78.81 \pm 5.12a	81.732 \pm 5.84a	67.72 \pm 11.61a
Fecundity (eggs)	252.91 \pm 29.61b	143.78 \pm 23.09c	211.59 \pm 39.55bc	724.12 \pm 151.97a

The standard errors were calculated using the bootstrap procedure with 100,000 resampling. The means followed by different letters in the same row are significantly different between cultivars using the paired bootstrap test at 5% significance level.

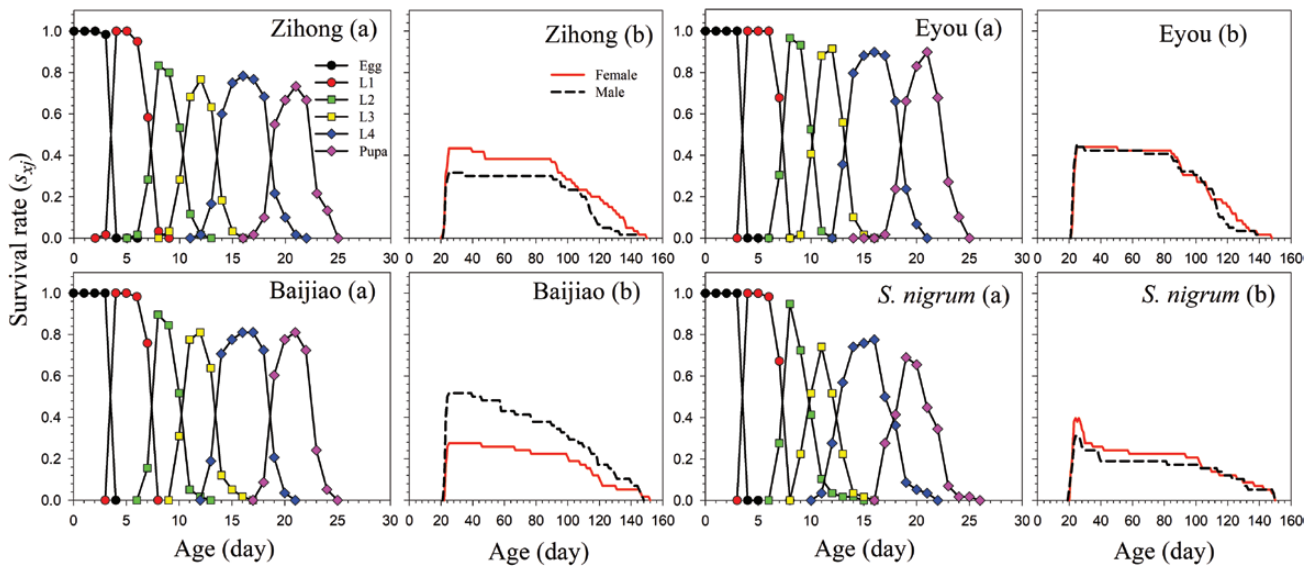


Fig. 1. Age-stage-specific survival rate (s_{xy}) of *H. vigintioctopunctata* reared on three eggplant cultivars and *S. nigrum*: (a) preadult stages and (b) adult stages.

