J. Entomol. Res. Soc., 27(2): 277-288, 2025
Doi: 10.51963/jers.v27i2.2806

Research Article
Online ISSN:2651-3579

Effects of Cupressaceous Host Plants on Life-history Traits and Life-table Parameters of *Planococcus vovae* (Nasonov, 1909) (Hemiptera: Pseudococcidae)

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ABSTRACT

Planococcus vovae (Nasonov, 1909) (Hemiptera, Pseudococcidae) is a newly discovered invasive species in China, which seriously damage cupressaceous plants. To study the effects of host plants on the biology of this insect pest, the developmental history, survival rate, adult longevity, and egg production on 12 species of common cupressaceous plants were measured at 26 ± 1°C, relative humidity 70 ± 5%, photoperiod L:D = 14 h:10 h. A population life table was constructed, and population dynamic parameters such as net reproductive rate, innate capacity of increase, finite rate of natural increase, a population trend index, average generation time, and population doubling time were calculated. The results showed that the nymphs could not complete their growth and development on only two species, *Platycladus orientalis* (L.) Franco and *Chamaecyparis lawsoniana* (A. Murray bis) Parl., while they could complete their life cycle on 10 other species of the Cupressaceae. The developmental period of nymphs feeding on *Juniperus formosana* Hayata 'Blue Arrow' was significantly shorter than that of other cupressaceous plants, with male and female nymphs developing within 25.44 d and 25.18 d, respectively. It was concluded that *P. vovae* had certain differences in feeding and adaptability when feeding on different species of the Cupressaceae, and had the strongest adaptability on *J. formosana* 'Blue Arrow' while *P. orientalis* and *C. lawsoniana* were non-hosts of *P. vovae*.

Keywords: invasive species, scale insects, life table parameters, host plant, development.

Wang, Y., Zhong, L., Wei, J., Xia, F., Li, G., Zhou, J., Li, N., & Qiu, L. (2025). Effects of cupressaceous host plants on life-history traits and life- table parameters of *Planococcus vovae* (Nasonov, 1909) (Hemiptera: Pseudococcidae). *Journal of the Entomological Research Society*, 27(2), 277-288.

Received: December 24, 2024 *Accepted: July 14, 2025*

INTRODUCTION

Trees in Cupressaceae include 27 genera and 147 species, which are widely distributed in the world except for Antarctica (Jin, Han, & Guo, 2012; Huang et al., 2018). *Sabina* is the largest genus in the family and consists of approximately 50 species. Cupressaceae tree wood has excellent texture and certain medicinal value (Lin, Fu, & Zhang, 2021; Park, Woo, & Park, 2023). Most plants of the Cupressaceae play important roles in afforestation, sand fixation, as well as in soil and water conservation. Many species form beautifully shaped trees and green or dark green leaves; they are often cultivated as garden trees with significant economic and ecological value (Chu, 2012; Du et al., 2015; Hu, Jin, Wang, Mao, & Li, 2015).

Planococcus vovae (Nasonov, 1909) (Hemiptera, Pseudococcidae) is a newly discovered invasive species in Beijing City and Hebei Province, China (Wu, Li, & Xu, 2023). This piercing-sucking pest originated in Europe, the Mediterranean region, and southwestern Asia (Hayon, Mendel, & Dorchin, 2016; Çiftci & Bolu, 2021). It prefers to feed on plants in the Cupressaceae (CABI, 2021) and was first recorded in Langfang City, Hebei Province, China, in 2020 (Yuan & Wei, 2022) . *P. vovae* has a strong ability to reproduce and adapt and can seriously damage cupressaceous plants such as *Juniperus chinensis*, *Juniperus chinensis* 'Kaizuka', and *Sabina vulgaris* in the cities of Langfang and Beijing, causing a decline in growth and a growth of mold that leads to contamination and hinders plant photosynthesis, which accelerates plant death (Wang et al., 2024).

