BioOne COMPLETE

Errata

Source: Florida Entomologist, 104(1) : 58

Published By: Florida Entomological Society

URL: https://doi.org/10.1653/024.104.0111

BioOne Complete (complete.BioOne.org) is a full-text database of 200 subscribed and open-access titles in the biological, ecological, and environmental sciences published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Complete website, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at www.bioone.org/terms-of-use.

Usage of BioOne Complete content is strictly limited to personal, educational, and non - commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

Downloaded From: https://bioone.org/journals/Florida-Entomologist on 29 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

Errata

We have been informed that the authors of a paper printed in the June 2019 (Volume 102, No. 2) wish to change the corresponding author for their paper. The paper is printed on pages 418–424.

Biological studies of the *Oligonychus litchii* (Trombidiformes: Tetranychidae) on four commercial litchi cultivars

Qiong Yao[1], Linfa Quan[1], Haiming Xu[1], Tao Jia[1], Wenjing Li[1], and Bingxu Chen[1,]*

*Corresponding author; E-mail: gzchenbx@163.com

Downloaded From: https://bioone.org/journals/Florida-Entomologist on 29 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

Biological studies of the *Oligonychus litchii* (Trombidiformes:Tetranychidae) on four commercial litchi cultivars

Qiong Yao[1,,†], Linfa Quan[1,†], Haiming Xu[1], Tao Jia[1], Wenjing Li[1], and Bingxu Chen[1]*

Abstract

Litchi is one of the most important pillars of the fruit industry in Southeast Asia and mainland China. The litchi spider mite, *Oligonychus litchii* Lo & Ho (Prostigmata: Tetranychidae), is a major pest of litchi. To determine the influence of different litchi cultivars on the life cycle, fecundity, and longevity of *O. litchii*, life tables of *O. litchii* on 4 popular commercial litchi cultivars in China ('Baili,''Fezixiao,''Sanyuehong,' and'Nuomici') were constructed under laboratory conditions at 25 ± 1 °C, 65 to 80% RH, and photoperiod of 14:10 h (L:D). Life stages of *O. litchii* consist of egg, larva, protonymph, deutonymph, and adult, with distinct body sizes and colors. The life table parameters were significantly influenced by litchi cultivars. Our results showed that the developmental time of immature *O. litchii* was significantly longer on Baili than on the other 3 litchi cultivars. The immature survival rates of *O. litchii* varied from 21.74% to 68.42%. *Oligonychus litchii* laid significantly more eggs on Nuomici (64.84 eggs per female) than on other cultivars. The population doubling time of *O. litchii* ranged from 4.56 to 22.42 d, and a significant varietal effect was seen. The mites feeding on Nuomici showed the lowest intrinsic rate of natural increase per d (r_m = 0.14 female per female per d). In addition, the net reproductive rate (R_0) and finite rate of increase (λ) of *O. litchii* had the highest value on Nuomici (22.86 female per female per generation, and 1.16 female per female per d, respectively). The comparison of r_m, R_0, and immature survival rate of *O. litchii* on host plants revealed that Nuomici is the most suitable cultivar, suggesting that Nuomici is more susceptible to the litchi spider mite than the other 3 litchi cultivars.

Key Words: spider mite; behavior; development; fecundity; life table

Resumen

El lichi es uno de los pilares más importantes de la industria frutícola en el sudeste asiático y en la China continental. La arañita de lichi, *Oligonychus litchii* Lo & Ho (Prostigmata: Tetranychidae), es una plaga importante del lichi. Para determinar la influencia de diferentes cultivares de lichi sobre el ciclo de vida, la fecundidad y la longevidad de *O. litchii*, se construyeron tablas de vida de *O. litchii* en 4 cultivares de lichi comercial populares en China ('Baili,''Fezixiao,''Sanyuehong,' y 'Nuomici') en condiciones de laboratorio a 25 ± 1 °C, 65 a 80% de HR, y un fotoperíodo de 14:10 h (L:D). Los estadios de vida de *O. litchii* consisten en huevo, larva, protoninfa, deutoninfa, y adulto, con distintos tamaños de cuerpo y colores. Los parámetros de la tabla de vida fueron significativamente influenciados por cultivares de lichi. Nuestros resultados mostraron que el tiempo de desarrollo de los inmaduros de *O. litchii* fue significativo para más tiempo sobre Baili que en los otros 3 cultivares de lichi. Las tasas de sobrevivencia de los inmaduros de *O. litchii* variaron de 21,74% a 68,42%. *Oligonychus litchii* puso significativamente más huevos sobre Nuomici (64.84 huevos por hembra) que en otros cultivares. El tiempo de duplicación de la población de *O. litchii* varió de 4.56 a 22.42 d, y se observó un efecto varietal significativo. Los ácaros que se alimentaron de Nuomici mostraron la tasa intrínseca más baja de aumento natural pordía (r_m = 0.14 hembra por hembra por d). Además, la tasa reproductiva neta (R_0) y la tasa de aumento finita (λ) de *O. litchii* tuvieron el valor más alto en Nuomici (22.86 hembras por hembra por generación y 1.16 hembras por hembra por d, respectivamente). La comparación de los r_m, R_0, y la tasa de sobrevivencia de los inmaduros de *O. litchii* en las plantas hospederas reveló que Nuomici es el cultivar más adecuado, lo que sugiere que Nuomici es más susceptible a la arañita de lichi que los otros 3 cultivares de lichi.

Palabras Clave: ácaro de araña; comportamiento; desarrollo; fecundidad; tabla de vida

Litchi (*Litchi chinensis* Sonn) (Sapindaceae) originated in the moist tropical and subtropical forests of southern China, and has a long history according to unofficial Chinese records going back to about 2000 BC (Huang et al. 2005). It is principally cultivated in Asia-Pacific regions, such as India, South Africa, Mauritius, Mexico, Australia, and Hawaii for its popular fruit (Menzel 2002; Wall 2006). The largest producer in Asia-Pacific regions is China, and the litchi is one of the most important pillars of the fruit industry in Southeast Asia and mainland China (Wei et al. 2015). The cultivated area of litchi and commercial litchi production in mainland China are estimated to exceed 635,524 ha and 1.42 million metric tons, respectively (Houbin 2017).