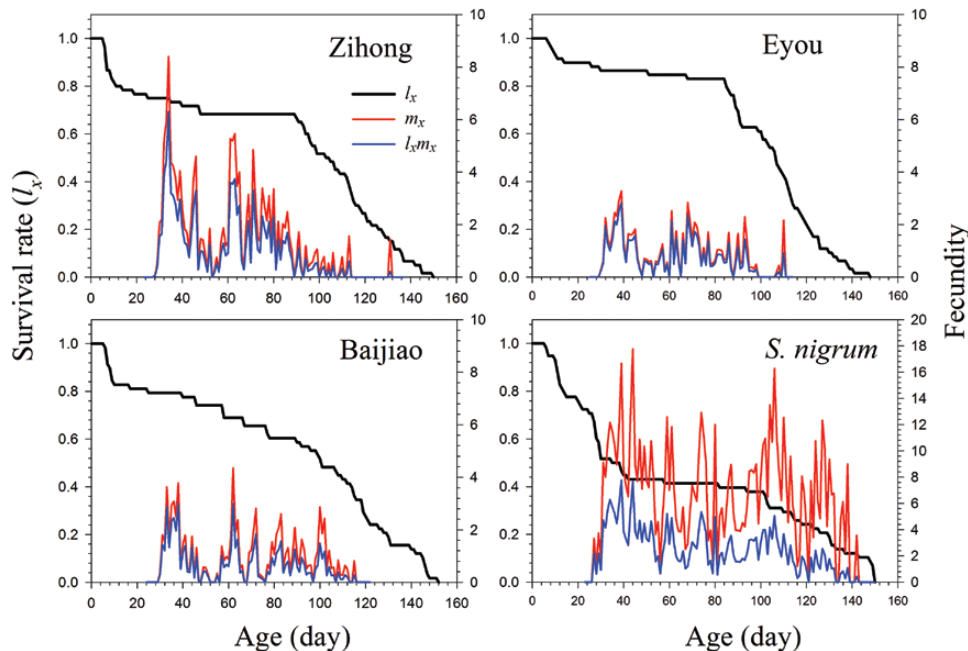


Fig. 2. Age-specific survival rate (l_x), age-specific fecundity (m_x), and age-specific maternity ($l_x m_x$) of *H. vigintioctopunctata* reared on three eggplant cultivars and *S. nigrum*. Because the fecundity on *S. nigrum* was much higher than on the eggplant cultivars, we used different scale ranges for the fecundity axis of *S. nigrum*.

1:0.75 for Zihong, Eyou, Baijiao, and *S. nigrum*, respectively. These curves not only revealed the difference in the male/female survival rates but also the stage differentiation and overlap that occurred between stages are also evident.

According to equation 1, the curve of l_x (Fig. 2) shows the simplified version of the s_{xy} as well as the survival rate of the total population at different ages. The survival rate of *H. vigintioctopunctata* did not significantly change from 30 to 90 d when reared on Zihong and Eyou but dramatically declined after 90 d. In contrast, the survival rate on Baijiao slowly declined throughout the developmental duration. A significantly lower survival rate was observed for *H. vigintioctopunctata* after 20 d of age when reared on *S. nigrum*. The m_x and

$l_x m_x$ curves showed many peaks, with significantly more peaks found on *S. nigrum* than on any of the eggplant cultivars. The occurrence of additional peaks on the m_x curve on *S. nigrum* is consistent with the increase in the number of oviposition days (37.67 d) on *S. nigrum*. The $l_x m_x$ curve on *S. nigrum* was significantly higher than those on the three eggplant cultivars. Because the fecundity on *S. nigrum* was considerably higher than it was on the eggplant cultivars, we used different scale ranges for the fecundity axis of *S. nigrum* (Fig. 2).

The life expectancy at age zero (e_{01}) is the mean longevity of the population. The e_{01} values on Zihong, Eyou, Baijiao, and *S. nigrum* were 84.8, 95.7, 87.0, and 65.4 d, respectively (Fig. 3). The reproductive values (v_{xy}) at age zero were 1.1101, 1.0896, 1.0907, and 1.1303

