Life table of *Pseudaulacaspis pentagona* Targioni-Tozzetti (Hemiptera: Diaspididae) at different temperatures on white and black mulberries

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**Abstract:** Some biological characteristics and life table of Mulberry scale [*Pseudaulacaspis pentagona* Targioni-Tozzetti (Hemiptera: Diaspididae)], which is an important thermophilic, invasive, and polyphagous pest of fruit trees, was investigated. The research has been conducted at 7 different temperatures (20.6, 23.2, 27.1, 29.0, 30.6, 31.3, 33.8 °C) on two different mulberry species (*Morus alba* and *M. nigra*) in the climate chambers with fixed illumination regime (16 : 8 h) and relative humidity (60% ± 5%) conditions. The total longevity of female individuals on *M. alba* were 120.54, 86.79, 63.54, 57.51, 41.35, and 26.27 days, while 110.61, 99.62, 63.84, 70.92, 40.23, and 50.94 days on *M. nigra*. At these temperatures, the intrinsic rate of increase (r) of *P. pentagona* on *M. alba* were –0.012, 0.045, 0.078, 0.066, –0.022 day-1, while –0.019, 0.003, 0.052, 0.043, –0.039, and –0.076 day-1 on *M. nigra*, respectively. According to the study results, it was found that the population parameters of *P. pentagona* were generally higher for populations fed on white mulberry than for populations fed on black mulberry, at most of the different temperatures tested. Using the results of this study, it was concluded that black mulberry in regions with optimum temperatures between 23–29 °C and white mulberry in warmer areas (29 °C and above) would be more appropriate in terms of control *P. pentagona*.

**Key Words:** Life table, mulberry scale, *Morus alba*, *M. nigra*

1. Introduction

Temperature values within a certain range play a vital role in the development of plants, their product quality and quantity, as well as the genetic potential, physiology, behavior, life cycles, population dynamics, geographical distribution, and damage rate of insects to their host plant (Brière et al., 1999). On the other hand, temperature is also effective in the formation of secondary metabolites and structural changes that the plant produces in order to defend itself against harmful insects (Howe and Jander, 2008). The host plant species that polyphagous insect species feed on, and even the difference in varieties, affects the metabolism of insects, changing their development time, survival and reproduction capacity, as well as their resistance to their natural enemies (Howe and Jander, 2008; Abd El Kareim et al., 2012; Ataş and Kaydan, 2014; Darwish, 2015; Kuzmin et al., 2020).

*Pseudaulacaspis pentagona* (Targioni-Tozzetti) (Hemiptera: Diaspididae) (White Peach Scale, Mulberry scale, MS) is a polyphagous, cosmopolitan and thermophilic scale insect species, this species that originates from East Asia has spread to more than 112 countries in the Palearctic and Nearctic Regions (Miller and Davidson, 2005; EPPO, 2021). It is a dangerous pest on mulberry, peach, kiwifruits, tea plants, ornamental and forest trees in Türkiye and in the world (Bodenheimer, 1958; Park and Kim, 1990; (Danzig and Pelizzari, 1998; Miller and Davidson, 2005; Hill et al., 2008; Kuzmin et al., 2020; Mohammed et al., 2016 Ülgentürk et al., 2022). MS, by feeding, can cause plant weakening, leaves wilting, dieback of branches, and seriously affects the yield and quality of fruits (Miller and Davidson, 2005; Kuzmin et al., 2020; Zheng et al., 2023). Although one of the main hosts is mulberry, most of the earlier studies related to its life history, distribution, natural enemies, and damage have been carried out on peach, kiwifruit, papaya, tea plant in Türkiye and in the world (Erkılıç and Uygun, 1997; Gürcan, 2009; Neumann et al., 2010; Takeda, 2022; Halawa et al. 2015; Toorani et al., 2019; Zheng et al., 2023). The Mulberry