Litchi is susceptible to a range of pests and diseases (Menzel 2002). The litchi spider mite, *Oligonychus litchi* Lo & Ho (Prostigmata: Tetranychidae) is one of the most damaging mite pests of litchi (Chyi-chen 2000). Reportedly, *O. litchii* has become the principal pest of *Dimocarpus longan* Lour (Sapindaceae), *Psidium guajava* Linn (Myrtaceae),

[1]Plant Protection Research Institute, Guangdong Academy of Agricultural Sciences, Guangzhou, Guangdong 510640, China; E-mails: joanyao0603@126.com (Q. Y.); linfa_quan2016@126.com (L. Q.); modeyouxiang@163.com (H. X.); 304087281@qq.com (T. J.); lwj4631221@aliyun.com (W. L.); gzchenbx@163.com (B. C.)
*Corresponding author; E-mail: gzchenbx@163.com
†Qiong Yao and Linfa Quan contributed equally to this work.

Downloaded From: https://bioone.org/journals/Florida-Entomologist on 29 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

Eriobotrya japonica (Thunb.) Lindl (Rosaceae), and *Syzygium samarangense* Merr. et Perry (Myrtaceae) in Taiwan (Ho 2004). Also, it was found recently to cause damage in other litchi-producing areas, such as Guangdong, Hainan, Guangxi, Yunnan, and Fujiang provinces in mainland China (Shu et al. 2014b; Wenhua et al. 2016). Their mouthparts (chelicerae) are specifically designed for puncturing the epidermal cells of leaves, producing characteristic reddish brown spots on the upper surface of mature leaves (Shu et al. 2014a). High population density of *O. litchii* leads to leaf defoliation and nutrition accumulation reduction of the host plants, further resulting in severe crop loss (Chyi-chen 2004; Shu et al. 2014b).

The impacts of host plant morphological and chemical features on teranychid mite species has been noted repeatedly (Awmack& Leather 2002; Vasquez et al. 2008). Host plant species or cultivars are among the most important extrinsic factors that affect development rate, longevity, and fecundity of mites (Van et al. 2003). For example, the adult longevity of *Oligonychus afrasiaticus* (McGregor) (Prostigmata: Tetranychidae) differed among 4 date palm cultivars with values ranging from 4.70 to 18.10 d (Ben et al. 2011). In a comparative study of *Panonychus ulmi* (Koch) (Prostigmata: Tetranychidae) on different apple cultivars, the total fecundity per female was significantly different among 4 apple cultivars (Dongyin et al. 2013). Furthermore, the egg hatchability of *Tetranychus urticae* Koch (Prostigmata: Tetranychidae) range from 88.25 to 94.20% on 6 common bean cultivars (Najafabadi et al. 2014).

In recent years, several important fruit trees, including litchi, guava, and loquat in southern China were attacked by *O. litchii*, among which litchi is the most important host plant for this mite pest. However, little is known about the occurrence of susceptible cultivars, or the development, survival, reproduction, and life table parameters of *O. litchii*. Hence, the purpose of this study was to better understand the influence of litchi cultivars on life-history parameters of *O. litchii*, by constructing the life tables of this spider mite on 4 popular commercial litchi cultivars in China.

Materials and Methods

MITE COLONY AND MAINTENANCE

Oligonychus litchii used in these experiments were originally collected at litchi orchards in Conghua city (northeast of Guangdong Province, China, a region dominated by a subtropical monsoon climate) in Mar 2013. A stock *O. litchii* colony was started on healthy litchi leaflets in a rearing chamber at 25 ± 1 °C, 65 to 80% RH, and a 14:10 h (L:D) photoperiod. The mites were cultured on leaflets of 4 litchi cultivars (Baili, Fezixiao, Sanyuehong, Nuomici) for at least 4 generations before being used as the test materials in this study.

LEAF DISCS

New litchi leaflets (30–40 d old) in the mature stage were obtained from a litchi orchard of the Institute of Plant Protection, Guangdong Academy of Agricultural Sciences, China, for leaf disc preparation. All host plants were irrigated at the same time and no fertilizers or pesticides were used during the experiments. A modified leaf-disc method was used to rear *O. litchii* in this study (Perumalsamy et al. 2010; Rahman et al. 2013). A sheet of cotton wool gauze was set in a large Petri dish (46 cm in diam), and distilled water was added to the Petri dish to keep the gauze water-saturated. The edge of all experimental litchi leaflets was wrapped with moist filter paper to prevent the escape of the tested mites and to keep the leaves fresh. Then each of the leaf discs was placed on the wetted gauze in the Petri dish with the top side facing upward. The new leaf discs were prepared and the mites transferred every 6 d.

DEVELOPMENT TIME, SURVIVAL OF IMMATURE STAGES, ADULT FECUNDITY, AND LONGEVITY

To obtain synchronized eggs for the experiments, 5 mated females from each colony were moved to a leaf disc with the same cultivars as those from which they were collected. The females were allowed to lay eggs for 12 h, and then only 1 egg was retained on the leaf disc after removing females and other eggs. In all, 60 to 70 eggs were tested for each litchi cultivar. The egg was observed each d until it hatched. The newly emerged larva was transferred to a fresh leaf disc, and observed under a binocular microscope (Olympus, SZ4045, Olympus (China) Co. Ltd., Shanghai, China) at 50× every d until they reached maturity. The presence of exuviae was used as the criterion of successful molting to the next development stage. The development time and survival of larvae, protonymphs, deutonymphs, males, and females were recorded. Each mature female that had emerged within the last 24 h was supplied with an additional adult male from each colony to ensure mating. The additional adult males were removed after mating with females. The remainder of the females and males were reared individually. To estimate the preoviposition period, observation was made at 8 h intervals until the first egg was deposited. To calculate the oviposition period, fecundity, and longevity, the number of eggs laid by each female on 4 litchi cultivar leaflets were checked and removed daily. All experiments were carried out in a rearing chamber with the same rearing conditions mentioned above.