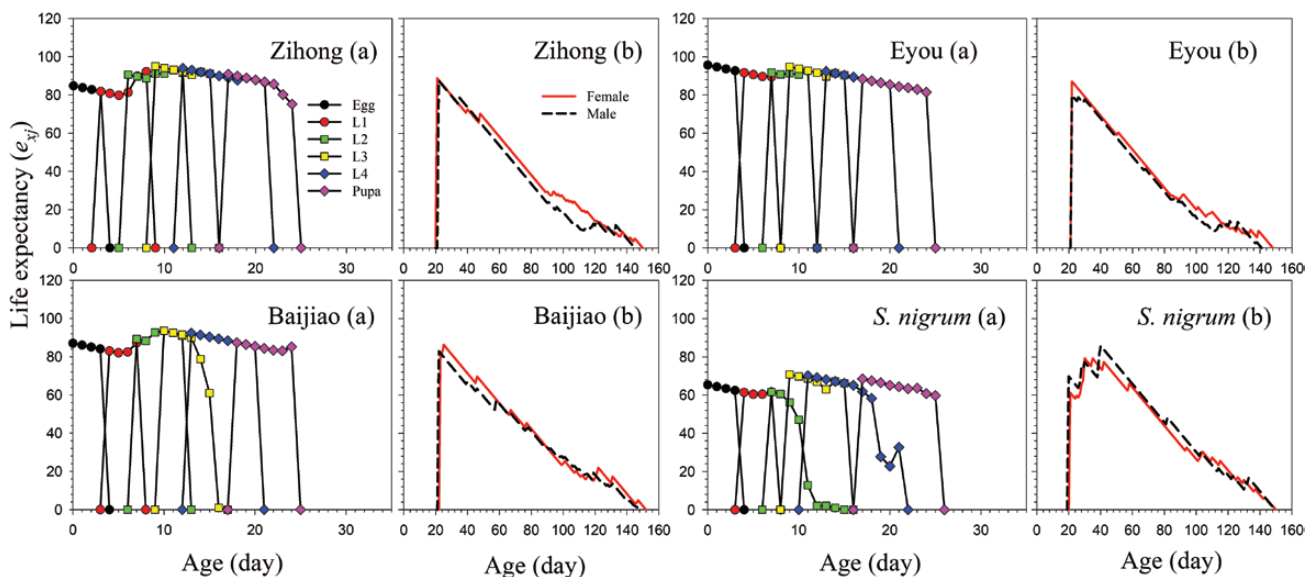


Fig. 3. Age-stage-specific life expectancy (e_{xj}) of *H. vigintioctopunctata* reared on three eggplant cultivars and *S. nigrum*: (a) preadult stages and (b) adult stages.

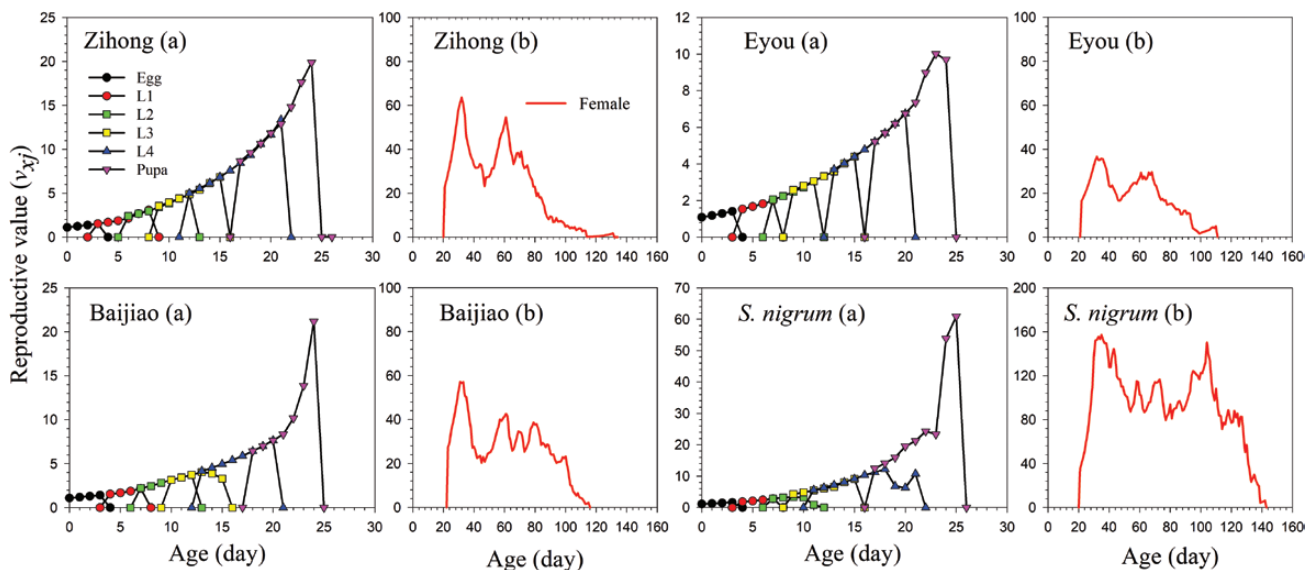


Fig. 4. Age-stage-specific reproductive value (v_{xj}) of *H. vigintioctopunctata* reared on three eggplant cultivars and *S. nigrum*: (a) preadult stages and (b) female adult.