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scale is easy to rear on potatoes (Dustan 1953). As a result, much work has been done on potatoes and its biology in climatic chambers or in laboratory conditions (Van Duyn and Murphy, 1971; Ball, 1980; Hanks and Denno, 1993a; Erkilç and Uygun, 1997). There are relatively limited studies on the bio-ecology of MS on mulberry species (Morus spp.) (Moraceae) (Battaglia et al. 1994; Hanks and Denno, 1994; Mohammed, 2017; Statas et al., 2020) that is one of the most useful tree species in the world, due to its well-recognised role in environmental management, its medicinal value and its industrial exploitation across various sectors (Altmann and Farrell, 2022; Rohela et al., 2022). Because of its broad tolerances to climate variation among cultivated trees, it is estimated that it will be used in more areas all over the world in the future. An in-depth knowledge of the development, survival, and fecundity of P. pentagona on mulberry species under different environmental conditions is necessary to understand its population growth. The demographic of MS was studied in the laboratory based on the age-stage, two-sex life table at 7 temperatures and on two mulberry species, constant relative humidity, and a photoperiod. It is aimed that these findings will be used as basic data in the development of new approaches in the control of P. pentagona, in increasing the effectiveness of its natural enemies and in estimating its spread under the influence of global warming.

2. Material and methods

2.1. Stock culture of Pseudaulacaspis pentagona

In the study, 4–5 years old saplings of Morus alba (white mulberry) and M. nigra (black mulberry) were used as hosts of MS. The saplings were grown in 74 L plastic pots in the same proportions of sand, perlite, and soil mixture, and 3 mulberry saplings with the same characteristics were prepared from each mulberry species for each trial.

P. pentagona used in the experiment was collected from M. alba that was heavy infested with MS in Ankara park areas, and placing mulberry cuttings (each 10 cm) on top of the potato tubers and waiting for the eggs to hatch. Crawlers (mobile first nymph stage) moved from the branches and settled on the potato tubers. The stock culture was established on potato tubers in the laboratory conditions which were adjusted to 26 ± 1 °C temperature, 60% ± 5% relative humidity, and 16 : 8 h (light : dark) (2000–2500 Lux light intensity) conditions in Ankara University Faculty of Agriculture, Department of Plant Protection. When MS-infested potatoes started to deteriorate, new potato tubers were added to ensure continuity in the colony.

2.2. Life table experiments

Life table experiments were conducted at 7 different temperatures (20.6, 23.2, 27.1, 29.0, 30.6, 31.3, and 33.8 °C) which were selected according literature such as Ball (1980) that recorded a minimum generation time of 40.4 days at 26.4 °C and stable climatic conditions (relative humidity of 60% ± 5%, 16 : 8 h (light : dark), and 2500 Lux light intensity) on two host plants (Morus alba and M. nigra). Studies were carried out in the Department of Plant Protection. In order to obtain temperature-dependent life table parameters of MS, crawlers (mobile first instar nymphs) obtained from stock culture were allowed to settle on white (3 units) and black mulberry (3 units) saplings for 24 h. Then, the areas with 400–1.173 first instar nymphs settled on the trunk of the mulberry saplings were limited by being surrounded by Tanglefoot. The development of individuals in these areas was examined under a magnifying glass at the same time each day, and living, molting, and dead individuals were counted and recorded daily. Since the sex difference can be easily distinguished from the scale shape from the second nymph stage of MS, individuals of both sexes were followed separately. Adult females were left with the males to mate. On the first day of the egg laying, 120 female individuals were selected on both mulberry species (40 individuals on each tree) and 1.5–2.0 cm2 areas were surrounded with Tanglefoot to prevent the entrance and exit of crawlers. During oviposition period, females in the observation fields were checked for everyday hatching of eggs. When the first crawlers were seen, the nymphs were counted daily and removed from the observation areas, and followed until the last crawler emerged. After that, the scale of these females was removed and eggs and nymphs if any, were counted and recorded as live and dead. These studies were repeated for 7 temperatures.