LIFE TABLE CONSTRUCTION

The raw data obtained in the studies of developmental time, survival of immature stages, adult fecundity, and longevity were used for a time-specific life table construction of *O. litchii* under laboratory conditions. The life table parameters were estimated from a life-fecundity table according to the equation given by Birch (1948) and Southwood and Henderson (2000):

$$\sum_{i=0}^{n} e^{-r_m x} l_x m_x = 1$$

where x is the age class, l_x is the possibility of survival at age x, and m_x is the daily number of female offspring at age x. The net reproductive rate R_0 is represented by R_0 =, the intrinsic rate of increase by $r_m = lnR_0/T_0$, the mean generation time T_0 (in d) by T=lnR_0/r_m, and the finite rate of increase (λ) by λ=. The doubling time (*DT*) by $DT = ln2/r_m$ was calculated as described by Deevey (1947), Birch (1948), and Mackauer (1983). The life table study is extremely time-consuming; thus, experimental replication is impractical in this study (Jih-Zu et al. 2005). Based on the bias corrected and accelerated bootstrap (BCaWW method) (Wyatt & White 1977), the life history parameters and 95% confidence limit (CI) were estimated using 1,000 bootstrap samples (Lawo & Lawo 2011).

STATISTICAL ANALYSIS

The data of developmental duration, immature survival rate, sex ratio, and effects of different litchi cultivars on female lifespan and fecundity of *O. litchii* were evaluated using 1-way analysis of variance (ANOVA), and means were separated by Tukey's test.

Downloaded From: https://bioone.org/journals/Florida-Entomologist on 29 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

Results

BIOLOGICAL AND BEHAVIORAL OBSERVATION

Life stages of *O. litchii* consist of egg, larva, protonymph, deutonymph, and adult (Fig. 1). The *O. litchii* went through 3 molts between the egg and adult stages. During each molt, the mites attached themselves to the surface of the host plant and underwent a quiescent period, in the same manner as other spider mites (Goldarazena et al. 2004; Negm et al. 2014; Oku 2016). Mating occurred within 24 h after the adult female reached sexual maturation. Gravid females move around slowly and prefer to spin visible webs near the midrib of host leaves, on which they walk and lay eggs. The newly deposited eggs are translucent, oval in shape, with a sticky surface, and become cream colored before hatching. The newly hatched larva has 3 pairs of legs, whereas the protonymph, deutonymph, and adult of *O. litchii* have 4 pairs of legs, as well as larger body size, darker brownish body color, and faster mobility than larvae. Gender can be easily identified in the adult stage, because the adult female is larger in body size and has a more rounded posterior margin of the abdomen than the adult male.

DEVELOPMENT AND SURVIVAL OF IMMATURE MITES

The development time of different stages (before maturation) of *O. litchii* is given in Table 1. Egg incubation period of *O. litchii* was significantly longer on Nuomici than on the other 3 cultivars ($P < 0.05$; Table 1). On the contrary, the deutonymph period of *O. litchii* on Nuomici was the shortest (1.94 ± 0.20 d) among the 4 litchi cultivars. Total development time ranged from 12.26 ± 0.32 to 14.56 ± 0.20 d (mean ± SE), but no significant difference was observed among Feizixiao, Sanyuehong, and Nuomici. In addition, due to the different development rates among individuals as well as between sexes, there were significant overlaps between different stages. The age-stage survival rate (s_{xj}) of *O. litchii* was the probability that a newly hatched larva will survive to age x and stage j (Fig. 2). Except for the overlaps between different stages, these curves also showed the stage differentiation and survivorship of *O. litchii*. The probability that a newly laid egg survives to adult stage was similar on Baili and Feizixiao (0.15, 0.17 for females, and 0.06, 0.07 for males, respectively), whereas survival was lower than that on Sanyuehong and Nuomici (0.48, 0.51 for females, and 0.15, 0.18 for males, respectively). The female adults emerged earlier and survived longer than males on all 4 tested litchi cultivars.

ADULT FEMALE LONGEVITY AND FECUNDITY

The longest female lifespan of *O. litchii* was 32.67 d on Nuomici, whereas the shortest female longevity was 25.95 d on Sanyuehong. In addition, different litchi cultivars had different impacts on fecundity of adult female mites. The longest preoviposition period and oviposition period were registered on Baili and Nuomici, respectively ($P < 0.05$; Table 2). Total fecundity of *O. litchii* was significantly different among the tested litchi cultivars, and was highest on Nuomici (64.84 ± 3.57 eggs per female). The progeny sex ratio [♀/(♀ + ♂)] on Nuomici and Sanyuehong was female-biased as shown in Table 2. Figure 3 illustrates m_x and l_x of *O. litchii*. The first eggs on Baili, Feizixiao, Sanyuehong, and Nuomici were laid at the d-age (from egg to the first eggs laid by female) of 11, 11, 10, and 12 d, respectively. The maximal daily oviposition per female on Nuomici and Sanyuehongwas significantly higher than on Feizixiao and Baili. Maximum egg production was observed on Nuomici. Moreover, the age-specific survival rate (l_x) of *O. litchii* reared on 4 litchi cultivars decreased sharply before the protonymph stage, and resulted in a plateau in the survivorship curve; subsequently, sur-