d^{-1} (Fig. 4) on Zihong, Eyou, Baijiao, and *S. nigrum*, respectively, which were also the finite rate of increase on each of the respective host plants. The v_{xj} value of *H. vigintioctopunctata* adults fed on the four plants reached their initial peaks on the 32nd day ($v_{xj} = 63.56$), 32nd d ($v_{xj} = 36.61$), 31st day ($v_{xj} = 57.11$), and 35th day ($v_{xj} = 157.22$) on Zihong, Eyou, Baijiao, and *S. nigrum*, respectively. When reared on *S. nigrum*, the reproductive value at age 32 d ($v_{xj} = 152.57$) was significantly higher than on any of the eggplant cultivars.

The population parameters, i.e., the intrinsic rate of increase (r), net reproductive rate (R_0), finite rate of increase (λ), and mean generation time (T), are listed in Table 3. The net reproductive rate (R_0) on the three eggplant cultivars (Zihong 109.62; Eyou 63.36; Baijiao 62.02 per offspring) were not significantly different ($P < 0.05$) but were significantly lower ($P < 0.05$) than the value observed for the cohort reared on *S. nigrum* (299.64 per offspring). The intrinsic rate

of increase (r) and finite rate of increase (λ) values for the cohort reared on *S. nigrum* (0.1225 and 1.1303 d^{-1} , respectively) were significantly higher ($P < 0.05$) than for those cohorts reared on Eyou (0.0858, 1.0896/d, respectively) and Baijiao (0.0868, 1.0907 d^{-1} , respectively). There were no significant differences in the r and λ values between *S. nigrum* and the Zihong variety ($P < 0.05$). There were no significant differences in the mean generation times between host plant cultivars ($P < 0.05$).

The population projections of *H. vigintioctopunctata* on the three eggplant cultivars and *S. nigrum* are shown in Fig. 5. It was assumed that the population would undergo five generations on the three eggplant cultivars and *S. nigrum* within a 160-d period. The growth rate of the *H. vigintioctopunctata* population on *S. nigrum* was significantly faster ($P < 0.05$) than it was on the three eggplant cultivars, with the predicted total population size reaching

Table 3. Mean (\pm SE) of population parameters (r , intrinsic rate of increase; λ , finite rate; R_0 , net reproductive rate; and T , mean generation time) of *H. vigintioctopunctata* fed on three eggplant varieties and *S. nigrum*

Variety	Population parameters			
	r (d^{-1})	λ (d^{-1})	R_0 (offspring/individual)	T (d)
Zihong	0.1043 \pm 0.0059ab	1.1101 \pm 0.0065ab	109.62 \pm 20.47b	44.89 \pm 1.52a
Eyou	0.0858 \pm 0.0057c	1.0896 \pm 0.0062c	63.36 \pm 13.66b	48.34 \pm 2.24a
Baijiao	0.0868 \pm 0.0094bc	1.0907 \pm 0.0102bc	62.02 \pm 16.96b	47.54 \pm 3.38a
<i>S. nigrum</i>	0.1225 \pm 0.0075a	1.1303 \pm 0.0084 a	299.6 \pm 77.6a	46.56 \pm 1.14a

Means in the same column followed by different letters are significantly different by using the paired bootstrap test ($B = 100,000$) at 5% significance level.