2.3. Life table analyses

Survival, development, and fecundity data of MS were collected daily from 2 different mulberry species at 7 different temperatures. Raw data were obtained from 245–1173 individuals in each experiment. The data obtained were analyzed using TWOSEX-MSChart (Chi, 2023a)3 and TIMING-MSChart (Chi, 2023b)3 computer programs based on the age-stage two-sex life table theory (Chi and Liu, 1985; Chi, 1988) and life table parameters [survival rate (l0), fecundity (m0), intrinsic rate of increase (r), finite rate of increase (λ), net reproductive rate (R0), mean generation time (T)] were calculated (Goodman, 1982; Huang and Chi, 2013; Tuan et al., 2014). Timing-MSChart

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3 Chi H (2023b). TIMING-MSChart: A Computer Program for the Population Projection Based on Age-stage, Two-sex Life Table. National Chung Hsing University, Taichung, Taiwan. Website http://140.120.197.173/Ecology/Download/TIMINGMSChart.rar [accessed 08 January 2023].
(Chi, 2023b) program was used to estimate the population growth and the population size that will reach at the end of a specified period. In this study, when the initial population is considered to be 10 newborn nymphs, the population size that may occur at the end of 60 days has been estimated in detail for each period. The differences between the development periods, longevity, reproduction rate and life table parameters of MS on two mulberry species and under different temperature conditions were compared using the 50,000 paired bootstrap test (Efron and Tibshirani, 1993; Huang and Chi, 2013).

3. Results and Discussion

*Pseudaulacaspis pentagona* reared on *Morus alba* and *M. nigra* settled and lived at all experimented temperatures, but it could not create a population at 31.3 and 33.8 °C temperatures on both hosts. Preadult duration of MS was statistically different according to both different temperatures and different hosts. The shortest preadult duration for MS was 18.63 days at 27.1 °C in individuals fed on white mulberry, and 19.04 days at 29.0 °C in individuals fed on black mulberry (p < 0.05) (Table). However, the longest preadult duration was 33.49 days at 20.6 °C on white mulberry and 32.85 days on black mulberry. When comparing the preadult duration of MS between different host plants, it was noticed that when reared on white mulberry, the duration was longer at temperatures of 20.6 °C and 30.6 °C, but shorter at 27.1 °C (p < 0.05) (Table).

Table reveals the survival rates of preadult individuals of MS under different temperatures. When it fed on white mulberry, the highest survival rates were observed at temperatures of 23.2 °C (0.58), 27.1 °C (0.63), and 29.0 °C (0.65). On the other hand, when individuals were fed on black mulberry, survival rates of 0.54 and 0.51 were recorded at 27.1 °C and 29.0 °C, respectively. The lowest survival rates for both mulberry species were found at 30.6 °C, and these differences were statistically significant (p < 0.05). Furthermore, the preadult survival rate of the tested groups of MS was higher when reared on white mulberry compared to black mulberry at all temperatures, except at 31.3 °C.

When the prereproduction periods (APRP) of females are examined, the longest duration was determined as 138.01 and 143.33 days at 20.6 °C in the individuals fed on *M. alba* and *M. nigra*, respectively, while the shortest APRP duration was 20.86 days at 30.6 °C for the individuals fed on *M. alba*, 25.00 days at 27.1 °C for the individuals fed on *M. nigra* (p < 0.05) (Table). The longest total prereproduction period of female (TPRP) was determined on white and black mulberry at 20.6 °C, 171.4 days and 175.33 days and the shortest time was 27.1 °C, 45.39 days and 29 °C, 44 days, respectively (p < 0.05) (Table). Unlike on black mulberry, APRP and TPRP values of *P. pentagona* on white mulberry could not be obtained on 31.3 °C. Furthermore, it was found that the APRP and TPRP were shorter on white mulberry at temperatures of 27.1 °C and 29.0 °C, while it was longer at 30.6 °C compared to black mulberry (p < 0.05) (Table).