Plants are indispensable as food and habitat for the herbivorous insects, and selecting suitable hosts is an important biological behavior (Hafsi & Duyck, 2017; Guo et al., 2021). The suitability of host plants for insect pests is the basis for evaluating the potential harm caused by pests and predicting pest conditions. The biology and behavior of herbivorous insects could reflect their degree of adaptation to their hosts to some extent, such as the duration of larval development, rates of survival, pupation, eclosion along with adult reproductive capacity, and a host suitability index (Li, Ai, Du, & Sun, 2015; Tang et al., 2020). Using the suitability of different host plants for herbivorous insects can allow researchers to select resistant plants and implement an effective green control strategy that can achieve the goal of reducing pest infestations. If plants with low suitability for insect larvae but high oviposition attraction for adults are planted reasonably, this method could be expected to decrease the infestation of some insect pests. Therefore, studying the adaptability of different cupressaceous plants to *P. vovae* is a necessary step for developing control strategies for this insect pest. The present study selected 12 species of cupressaceous plants for indoor feeding by *P. vovae* and measured the effects of these plants on the growth, development, reproduction, and population parameters. The differences in host fitness for *P. vovae* among 12 species of cupressaceous plants were clarified, providing information for screening cupressaceous plants for insect resistance.

MATERIALS AND METHODS

Insect source

Adult *P. vovae* insects were collected from the Temple of Heaven in Beijing (39°88’19”N, 116°41’08”E). Insects were fed on *Sabina chinensis* ‘Beijingensis’ and maintained in the insectary at 26 ± 1°C, a humidity of 70% ± 5%, and a photoperiod of 14 L:10 D. Ten generations were established before conducting experiments.

Host plants

Twelve species in the Cupressaceae used for testing were all purchased from Beijing Huamu Co., Ltd., Beijing, China (Table 1). All test plants cultured in a greenhouse were subjected to uniform fertilizer and water management. Experiments were conducted when these host species were in their peak growth period.

Table 1 Scientific names of 12 cupressaceous species tested in this study at the age of 4 years

Number	Species
1	*Juniperus chinensis* ‘Pyramidalis Aurea’
2	*Juniperus formosana* ‘Blue Arrow’
3	*Juniperus formosana* ‘Fire Dragon’
4	*Juniperus chinensis* ‘Blue Alps’
5	*Juniperus horizontalis* ‘Blue Chip’
6	*Juniperus squamata* ‘Blue Carpet’
7	*Thuja occidentalis* ‘Golden Globe’
8	*Juniperus chinensis* ‘Shimpaku Gold’
9	*Platycladus orientalis*
10	*Sabina chinensis* ‘Beijingensis’
11	*Chamaecyparis lawsoniana*
12	*Thuja standishii*

Development and reproductive indicators of *P. vovae* grown on 12 cupressaceous host species

The finger tube method (volume: 4 mL) was used to rear *P. vovae*, with a circular hole (2 mm) drilled on each tube cover. Each finger tube was filled with pure water, fresh branches of one of the host plants were cut and inserted into the tube through the circular hole (Fig. 1), and these were then placed in culture dishes (90 mm in diameter).

Figure 1. Schematic diagram of the experimental device for rearing *P. vovae.*

To inoculate the plants, well-developed *P. vovae* nymphs of the same age were picked up with a soft brush and attached to the upper part of each fresh branch. One newly hatched nymph was inoculated on each branch. Using this method, 30 heads of each host plant were inoculated three times. Then, all samples for all treatments were incubated at 26±1°C, with humidity of 70% ± 5% and a photoperiod of 14 L:10 D. The duration of development in each stage along with the survival rate, pupation status, number of emerged males, adult longevity, and egg laying status of female *P. vovae* were recorded daily. To clearly demonstrate the life history of *P. vovae*, different stages of both sexes are shown in Table 2.

Table 2. Life history of *P. vovae*.