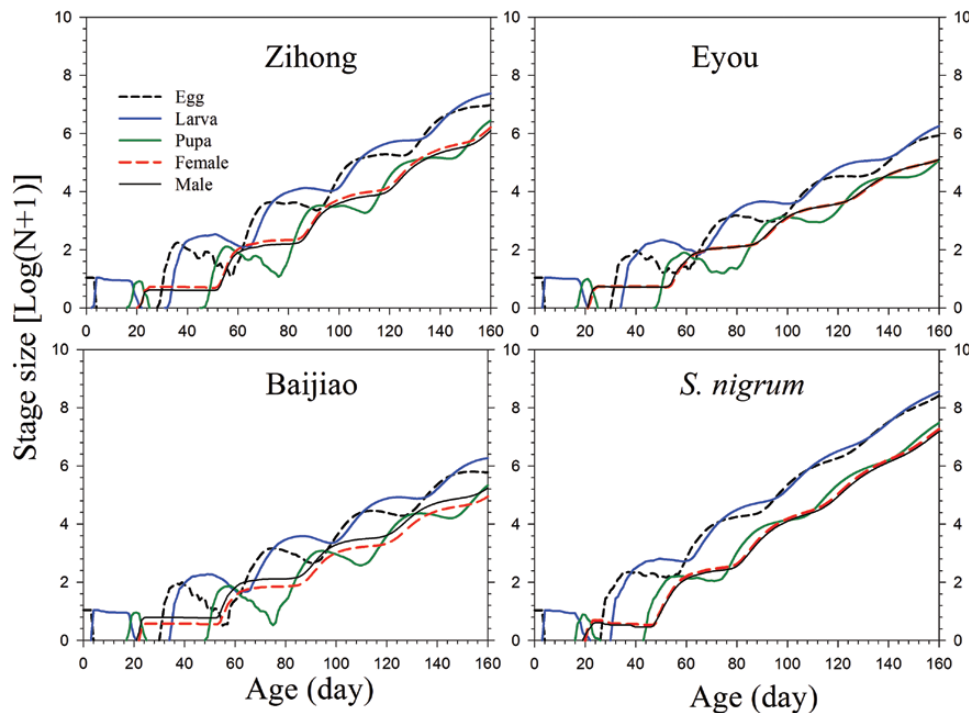


Fig. 5. Population projection of *H. vigintioctopunctata* on three eggplant cultivars and *S. nigrum*. Population projection started with 60 eggs of *H. vigintioctopunctata*. Because the population size of female and male adults are very close on Eyou and *S. nigrum*, their curves overlap.

6.52×10^8 , but only 3.95×10^7 , 3.04×10^6 , and 2.92×10^6 on the Zihong, Eyou, and Baijiao cultivars, respectively.

Discussion

Life tables, which are one of the basic research tools used in population ecology studies, are often used to summarize the survival, development, and reproductive capabilities of a population cohort under different ecological conditions. They are increasingly popular tools for evaluating differences in plant resistance in different cultivars, as well as for making pest population forecasts (Morris and Miller 1954, Ying et al. 2012). Tuan et al. (2014) assessed the effect of green manure cover crops on a *Spodoptera litura* (F.) (Lepidoptera: Noctuidae) population using the two-sex life table technique and concluded that the use of green manures as sources of nutrients should be significantly reassessed. Reddy and Chi (2015) compared life table parameters of the sweetpotato weevil, *Cylas formicarius* (F.) (Coleoptera: Brentidae), reared on its major host, *Ipomoea batatas* (L.), with weevils reared on an alternative host, *I. triloba* (L.), and demonstrated the role of an alternative host in formulating an integrated control strategy for *C. formicarius*. In this study,

age-stage, two-sex life table data were collected for *H. vigintioctopunctata* cohorts reared on three eggplant cultivars (Zihong, Eyou, and Baijiao) and an alternative wild host, *S. nigrum*, to evaluate the relative fitness of *H. vigintioctopunctata* on the four different hosts.

The age-stage survival rate (s_{xj}) takes into account the overlapping of stages and variations in the developmental rate (Fig. 1). This technique allowed us to observe that the second instar and third instar were present at the same time on the 10th day. In addition, the sex ratio and survival rate of the female and male adults could also be clearly observed. Some of the values in Fig. 1 seem inconsistent with the preadult survival rates of 89.8 (Eyou), 81.0 (Baijiao), and 72.5 (*S. nigrum*) (Table 1). This is due to the variable developmental rate and longevity. Some adults emerged earlier but died before other adults emerged, resulting in this apparent inconsistency. Similar phenomena have been observed in other studies, e.g., Polat-Akköprü et al. (2015).