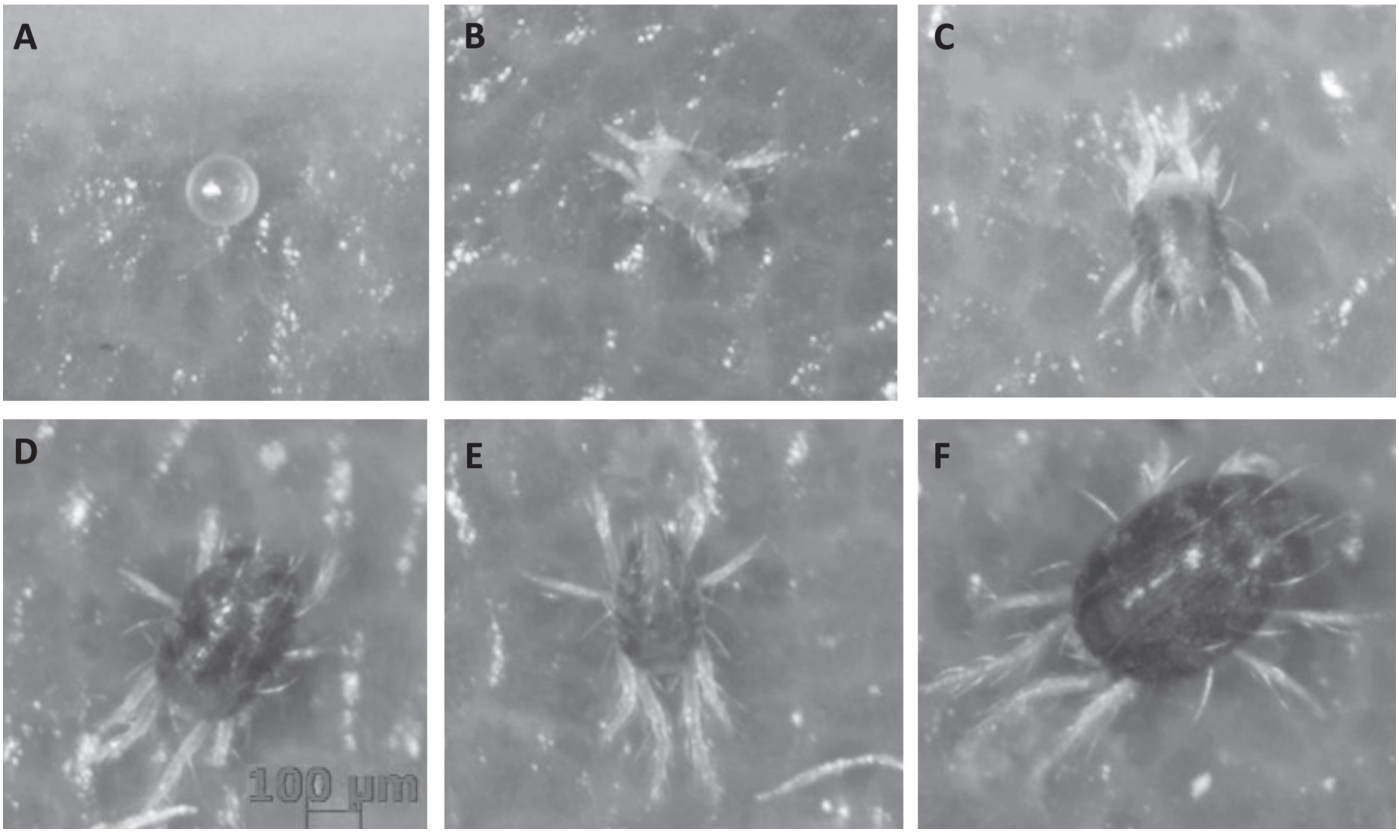


Fig. 1. Life stages of *Oligonychus litchi*: (A) egg; (B) larva; (C) protonymph; (D) deutonymph; (E) adult male; (F) adult female.

Downloaded From: https://bioone.org/journals/Florida-Entomologist on 29 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

Table 1. Duration of the development stages and immature survival rate (ISR) of *Oligonychus litchii* mites on 4 litchi cultivars under laboratory conditions.

	Duration of development stage (d)					
Litchi cultivars	E	L	P	D	TDT	ISR (%)
Baili	2.71 ± 0.21 b	3.13 ± 0.22 a	3.31 ± 0.36 a	3.08 ± 0.34 a	14.56 ± 0.20 a	21.74 ± 1.30 c
Feizixiao	2.53 ± 0.12 b	2.56 ± 0.10 b	2.22 ± 0.13 b	2.63 ± 0.22 ab	11.80 ± 0.61 b	23.91 ± 1.70 c
Sanyuehong	2.60 ± 0.11 b	2.33 ± 0.13 b	2.21 ± 0.14 b	2.27 ± 0.16 bc	10.57 ± 0.40 b	60.25 ± 3.40 b
Nuomici	3.50 ± 0.15 a	3.51 ± 0.16 a	2.03 ± 0.03 b	1.94 ± 0.20 c	12.26 ± 0.32 b	68.42 ± 2.80 a

E = egg; L = larva; P = protonymph; D = deutonymph; TDT = total development time; ISR = immature survival rate. Data in the table is mean ± SE; means in a column followed by different letters indicated significant differences (Tukey's test; $P < 0.05$).

vival continued to decrease until death (Fig. 3). However, the survival rate (the probability that a newly laid egg will survive to the sexual maturation stage) varied significantly among different litchi cultivars, with a range from 21.74 ± 1.30% on Baili to 68.42 ± 2.80% on Nuomici (Table 1). The l_x curve also showed that *O. litchii* survived and reproduced most successfully on Nuomici among the 4 tested litchi cultivars.

EFFECTS OF DIFFERENT LITCHI CULTIVARS ON THE LIFE TABLE PARAMETERS

Variation of life table parameters of *O. litchii* on 4 litchi cultivar leaves is presented in Table 3. These parameters were strongly affected by host plant cultivars. The intrinsic rate of population increase (r_m) showed a similar pattern to finite rate of increase (λ), in which the highest value occurred on Nuomici and Sanyuehong, followed by Feizixiao, whereas the lowest value was on Baili. The net reproductive rate (R_0) value was the highest on Nuomici and the lowest on Baili. The mean generation time (*T*) is the required time for the population of *O. litchii* to multiply, where R_0 and the *T* value varied from 27.19 ± 2.13 d (on Nuomici) to 18.93 ± 1.01 d (on Baili). The values of population doubling time (*DT*) ranged from 22.42 ± 2.67 (on Baili) to 4.56 ± 1.02 (on Sanyuehong).

Discussion

In this study, biological characteristics of *O. litchii* were investigated on 4 important commercial litchi cultivars. The 4 litchi cultivars tested varied in their date of fruit maturity: the early-maturing cultivar Sanyuehong, the mid-maturing cultivar Feizixiao, the mid-to-late-maturing cultivar Nuomici, and the late-maturing cultivar Baili. The results showed that *O. litchii* fed, survived, and developed on all 4 litchi cultivars. The development of *O. litchii* consists of 5 life stages with distinct biological characteristics, and it is only after the deutonymphal stage that the male and female litchi spider mites may be identified. The population growth parameters of *O. litchii*, such as the developmental duration of the egg, larva, protonymph, and deutonymph, varied in response to changes in litchi cultivars as show in Table 1. The dif-