Gender	Life history
Female	Egg→1st instar nymph→2nd instar nymph→3rd instar nymph→adult
Male	Egg→1st instar nymph→2nd instar nymph→pupa→adult

Population growth parameters of *P. vovae* on different host plant species

The analysis of the raw data and the calculation of life table parameters were performed using the Jackknife technique of the TWOSEX-MSChart program (Ge, 2008) as follows:

Net reproductive rate $R_0 = \sum l_x m_x$,

Average generation time $T = \sum x l_x m_x / \sum l_x m_x$,

Innate capacity of increase $r_m = \ln(R_0)/T$,

Finite rate of natural increase $\lambda = \exp(r_m)$,

Population trend index $I = N_{n+1}/N_n$,

Population doubling time $T_d = \ln(2)/r_m$,

where l_x represents the survival rate of individuals during period x, m_x represents the average number of offspring of one maternal during period x, N_{n+1} represents the number of next generation or next stage of insects, and N_n represents the number of previous generation or previous stage of insects.

Statistical analysis

Excel 2010 was used to organize the original preliminary data, and SPSS 26.0 was used for one-way analysis of variance. Data are presented as mean ± standard error (SE) or standard deviation (SD). Duncan's test was used to compare significant differences between treatments (α = 0.05). Excel 2010 was used to calculate the period of development, as well as the net reproductive rate (R_0), innate capacity of increase (r_m), finite rate of natural increase (λ), population trend index (I), average generation time (T), and population doubling time (T_d) of the experimental population.

RESULTS

Effect of host plants on the developmental period of *P. vovae*

Data showed that the nymphs could not complete their life cycle on *C. lawsoniana* and *P. orientalis*; all nymphs inoculated on these two species died during the first instar nymph stage (Table 3). However, nymphs were able to complete their life cycle on the other 10 host species. Moreover, different cupressaceous species had varying degrees of influence on the developmental duration of different stages of *P. vovae*. When comparing the total duration of *P. vovae* nymphs, significant differences were observed among different cupressaceous hosts (female: $F = 22.371$, $df = 334, 9$, $P < 0.05$; male: $F = 22.890$, $df = 200, 9$, $P < 0.05$). The total duration of the nymph stage of *P. vovae* was significantly shorter on *J. formosana* 'Blue Arrow' than on the other nine hosts in the Cupressaceae, with female and male nymphs developing for 25.44d and 25.18d, respectively. Nymphs survive the longest on *J. squamata* 'Blue Carpet', with female and male nymphs living for an average of 29.87d and 30.59d, respectively. Table 3 shows the developmental period from nymph to adult of *P. vovae* on the 12 host plants. Therefore, the developmental progress of *P. vovae* on *J. squamata* 'Blue Carpet' was relatively slow, while *J. formosana* 'Blue Arrow' had the highest suitability for the development of *P. vovae*.

Table 3. Duration of development for *P. vovae* on 12 species of cupressaceous plants

Host	Developmental duration (d) from nymph to adult	
	Female	Male
J. chinensis 'Pyramidalis Aurea'	28.47 ± 0.31bc	28.35 ± 0.32cd
J. formosana 'Blue Arrow'	25.44 ± 0.26f	25.18 ± 0.24g
J. formosana 'Fire Dragon'	28.74 ± 0.25b	29.42 ± 0.35b
J. chinensis 'Blue Alps'	27.51 ± 0.26d	27.72 ± 0.40de
J. horizontalis 'Blue Chip'	27.85 ± 0.31cd	28.70 ± 0.39bc
J. squamata 'Blue Carpet'	29.87 ± 0.24a	30.59 ± 0.25a
T. occidentalis 'Golden Globe'	27.79 ± 0.45cd	27.15 ± 0.20ef
J. chinensis 'Shimpaku Gold'	28.42 ± 0.28bc	29.16 ± 0.38bc
P. orientalis	-	-
S. chinensis 'Beijingensis'	26.67 ± 0.20e	26.69 ± 0.35f
C. lawsoniana	-	-
T. standishii	27.90 ± 0.21cd	27.37 ± 0.21ef

Note: Different lowercase letters within the same column indicate significant differences ($P < 0.05$) among different host species based on Duncan's test.