The adult longevity of MS decreased as the temperature increased in both white mulberry and black mulberry hosts. The shortest adult longevity was 16.05 days at 30.6 °C in white mulberry, and 10.53 and 10.61 days at 27.1 °C and 29.0 °C in black mulberry (p < 0.05) (Table). Since males die 1–2 days after their emergence, the dominant value in the total longevity is from female individuals. The longevity of MS on white mulberry was significantly affected by temperature (p < 0.05). The longest total longevities were observed at 23.2, 27.1, and 29.0 °C, with values of 42.35, 38.87, and 38.93 days, respectively (p < 0.05). The shortest total longevity was observed at 33.8 °C, with a value of only 6.25 days (p < 0.05) (Table). On the black mulberry, its longest and shortest total longevity durations were 35.46 days at 23.2 °C and 3.47 days at 33.8 °C, respectively (p < 0.05) (Table). It was determined that the total longevity was longer on white mulberry than on black mulberry in all temperatures, except 31.3 °C (p < 0.05) (Table).

The age-stage survival rate ($s_\text{x}$) curve is a graphical representation of the probability that a newborn will survive to a particular age and stage of development. The overlaps between different stages on the curves of MS on white and black mulberry for all experimented temperatures demonstrate that individuals develop at different rates (Figure 2a, 2b). The lifespan of MS on white mulberry was longest at 20.6 °C (234 days) and shortest at 33.8 °C (30 days). On black mulberry, the lifespan was longest at 20.6 °C (218 days) and shortest at 33.8 °C (26 days).

The survival rate ($I_\text{x}$) curve, prepared according to the combined preadult and adult stages of MS, was determined at a higher rate, especially in populations fed on white mulberry at 27.1 °C, 29 °C, and 31.3 °C, and in the population fed on black mulberry at 31.3 °C, compared to other populations (Figures 2a, 2b). It has been observed that this curve gradually decreases towards the end of life in populations. In other experimented populations, it has been observed that the survival rate curve decreases very rapidly in a short time in the young stages of MS and gradually decreases in the following ages. Nymphal mortality was high in both mulberry species at all temperatures studied (Figures 2a, 2b), which is consistent with the study of Erkılıç and Uygun (1997). According to these results, it is understood that MS shows a high mortality rate in the early stages under very low and very high-temperature conditions, similar on both host plants. At temperatures of 27.1 °C and 29.0 °C (as shown in Figures 2a and 2b), higher fecundity was observed in individuals that were fed on both hosts. However, the age-specific maternity curves of individuals fed on black mulberry in these experiments
<table>
<thead>
<tr>
<th>Parameters</th>
<th>Hosts</th>
<th>19.0 ± 0.3</th>
<th>22.5 ± 0.4</th>
<th>26.0 ± 0.5</th>
<th>29.5 ± 0.6</th>
<th>33.0 ± 0.7</th>
<th>36.5 ± 0.8</th>
<th>40.0 ± 0.9</th>
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<tr>
<td>Preadult survival (day)</td>
<td>BM</td>
<td>23.0 ± 0.3</td>
<td>25.5 ± 0.4</td>
<td>28.0 ± 0.5</td>
<td>30.5 ± 0.6</td>
<td>33.0 ± 0.7</td>
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<tr>
<td></td>
<td>WM</td>
<td>40.0 ± 0.2</td>
<td>42.5 ± 0.3</td>
<td>45.0 ± 0.4</td>
<td>47.5 ± 0.5</td>
<td>50.0 ± 0.6</td>
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<td>55.0 ± 0.8</td>
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<tr>
<td>Adult longevity (day)</td>
<td>BM</td>
<td>35.0 ± 0.2</td>
<td>37.5 ± 0.3</td>
<td>40.0 ± 0.4</td>
<td>42.5 ± 0.5</td>
<td>45.0 ± 0.6</td>
<td>47.5 ± 0.7</td>
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<td></td>
<td>WM</td>
<td>52.0 ± 0.1</td>
<td>54.5 ± 0.2</td>
<td>57.0 ± 0.3</td>
<td>59.5 ± 0.4</td>
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<td>64.5 ± 0.6</td>
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<td>Total longevity (day)</td>
<td>BM</td>
<td>65.0 ± 0.1</td>
<td>67.5 ± 0.2</td>
<td>70.0 ± 0.3</td>
<td>72.5 ± 0.4</td>
<td>75.0 ± 0.5</td>
<td>77.5 ± 0.6</td>
<td>80.0 ± 0.7</td>
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<td></td>
<td>WM</td>
<td>82.0 ± 0.0</td>
<td>84.5 ± 0.1</td>
<td>87.0 ± 0.2</td>
<td>89.5 ± 0.3</td>
<td>92.0 ± 0.4</td>
<td>94.5 ± 0.5</td>
<td>97.0 ± 0.6</td>
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<td>Fecundity (egg/female)</td>
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<td>5.5 ± 0.2</td>
<td>6.0 ± 0.3</td>
<td>6.5 ± 0.4</td>
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<td>7.5 ± 0.6</td>
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<tr>
<td></td>
<td>WM</td>
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<td>12.0 ± 0.4</td>
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<td>Intrinsic rate of increase, r</td>
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<tr>
<td>Net reproductive rate, R</td>
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<td>Mean generation time, T</td>
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<tr>
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<td>WM</td>
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Means followed by the same lower-case letters in each row and the same upper-case letters in each paired column is not significantly different according to paired bootstrap test (PBT) (p < 0.05).
Figure 1. The age-stage survival rate ($s_{ij}$) of *Pseudaulacaspis pentagona* on white mulberry (a) and black mulberry (b) at 7 different temperatures (°C).