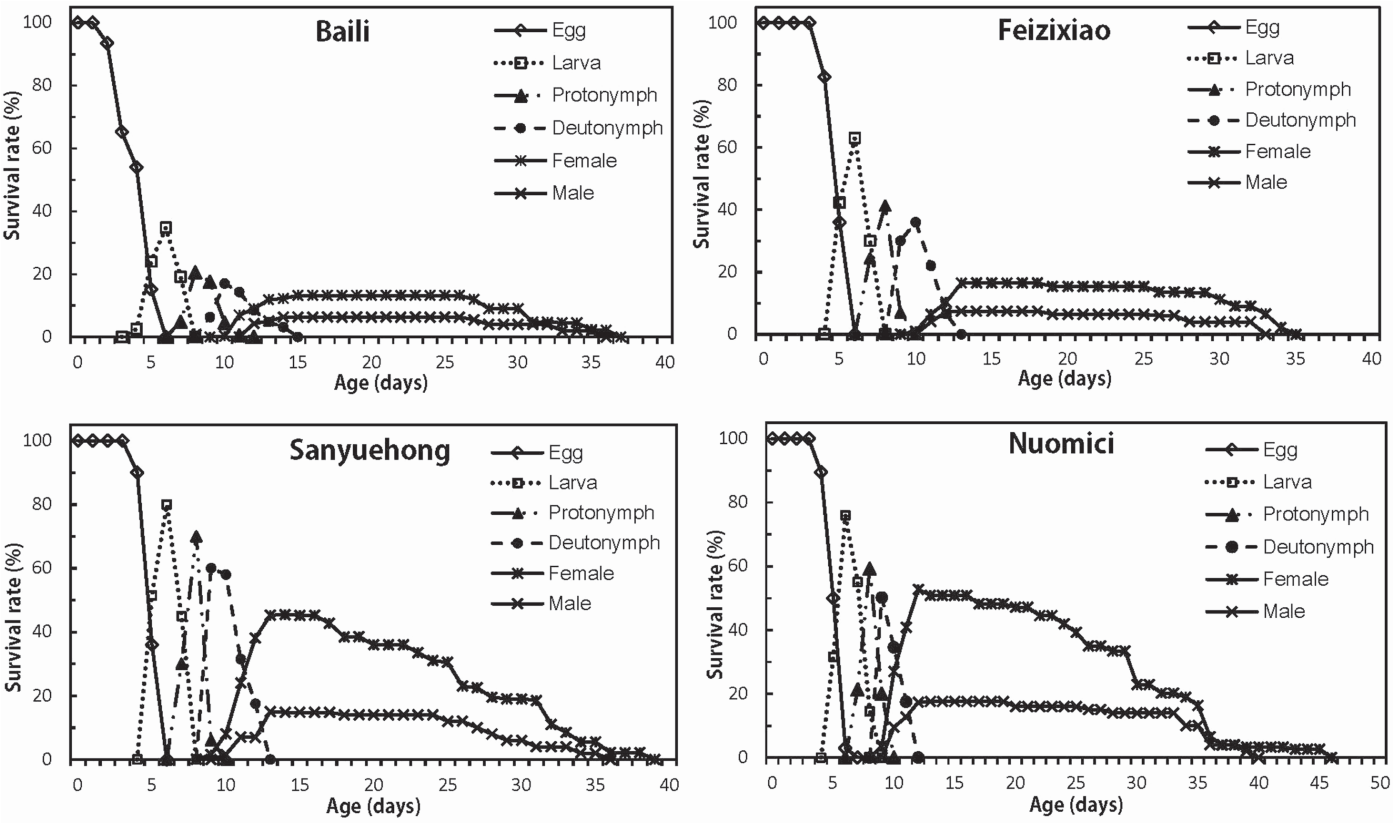


Fig. 2. Age-stage-specific survival rate of *O. litchii* reared on different litchi cultivars at 25 ± 1 °C, 65 to 80% RH, and a photoperiod of 14:10 h (L:D).

Downloaded From: https://bioone.org/journals/Florida-Entomologist on 29 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

Table 2. Effects of different litchi cultivars on lifespan and fecundity of female *Oligonychus litchii*.

Litchi cultivar	Female lifespan (egg to death; d)	Fecundity			
		Preoviposition period (d)	Oviposition period (d)	Total fecundity (eggs per female)	Sex ratio (% females)
Baili	29.50 ± 2.03 b	2.44 ± 0.35 a	9.78 ± 1.53 c	14.78 ± 1.66 d	67.67 ± 2.77 b
Feizixiao	29.70 ± 0.92 b	1.40 ± 0.16 b	15.50 ± 1.30 b	22.30 ± 1.59 c	68.92 ± 3.05 b
Sanyuehong	25.95 ± 1.09 c	0.86 ± 0.19 c	12.40 ± 1.20 c	38.55 ± 2.34 b	76.09 ± 2.16 a
Nuomici	32.67 ± 1.62 a	1.37 ± 0.21 b	19.70 ± 1.73 a	64.84 ± 3.57 a	75.24 ± 1.98 a

Data in the table is mean ± SE; means in a column followed by different letters indicated significant differences (Tukey's test; $P < 0.05$).

ferences in population growth parameters could be ascribed to the variations in host plant quality and availability of nutrition for the mite pests (Awmack & Leather 2002; Van et al. 2003). In previous studies of other spider mites, Vasquez et al. (2008) reported that the average longevity of *Oligonychus punicae* (Prostigmata: Tetranychidae) females ranged from 8.10 to 17.50 d on 6 different grapevine cultivars. Dongyin et al. (2013) observed that the duration of development of *P. ulmi* was slightly different on 3 apple cultivars with a range from 10.70 to 11.70 d, and Najafabadi et al. (2014) reported that the duration of development of *T. urticae* was highly affected by different bean cultivars, with a range from 12.00 to 24.74 d. Thus, different host plant cultivars have a decisive impact on the duration of development in spider mites. In our study, the total development time of *O. litchii* on Baili(14.56 ± 0.20 d) was significantly longer than that for the other 3 cultivars, and this was predominantly due to longer larva, protonymph, and deutonymph duration on Baili cultivar. Furthermore,the survival rate of immature stages of *O. litchii* on litchi cultivars ranged from 21.74% to 68.42%, and the lowest immature survival rate of *O. litchii* was observed on Baili cultivar (Table 1, Fig. 3). These results suggested that the Baili cultivar was less suitable to immature development of the litchi spider mite, and different litchi cultivars had significant impacts on the developmental duration of litchi spider mite. A possible explanation is the differences in the characteristics among the 4 litchi cultivars, and include nutritional components, secondary metabolites, and morphology of the leaf surface. Baili is a late-maturing cultivar, with light-green leaf color that results in lower levels of nutrient accumulation in leaves as compared to the other 3 litchi cultivars tested.