Effect of host plants on the survival rate of various stages of *P. vovae*

The effects of different host plants on the rate of survival of *P. vovae* nymphs are shown in Table 4. The survival rate of *P. vovae* nymphs increased with the progression of development, but certain differences were observed among different host plants. Except for *C. lawsoniana* and *P. orientalis*, *P. vovae* nymphs feeding on different cupressaceous hosts were found to be in the 1st instar ($F = 1.490$, $df = 20,9$, $P >$

0.05), 2nd instar (*F* = 1.564, *df* = 20,9, *P* > 0.05), and 3rd instar female nymphs (*F* = 1.606, *df* = 20, 9, *P* > 0.05) and pupal stages (*F* = 0.19, *df* = 20, 9, *P* > 0.05). No significant difference was observed in the survival rate of male nymphs (*F* = 2.017, *df* = 20, 9, *P* > 0.05) among the 12 tested plant taxa, while a significant difference was observed in the survival rate of female nymphs in *P. vovae* (*F* = 5.846, *df* = 20, 9, *P* < 0.05). The survival rate of female nymphs was highest on *J. formosana* 'Blue Arrow', at 73.34%, followed by *S. chinensis* 'Beijingensis', at 69.48%, and the lowest on *J. squamata* 'Blue Carpet', at 53.35%. Table 4 shows the survival rates of *P. vovae* nymphs on the 12 host plants; *J. formosana* 'Blue Arrow' was the most suitable host, and *J. squamata* 'Blue Carpet' was the least suitable. Each different host plant had a certain impact on the survival rate of *P. vovae* nymphs at different stages. The findings obtained indicate that *P. vovae* nymphs feeding on *J. formosana* 'Blue Arrow' had a higher fitness for survival than other tested plants.

Table 4. Survival rates of *P. vovae* on 12 species of cupressaceous plants.

Host	Survival rate (%)	
	Nymph to adult	
	Female	Male
J. chinensis 'Pyramidalis Aurea'	57.79 ± 0.61cd	58.00 ± 2.67bc
J. formosana 'Blue Arrow'	73.34 ± 2.46a	73.58 ± 1.94a
J. formosana 'Fire Dragon'	56.06 ± 3.59cd	57.63 ± 4.07bc
J. chinensis 'Blue Alps'	62.93 ± 2.24bc	64.26 ± 5.74abc
J. horizontalis 'Blue Chip'	60.91 ± 1.94cd	60.35 ± 3.27bc
J. squamata 'Blue Carpet'	53.35 ± 2.55d	53.61 ± 4.19c
T. occidentalis 'Golden Globe'	62.20 ± 2.65bc	62.02 ± 5.13abc
J. chinensis 'Shimpaku Gold'	58.61 ± 1.76cd	58.42 ± 4.12bc
P. orientalis	-	-
S. chinensis 'Beijingensis'	69.48 ± 3.95ab	68.06 ± 2.78ab
C. lawsoniana	-	-
T. standishii	62.55 ± 1.23bc	62.67 ± 4.44abc

Note: Different lowercase letters within the same column indicate significant differences (*P* < 0.05) among different host species based on Duncan's test.

Effect of host plants on the longevity and reproductive capacity of *P. vovae* adults

The effects of different cupressaceous plants on the longevity and reproductive capacity of *P. vovae* adults are shown in Table 5. Significant differences were observed in the longevity of male and female adults of *P. vovae* when feeding on different cupressaceous plants (female: *F* = 8.147, *df* = 230, 9, *P* < 0.05; male: *F* = 5.470, *df* = 230, 9, *P* < 0.05). The average longevity of adult *P. vovae* on *S. chinensis* 'Beijingensis' was the longest, followed by *J. formosana* 'Blue Arrow'; the longevity on *J. squamata* 'Blue Carpet' was the shortest (Table 5).

Finding *P. vovae* adults fed on different cupressaceous plants revealed a significant effect on the pre-oviposition period (*F* = 7.690, *df* = 230, 9, *P* < 0.05) and oviposition period (*F* = 16.720, *df* = 230, 9, *P* < 0.05) of *P. vovae*. Among them, adults of *P. vovae* fed on *S. chinensis* 'Beijingensis' had the shortest pre-oviposition period; adults fed on *J. formosana* 'Blue Arrow' had the shortest oviposition period; and adults fed on *J. squamata* 'Blue Carpet' had the longest pre-oviposition and oviposition periods of 13.33d and 13.25d, respectively.