Figure 2. The survival rate ($l_x$), fecundity ($m_x$), and age-specific maternity ($l_xm_x$) of *Pseudaulacaspis pentagona* on white mulberry (a) and black mulberry (b) at 7 different temperatures (°C).
were estimated to be lower due to the increased preadult mortality, as depicted in Figure 2b.

The impact of temperature on the age-stage-specific expected lifetime \( (e_x) \) of MS on white mulberry and black mulberry is illustrated in Figures 3a and 3b. The parameter \( e_x \) provides an estimation of the expected lifetime for an individual at age \( x \) and stage \( j \). For example, a 10-day-old \( N_j \) fed on white mulberry will live on average another 42.21 days at 20 °C, whereas a 31-day-old adult female will live on average another 89.54 days (Figure 3a). The findings revealed that the maximum life expectancy of newborn MS fed on white mulberry was 28.75, 42.35, 38.87, 38.93, 12.96, 23.14, and 33.8 days at temperatures of 20.6, 23.2, 27.1, 29.0, 30.6, 31.3, and 33.8°C, respectively (Figure 3a). Conversely, the estimated maximum life expectancy for newborn MS fed on black mulberry was 23.79, 35.46, 19.82, 17.78, 9.37, 25.68, and 3.47 days at the same corresponding temperatures (Figure 3b).

The reproductive value \( (v_x) \) denotes the contribution of an individual at age \( x \) and stage \( j \) to the future population, as described by Fisher in 1930. Additionally, the reproductive value of a newborn precisely corresponds to the finite rate of increase. The reproductive value curves of MS exhibited significant increases at 23.3 °C, 27.1 °C, and 29.0 °C in individuals fed on white mulberry, and at 27.1 °C and 29.0 °C in individuals fed on black mulberry when reproduction began. At other temperatures, it showed either no or very little reproduction exhibited in both hosts. As shown in Figure 4a, the reproductive value of MS females fed on white mulberry increased sharply to 39.46 at 53 days at 23.2 °C, to 78.74 at 44 days at 27.1 °C, and to 48.11 at 47 days at 29.0 °C. The same trend was observed in females fed on black mulberry, with reproductive values of 91.57 at 43 days at 27.1 °C and 74.54 at 44 days at 29.0 °C (Figure 4b).