Female lifespan, preoviposition and oviposition period, and total fecundity were highly affected by host plant cultivars. Previous studies suggested that the increase of female longevity is an important adaptation for insects to maintain a population when nutrition supply is limited or food quality is low (Uçkan & Ergin 2002; Najafabadi et al. 2014). In the comparative demography study of *O. afrasiaticus* on palm cultivars, the adult longevity on Deglet Noor cultivar (13.46 d) was significantly longer than that on Bessr cultivar (7.6 d), whereas no statistically significant differences were found in egg hatchability among the experimental cultivars (Ben et al. 2011). A range of different total fecundity values from 20.62 to 34.12 was observed in the study of *P. ulmi* on 4 apple cultivars

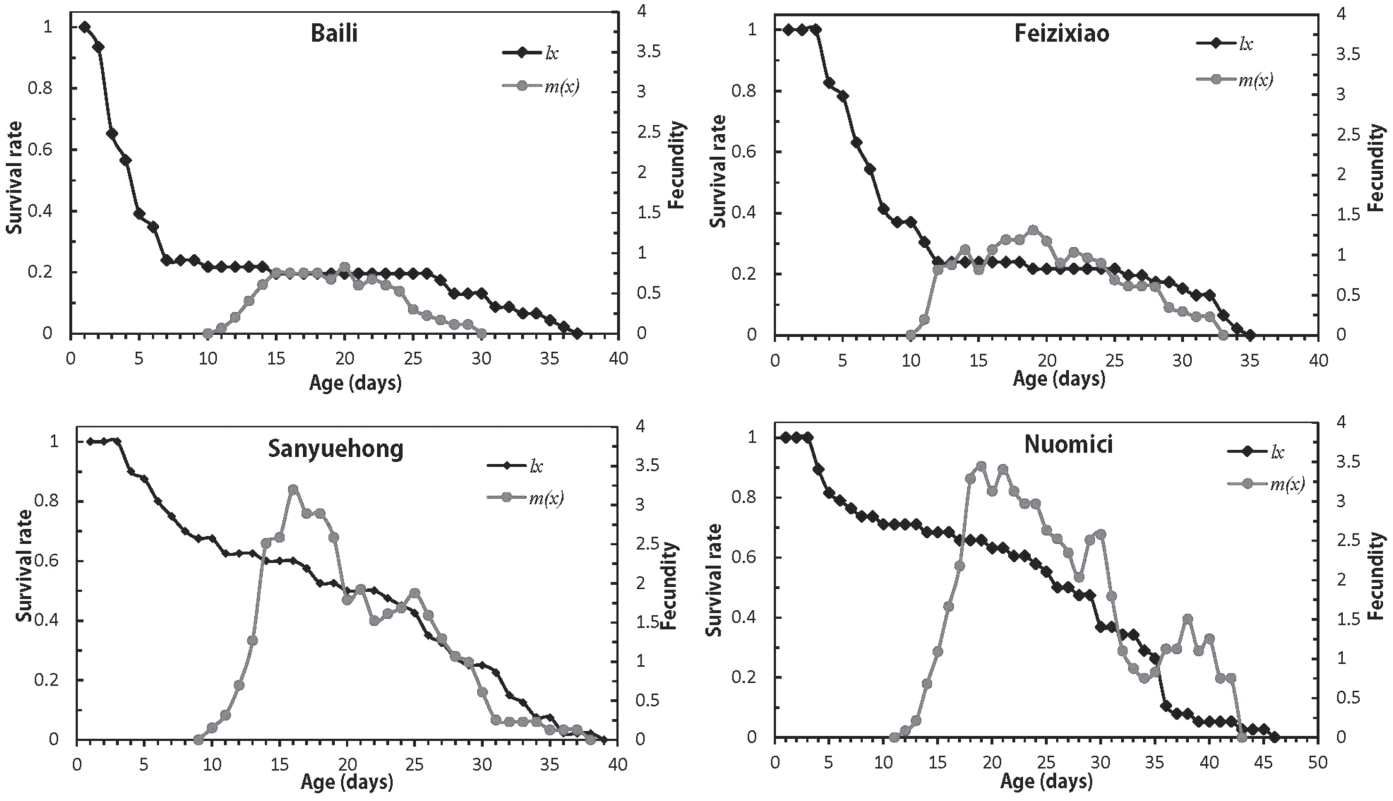


Fig. 3. Age-specific survival rate (l_x), age-specific fecundity (m_x) of *O. litchii* reared on different litchi cultivars at 25 ± 1 °C, 65 to 80% RH, and a photoperiod of 14:10 h (L:D).

Downloaded From: https://bioone.org/journals/Florida-Entomologist on 29 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

Table 3. Life table parameters of *Oligonychus litchii* reared on 4 litchi cultivars under laboratory conditions.

	Life table parameters				
Litchi cultivars	r_m (♀/♀ per d)	R_0 (♀/♀ per generation)	T (d)	λ (♀/♀ per d)	DT (d)
Baili	0.04 ± 0.01 c	1.79 ± 0.35 d	18.93 ± 1.01 b	1.03 ± 0.01 c	22.42 ± 2.67 a
Feizixiao	0.07 ± 0.01 b	3.76 ± 0.61 c	19.49 ± 0.98 b	1.07 ± 0.01 b	10.20 ± 0.90 b
Sanyuehog	0.15 ± 0.02 a	17.80 ± 2.14 b	18.89 ± 2.03 b	1.16 ± 0.02 a	4.56 ± 1.02 c
Nuomici	0.14 ± 0.03 a	22.86 ± 2. 36 a	27.19 ± 2.13 a	1.16 ± 0.04 a	4.80 ± 0.86 c

Data in the table is mean ± SE; means in a column followed by different letters indicated significant differences (Tukey's test: $P < 0.05$).
r_m = instrnsic rate of natural increase per d; R_0 = net reproductive rate; T = mean generation time; λ = finite rate of increase; DT = population doubling time.