The egg production of female adults of *P. vovae* varied on different host plants, the highest eggs produced per female on *J. formosana* 'Blue Arrow', followed by *S. chinensis* 'Beijingensis'; these data were significantly higher than data for egg production of *P. vovae* on other host plants (F = 30.955, df = 230, 9, P < 0.05). The lowest egg production was observed on *J. squamata* 'Blue Carpet'. Table 4 shows the longevity and egg production of *P. vovae* adults on 12 species of cypress hosts. These findings indicate that different host plants had a significant impact on the longevity and egg production of *P. vovae* female adults.

Table 5. Longevity and egg production of *P. vovae* adults on 12 species of cupressaceous plants

Host	Pre-oviposition duration (d)	Oviposition duration (d)	Fecundity	Adult longevity (d)	
				Female	Male
J. chinensis 'Pyramidalis Aurea'	13.17 ± 0.17abc	12.67 ± 0.49ab	181.83 ± 4.07de	25.67 ± 0.49cde	1.88 ± 0.12cdef
J. formosana 'Blue Arrow'	12.33 ± 0.21fg	11.08 ± 0.27e	208.17 ± 5.28a	26.33 ± 0.33abc	2.00 ± 0.13abc
J. formosana 'Fire Dragon'	13.00 ± 0.26abcd	13.17 ± 0.40a	179.00 ± 3.63de	25.25 ± 0.63de	1.96 ± 0.04bcd
J. chinensis 'Blue Alps'	12.83 ± 0.48bcde	11.67 ± 0.42de	186.33 ± 4.51cd	26.50 ± 0.43ab	1.92 ± 0.08cde
J. horizontalis 'Blue Chip'	12.50 ± 0.22efg	12.83 ± 0.31ab	190.67 ± 3.37bc	25.33 ± 0.42de	2.13 ± 0.09a
J. squamata 'Blue Carpet'	13.33 ± 0.21a	13.25 ± 0.31a	173.84 ± 2.63f	24.50 ± 0.43f	1.79 ± 0.17ef
T. occidentalis 'Golden Globe'	12.67 ± 0.42def	11.91 ± 0.61cd	185.67 ± 3.61cd	25.83 ± 0.87bcd	1.83 ± 0.11def
J. chinensis 'Shimpaku Gold'	13.25 ± 0.25ab	13.08 ± 0.27a	174.33 ± 3.23f	24.92 ± 0.45ef	1.75 ± 0.17f
P. orientalis	-	-	-	-	-
S. chinensis 'Beijingensis'	12.16 ± 0.17g	11.17 ± 0.31e	193.67 ± 4.24b	26.67 ± 0.42a	2.08 ± 0.08ab
C. lawsoniana	-	-	-	-	-
T. standishii	12.75 ± 0.44cdef	12.33 ± 0.67bc	187.83 ± 3.89c	25.58 ± 0.55de	1.95 ± 0.10bcde

Note: Different lowercase letters within the same column indicate significant (P< 0.05) differences among different host species based on Duncan's test.

Effect of host plants on the population life parameters of *P. vovae*

Table 6 shows that the net reproductive rate (R_0), population trend index (I), innate capacity of increase (r_m), and finite rate of natural increase (λ) of the experimental population of *P. vovae* were all the highest when raised *J. formosana* 'Blue Arrow', followed by *S. chinensis* 'Beijingensis', and were all the lowest when raised on *J. squamata* 'Blue Carpet'.

The average generation period (T) and population doubling time (T_d) of *P. vovae* on *J. formosana* 'Blue Arrow' were the shortest, respectively. The average generation period and population doubling time of *P. vovae* on *J. squamata* 'Blue Carpet' were the longest, respectively. This indicated that *P. vovae* developed faster on *J. formosana* 'Blue Arrow', making it the most suitable host for *P. vovae*. However, its relatively long period to produce one generation on *J. squamata* 'Blue Carpet' suggested its weaker reproductive ability and slightly lower adaptability.