The age-specific fecundity (m_x) can potentially reveal periodic reproductive peaks of a population. However, due to the variable TPOP and high variable time gap between the two egg productions, the periodicity was not very evident, instead noisy fluctuation was observed. Although *H. vigintioctopunctata* individuals are able to survive longer than 150 d on the three eggplant cultivars (Fig. 1), the m_x

values (Fig. 2) and reproductive, v_{xp} , values (Fig. 4) showed that female adults did not contribute to population growth after 131, 110, and 115 d, when reared on Zihong, Eyou, and Baijiao cultivars, respectively. In contrast, *S. nigrum* contributed to population growth of *H. vigintioctopunctata* until 142 d, indicating that *S. nigrum* is capable of serving as an important wild host for the survival of *H. vigintioctopunctata*.

Population projections based on life table data for survival rate, developmental rate, and fecundity can predict the changes of stage structure during population growth (Chi 1990, Reddy and Chi 2015). By using population projection, valuable information on the trends and emergence timing of egg, larva, pupa, and female and male stages can be predicted. Population projection is an important and promising tool that can be used to plan and time pest control strategies (Chi 1990). The present study demonstrated that the growth of the *H. vigintioctopunctata* population would be the fastest on the alternative host plant, *S. nigrum*.

The developmental periods for each of the larval and pupal stages, the APOP, TPOP, oviposition period, and female and male longevities of *H. vigintioctopunctata* were not significantly different in the three eggplant cultivars ($P < 0.05$), indicating that no noticeable difference in resistance to *H. vigintioctopunctata* exists in the different eggplant cultivars tested. Although Wang (2001) did report that the developmental periods of *H. vigintioctopunctata* larvae were significantly different on different eggplant cultivars, he did not include the fecundity and adult longevity data of *H. vigintioctopunctata* on the eggplant cultivars studied. Therefore, it is not possible to evaluate the resistance of these eggplant cultivars to *H. vigintioctopunctata*.

Although there were no significant differences ($P < 0.05$) in the preadult duration of *H. vigintioctopunctata* on the different host plants and the preadult survival rate was low on *S. nigrum*, the shorter TPOP, longer oviposition period, increased number of oviposition days, and higher fecundity resulted in a higher intrinsic rate of *H. vigintioctopunctata*. As Lewontin (1965) pointed out, the first reproductive age, age of reproductive peak, and length of reproductive period play important roles in the population growth rate. The finite rate of increase (λ) and the intrinsic rate of increase (r) can accurately reflect the overall growth, development, and fecundity capability of a population and are, therefore, important parameters in measuring population growth potential (Polat-Akköprü et al. 2015). The intrinsic rate of increase of *H. vigintioctopunctata* on *S. nigrum* (0.1216) was significantly higher than that on Eyou and Baijiao ($P < 0.05$). In the present study, comparative analysis of the r , λ , and R_0 values indicated that, among the four host plants tested, *S. nigrum* was the most suitable host for the development of *H. vigintioctopunctata*, although the preadult survival rate was the lowest on this host.

These results were similar to those published by Zhou et al. (2015) where the highest density of *H. vigintioctopunctata* eggs occurred on eggplant (3440 eggs per 100 host) in the Jiangnan Plain region, inferring that *H. vigintioctopunctata* larvae prefer eggplant as a host. The same authors reported that the most suitable temperature for *H. vigintioctopunctata* was 25°C (Zhou et al. 2014). Because the wild host plant, *S. nigrum*, normally grows in a shaded habitat under tree cover, the alternate host can provide ideal habitat conditions and nutrients for *H. vigintioctopunctata* during the hot summer and autumn periods characteristic to this region of China.

In summary, this study demonstrated that no significant difference in development and fecundity of *H. vigintioctopunctata* occurred among the three eggplant cultivars, Zihong, Eyou, and Baijiao, while concurrently showing that *S. nigrum* was a suitable alternate host plant for *H. vigintioctopunctata* (although eggplant does exert an apparent strong effect on the fecundity of *H. vigintioctopunctata*

compared to *S. nigrum*). We suggest that growers should try to eradicate *S. nigrum* from areas near and adjacent to eggplant fields in order to eliminate the available food supply and overwintering sites for *H. vigintioctopunctata*.

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