(Dongyin et al. 2013). In our study, the longest lifespan of female mites was registered on Nuomici (32.67 d), followed by that on Feizixiao (29.70 d) and Baili (29.50 d), and the shortest one was recorded on Sanyuehong (25.95 d) (Table 2). Intriguingly, total fecundity of female *O. litchii* on Sanyuehong (38.55 eggs per female) was significantly higher than on Feizixiao (22.30 eggs per female) and Baili (14.78 eggs per female). Shorter duration of development together with higher total fecundity of tetranychid species indicates greater suitability of a host plant (Awmack & Leather 2002). Our results showed that the shortest female lifespan of *O. litchii* was observed on Sanyuehong, but the maximal daily oviposition per female and the highest total fecundity were observed on Nuomici (Table 2, Fig. 3). Thus, it is difficult to evaluate the suitability of these 4 litchi cultivars for litchi spider mites in our study according to lifespan and fecundity parameters.

Life table study is a powerful tool to describe information on development, fecundity, and population dynamics of insects (Mahmood 1997; Hongsen et al. 2014). Previous studies have demonstrated cultivar effects on life table parameters of tetranychid species. The study of *O. punicae* on 6 grapevine cultivars showed the r_m value ranged from 0.14 to 0.31, the R_0 value ranged from 3.85 to 18.47, and the T value ranged from 14.13 to 17.96 (Vasquez et al. 2008). The life parameters of *T. urticae* varied significantly on 6 bean cultivars with a r_m value range from 0.13 to 0.27, a bigger R_0 value range from 26.11 to 62.38, a λ value varied from 1.13 to 1.30, and a DT value varied from 2.54 to 5.33 (Najafabadi et al. 2014). Among all the life-history parameters, the intrinsic rate of natural increase per d (r_m) and the net reproductive rate (R_0) are the most important demographic indicators to predict and evaluate the tetranychid population dynamics under given environmental conditions. Comparisons of these 2 indicators could provide more comprehensive insight than independent analysis of individual life table parameters (Mahmood 1997; Kasap 2003; Vasanthakumar & Babu 2013). In the current study, the r_m and R_0 of the litchi spider mite were highly affected by litchi cultivars. The r_m value varied from 0.04 to 0.14 females per female per d. Hence, the population development of *O. litchii* was the shortest on Sanyuehong and Nuomici. These results were probably due to short immature duration and high total fecundity on those 2 litchi cultivars. The highest R_0 value was observed on Nuomici (22.86 per d), followed by Sanyuehong (17.80 per d) and Feizixiao (3.76 per d), and the shortest was on Baili (1.79 per d) (Table 3). A significant difference in R_0 values could induce remarkable difference in population growth over time. Furthermore, the higher r_m and R_0 value indicated the susceptibility of a litchi cultivar to *O. litchii*, whereas the lower value of the 2 indicators indicate the resistance of a litchi cultivar to litchi spider mite. However, our findings have revealed that Nuomici is the most suitable and susceptible cultivar for *O. litchii*, whereas Baili is the most resistant cultivar to *O. litchii* among these 4 important commercial litchi cultivars.

Spider mites are recognized as a major secondary pest and a threat to agricultural production (Chyi-chen 2000; Perumalsamy et al. 2010), because natural enemies of mites are suppressed by the broad usage of pesticides. Currently, the litchi spider mite has become a serious pest, damaging over 70 plant species, including some very important fruit crops including litchi, guava, loquat, and wax apple in southern China and Taiwan (Ho 2004; Shu et al. 2014b; Wenhua et al. 2016). Basic information on the developmental duration, female longevity, and fecundity and life history parameters would be helpful to better understand the occurrence and population dynamics of *O. litchii*. This information, together with further field research in litchi orchards would provide comprehensive information for elucidating the nature of host suitability and improving the integrated pest management of *O. litchii*.

Acknowledgments

We are grateful to K. Lu (College of Life Sciences, Fujian Agriculture and Forestry University, Fujian, China) for his suggestions for the manuscript. This study received financial support from the National Science Foundation of China (Grant No. 31801800), the Natural Science Foundation of Guangdong Province (Grant No. 2017A030310095), the Pearl River Nova Program of Guangzhou (Grant No. 201710010180), and the China Litchi and Longan Research System Foundation (CARS-32-12).

References Cited

Awmack CS, Leather SR. 2002. Host plant quality and fecundity in herbivorous insects. Annual Review of Entomology 47: 817–844.

Ben Chaaban S, Chermiti B, Kreiter S. 2011. Comparative demography of the spider mite, *Oligonychus afrasiaticus*, on four date palm varieties in southwestern Tunisia. Journal of Insect Science 11: 136. doi:10.1673/031.011.13601

Birch LC. 1948. The intrinsic rate of natural increase of an insect population. Journal of Animal Ecology 17: 15–26.

Chyi-chen H. 2000. Spider-mite problems and control in Taiwan. Experimental and Applied Acarology 24: 453–462.

Chyi-chen H. 2004. Litchi spider mite (*Oligonychus litchii*) has become an important agricultural spider mite in Taiwan. The Plant Protection Bulletin 31: 927–930. (in Chinese).

Deevey J. 1947. Life tables for natural populations of animals. The Quarterly Review of Biology 22: 283–314.

Dongyin W, Guisheng Q, Wentao Y, Lina S, Huaijiang Z, Chunsen M, Adaobi UP. 2013. Age-stage two-sex life tables of *Panonychus ulmi* (Acari: Tetranychidae), on different apple varieties. Journal of Economic Entomology 106: 2118–2125.

Goldarazena A, Aguilar H, Kutuk H, Childers CC. 2004. Biology of three species of *Agistemus* (Acari: Stigmaeidae): life table parameters using eggs of *Panonychus citri* or pollen of *Malephora crocea* as food. Experimental and Applied Acarology 32: 281–291.

Ho CC. 2004. Litchi spider mite (*Oligonychus litchii*) has become an important agricultural spider mite in Taiwan. Plant Protection Bulletin 46: 299–302.

Houbin C. 2017. A survey on lychee and longan industry in China, pp. 3–4 *In* Annual Meeting for Work Reports of China Litchi and Longan Research System. Guangzhou, China, 27–30 Dec 2017. (in Chinese).