Table 6. Population life parameters of *P. vovae* on 12 species of cupressaceous plants.

Different host species	Net reproductive rate (R_0)	Innate capacity of increase (r_m)	Finite rate of natural increase (λ)	Average generation time (T)/d	Population doubling time (T_d)/d	Population trend index (I)
J. chinensis 'Pyramidalis Aurea'	106.736	0.096	1.101	48.5	7.198	53.368
J. formosana 'Blue Arrow'	152.586	0.114	1.121	44.0	6.066	76.203
J. formosana 'Fire Dragon'	100.419	0.095	1.100	48.5	7.293	50.210
J. chinensis 'Blue Alps'	117.204	0.101	1.107	47.0	6.838	58.602
J. horizontalis 'Blue Chip'	116.116	0.101	1.106	47.0	6.852	58.058
J. squamata 'Blue Carpet'	92.827	0.090	1.094	50.5	7.726	46.414
T. occidentalis 'Golden Globe'	115.486	0.101	1.106	47.0	6.860	57.742
J. chinensis 'Shimpaku Gold'	102.159	0.095	1.100	48.5	7.266	51.080
P. orientalis	-	-	-	-	-	-
S. chinensis 'Beijingensis'	134.598	0.110	1.116	44.5	6.292	67.299
C. lawsoniana	-	-	-	-	-	-
T. standishii	117.396	0.101	1.107	47.0	6.836	58.698

DISCUSSION

The host plant is one of the important factors affecting the transmission and reproduction of *P. vovae*. Studying the oviposition and feeding preference of herbivores on different host species is of great significance for clarifying the evolutionary relationship between insects and host plants and for developing new plant protection strategies (Agelopoulos et al., 1999; Wang, Cheng, Sun, Yang, & Su, 2023). Host plants affect not only the growth and development of insect nymphs but also the reproduction of adults (Qin, 1962; Jaenike, 1978). Host plants that are beneficial for the growth and development of nymphs are usually beneficial for the oviposition of adult insects, and vice versa (Harcourt, 1969; Ma et al., 2017). The developmental period of insect nymphs is one of the important indices for measuring the suitability of host plants for specific herbivores (Lu et al., 2016b; Wang, Wang, Zhang, & Wang, 2021; Carrasco & Larsson, 2015). The results of this study indicated that *P. vovae* could not complete its life cycle on *C. lawsoniana* and *P. orientalis* and died during the first instar nymph stage on those species. However, nymphs can complete its life cycle on the other 10 species of cupressaceous plants, with significant differences in host adaptability for *P. vovae* for different cupressaceous plants. *P. vovae* individuals were found to have a strong preference for *J. formosana* 'Blue Arrow' throughout the entire nymphal stage, and this preference does not weaken with the age of nymphs. The developmental period of *P. vovae* nymphs fed on *J. formosana* 'Blue Arrow' was significantly shorter than for those feeding on other cupressaceous plants. At the same time, *P. vovae* feeding on *J. formosana* 'Blue Arrow' had the highest nymph survival rate, adult longevity, and egg production compared with those feeding on other cupressaceous plants. Therefore, under laboratory conditions, we could draw a conclusion that *J. formosana* 'Blue Arrow' is more suitable for the growth, development, and reproduction of *P. vovae* and can be used as the most suitable host for rearing this insect species in an experimental setting. It may be that the upright tree shape without branches of this taxon is more conducive to feeding by *P. vovae*. In addition, *S. chinensis* 'Beijingensis' and *J. horizontalis* 'Blue Chip' are relatively suitable for the growth and development of *P. vovae* nymphs.

Constructing a life table for an experimental population can theoretically allow researchers to analyze population characteristics as well as estimate population dynamic trends and ecological adaptability (Jia, Cheng, Cai, Luo, & Guo, 2012; Yang et al., 2015; Ning, Zhang, Sun, & Feng, 2017). The abundance of insect populations is determined by a combination of factors such as growth and development rate, survival rate, and reproductive capacity (Yu, Chi, & Chen, 2005; Moreau, Benrey, & Thiéry, 2006; Gou, Sun, Liu, Dilinuer, & Feng, 2019; Qiu et al., 2020). The intrinsic growth rate of a population is the main parameter used to measure the growth and reproduction ability of an insect species. Having a short developmental period and strong reproductive ability in insects feeding on plants reflects their strong ability to adapt to a plant species (Lenteren & Noldus, 1990; Li, Liu, & Tian, 2004). The present study established a life table for an experimental population of *P. vovae* on 12 species of cupressaceous plants. The results showed that the growth rate of *P. vovae* on *J. formosana* 'Blue Arrow' was significantly higher than that on other cupressaceous plants. Therefore, the adaptability of *P. vovae* on different tested host plants was highest on *J. formosana* 'Blue Arrow', followed by *J. horizontalis* 'Blue Chip' and *S. chinensis* 'Beijingensis', which also had the potential for outbreaks of infestations. The growth rate of the population of *P. vovae* on *J. squamata* 'Blue Carpet' was the lowest.

Host plants have a significant impact on the feeding behavior, growth, development, and population reproduction of insects. Suitable hosts can enable the offspring populations of insect to have increased rates of development along with higher survival rates and reproductive abilities than those occur on other host species (Qin, 1962; Wang et al., 2004; Anderson, Sadek, & Wäckers, 2011; Lu et al., 2016a). The results of the present study confirmed that the adaptability of the nymphal stage of *P. vovae* was an important factor affecting its general reproductive ability. When feeding on *J. formosana* 'Blue Arrow' during the nymphal stage, survival of a single maternal egg was significantly higher than when feeding on other cupressaceous plants, indicating that feeding on *J. formosana* 'Blue Arrow' during this stage was beneficial for improving the reproductive ability of *P. vovae*. This finding suggests that strengthening prevention and control measures during the nymphal stage of *P. vovae* could mitigate the degree of damage to host plants. Although the results of this study were obtained under constant temperature conditions in the laboratory and had some differences with the actual situation in the field, they have a certain reference value for pest investigation, monitoring, and comprehensive prevention and control.

This study only investigated the duration of development, survival rate, adult longevity, egg production, and population life parameters of *P. vovae* nymphs on 12 species of cupressaceous plants. However, the relationship between host plants and insects is very complicated and can involve characteristics such as the nature of the surface structure of the plant, metabolites in the plant, and semiochemicals (volatiles) that can affect a series of life activities such as insect tropism, feeding, egg laying, reproduction, and survival (Bossart & Scriber, 1999; Carter & Feeny, 1999; Kartik, Balagopalan, & Giasuddin, 2011). For example, Huang, Zou, Bi, Luo, & Wang (2008) believed that the thickness of the wax layer on the surface of plant leaves affects insect feeding, egg laying, and hatching, and a thicker wax layer is more unfavorable to insect feeding, egg laying, and other behaviors. Malheiro, Casal, Cunha, Baptista, & Pereira (2016) found that the release of toluene and limonene from olives was significantly positively correlated with the degree of damage caused by *Bactrocera oleae*. Cao, Liu, Wu, Liu, & Wang (2015) found through studying the selection of different grape varieties by *Thrips tabaci* and the correlation between the main factors involved in insect infestation that the selection of different grape varieties by *T. tabaci* was significantly negatively correlated with the flavonoid, tannin, and wax content in the leaves and positively correlated with the soluble sugar content, total phenolic content, and leaf thickness in the host. Therefore, further research is needed on the mechanism of differences in insect resistance to different varieties of the Cupressaceae to *P. vovae*. In addition, *P. vovae* was unable to complete its growth and development in *P. orientalis* in this study, which is inconsistent with a previous report (Yuan & Wei, 2022). The results of the present study confirmed that *P. vovae* cannot complete its life cycle on *P. orientalis* and *C. lawsoniana*, providing a reference for further development of plant-based repellents.

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