Downloaded From: https://bioone.org/journals/Florida-Entomologist on 29 Mar 2024
Terms of Use: https://bioone.org/terms-of-use

Huang X, Zeng L, Houbin C. 2005. Lychee and longan production in China. Acta Horticulturae 665: 27–36.

Hongsen P, Bing L, Yanghui L, Desneux N. 2014. Life table parameters of three mirid bug (*Adelphocoris*) species (Hemiptera: Miridae) under contrasted relative humidity regimes. PloS One 9: e115878. doi:10.1371/journal.pone.0115878

Jih-Zu Y, Hsin C, Bing-Huei C. 2005. Life table and predation of *Lemnia biplagiata* (Coleoptera: Coccinellidae) fed on *Aphis gossypii* (Homoptera: Aphididae) with a proof on relationship among gross reproduction rate, net reproduction rate, and preadult survivorship. Annals of the Entomological Society of America 98: 475–482.

Kasap I. 2003. Life history of hawthorn spider mite *Amphitetranychus viennensis* (Acarina: Tetranychidae) on various apple cultivars and at different temperatures. Experimental and Applied Acarology 31: 79–91.

Lawo JP, Lawo NC. 2011. Misconceptions about the comparison of intrinsic rates of natural increase. Journal of Applied Entomology 135: 715–725.

Mackauer M. 1983. Quantitative assessment of *Aphidius smithi* (Hymenoptera: Aphidiidae): fecundity, intrinsic rate of increase, and functional response. Canadian Entomologist 115: 399–415.

Mahmood F. 1997. Life-table attributes of *Anopheles albimanus* (Wiedemann) under controlled laboratory conditions. Journal of Vector Ecology 22: 103–108.

Menzel C. 2002. Major pests and diseases. The lychee crop in Asia and the Pacific. Publication 2002/16. Food and Agriculture Organization of the United Nations Regional Office for Asia and the Pacific, Bangkok, Thailand. http://www.fao.org/docrep/005/ac681e/ac681e00.htm (last accessed 4 Jan 2019).

Najafabadi SS, Shoushtari RV, Zamani AA, Arbabi M, Farazmand H. 2014. Life parameters of *Tetranychus urticae* (Acari: Tetranychidae) on six common bean cultivars. Journal of Economic Entomology 107: 614–622.

Negm MW, Alatawi FJ, Aldryhim YN. 2014. Biology, predation, and life table of *Cydnoseius negevi* and *Neoseiulus barkeri* (Acari: Phytoseiidae) on the old world date mite, *Oligonychus afrasiaticus* (Acari: Tetranychidae). Journal of Insect Science 14: 177. doi.org/10.1093/jisesa/ieu039

Oku K. 2016. Precopulatory mate guarding influences the development of quiescent deutonymph females in the two-spotted spider mite (Acari: Tetranychidae). Experimental and Applied Acarology 68: 33–38.

Perumalsamy K, Selvasundaram R, Roobakkumar A, Rahman VJ, Muraleedharan N. 2010. Life table and predatory efficiency of *Stethorus gilvifrons* (Coleoptera: Coccinellidae), an important predator of the red spider mite, *Oligonychus coffeae* (Acari: Tetranychidae), infesting tea. Experimental and Applied Acarology 50: 141–150.

Rahman VJ, Babu A, Roobakkumar A, Perumalsamy K. 2013. Life table and predation of *Neoseiulus longispinosus* (Acari: Phytoseiidae) on *Oligonychus coffeae* (Acari: Tetranychidae) infesting tea. Experimental and Applied Acarology 60: 229–240.

Shu X, Kaige C, Qiong Y, Yizhi D, Binxu C. 2014a. Sublethal effects of pyridaben on *Oligonychus litchii*. Journal of Fruit Science 31: 927–930. (in Chinese).

Shu X, Yao Y, Kaige C, Tao J, Binxu C. 2014b. Toxicity test and field efficacy of 5 kinds of acaricides against *Oligonychus litchii*. Guangdong Agriculture Science 14: 83–85. (in Chinese).

Southwood TRE. 2000. Age-grouping, time-specific life tables, and predictive population models, pp. 404–454 *In* Southwood TRE, Henderson PA [eds.], Ecological Methods, 3rd edition. Blackwell Science Press, Oxford, United Kingdom.

Uçkan F, Ergin E. 2002. Effect of host diet on the immature developmental time, fecundity, sex ratio, adult longevity, and size of *Apanteles galleriae* (Hymenoptera: Braconidae). Environmental Entomology 31: 168–171.

Van BC, Van-beek TA, Dicke M. 2003. Differences among plant species in acceptance by the spider mite *Tetranychus urticae* Koch. Journal of Applied Entomology 127: 177–183.

Vasanthakumar D, Babu A. 2013. Life table and efficacy of *Mallada desjardinsi* (Chrysopidae: Neuroptera), an important predator of tea red spider mite, *Oligonychus coffeae* (Acari: Tetranychidae). Experimental and Applied Acarology 61: 43–52.

Vasquez C, Aponte O, Morales J, Sanabria ME, Garcia G. 2008. Biological studies of *Oligonychus punicae* (Acari: Tetranychidae) on grapevine cultivars. Experimental and Applied Acarology 45: 59–69.

Wall MM. 2006. Ascorbic acid and mineral composition of longan (*Dimocarpus longan*), lychee (*Litchi chinensis*) and rambutan (*Nephelium lappaceum*) cultivars grown in Hawaii. Journal of Food Composition and Analysis 19: 655–663.

Wyatt IJ, White PF. 1977. Simple estimation of intrinsic increase rates for aphids and tetranychid mites. Journal of Applied Entomology 14: 757–766.

Wei L, Zhidan X, Xiuli B, Xiaoyang Y, Jing F, Xiang X. 2015. Identifying litchi (*Litchi chinensis* Sonn.) cultivars and their genetic relationships using single nucleotide polymorphism (SNP) markers. PloS One 10: e0135390. doi:10.1371/journal.pone.0135390

Wenhua C, Chaoyu LY, Tsuiying C. 2016. Temperature-dependent development and life history of *Oligonychus litchii* (Acari: Tetranychidae), on wax apple. Journal of Asia-Pacific Entomology 19: 173–179.

Downloaded From: https://bioone.org/journals/Florida-Entomologist on 29 Mar 2024
Terms of Use: https://bioone.org/terms-of-use