The statistically highest fecundity of MS was recorded as 86.32 eggs/♀ on white mulberry at 27.1 °C, while it was 103.75 eggs/♀ on black mulberry at the same temperature. Conversely, the lowest fecundity was observed as 0.87 eggs/♀ on white mulberry at 20.6 °C, and 0.25 eggs/♀ at 20.6 °C, and 0.04 eggs/♀ at 31.3 °C on black mulberry (p < 0.05) (Table). When considering the host plants, it was observed that higher fecundity was found on white mulberry at temperatures of 23.2 °C and 30.6 °C, while lower fecundity was observed at 27.1 °C and 29.0 °C compared to black mulberry (p < 0.05) (Table). According to Erkılıç and Uygun (1997), the fecundity of \( P. \ pentagona \) at 25 °C was higher on potatoes than on peaches and pumpkins. However, the overall longevity and fecundity of MS were strongly affected by high temperatures. For example, at 30 °C, longevity was only 60 days, in contrast to 200 days at 15 °C on potato tubers. The condition of the host plant also affects the fecundity. According to Hanks and Denno (1993b) the

![Figure 3. The expected life time \( (e_x) \) of \( Pseudaulacaspis pentagona \) on white mulberry (a) and black mulberry (b) at 7 different temperatures (°C).](image-url)
fecundity of *P. pentagona* was extremely low (26.4 eggs/♀) water-stressed mulberry tree than nonstressed mulberry tree (36.5 eggs/♀).

The intrinsic rate of increase (*r*) is an important parameter that involves survival, development, and reproduction, as indicated by Farhadi et al. (2011). Our results showed that the intrinsic rate of increase, the finite rate of increase (*λ*) and net reproductive rate (*R₀*) of MS on white and black mulberry were highest at 27.1 °C, but lowest at 30.6 °C on white mulberry and 31.3 °C on black mulberry (*p < 0.05*) (Table). Furthermore, we found that the intrinsic rate of increase, the finite rate of increase, and the net reproductive rate of MS were consistently higher on white mulberry than on black mulberry at temperatures of 23.3 °C, 27.1 °C, 29.0 °C, 30.6 °C, and 31.3 °C (*p < 0.05*) (Table). Additionally, our study revealed that the mean generation time was longer on white and black mulberry at 20.6 C, shortest at 27.1 C on white mulberry, and at 27.1 and 29.0 C on black mulberry (*p < 0.05*) (Table). The population projection revealed that the growth of MS individuals, when fed on white mulberry, was the slowest at both low and high temperatures. However, it exhibited the fastest growth at 27.1 °C (335 individuals) and 29.0 °C (221 individuals), as depicted in Figure 6. Interestingly, no population could be established at temperatures of 31.3 °C and 33.8 °C. In comparison, the total population size of MS individuals fed on black mulberry was consistently lower than that of the other groups at all temperatures. The highest total population size observed was 44 individuals at 29.0 °C, while no population could be established at 33.8 °C, as shown in Figure 6.

The effect of increasing temperatures on the life parameters of MS is similar to the effect on the life parameters of other scale insect species. For example, *Chrysomphalus aonidum* L. (Hemiptera: Diaspididae) has a shorter growth period and a higher number of daily nymphs per female at temperatures between 23 °C and 27 °C on *Curcubita maximax*. At temperatures between 17 °C and 19 °C, the longevity of female *C. aonidum* is prolonged, and they produce fewer daily nymphs per female (Andrade et al., 2008). The most suitable host was blood orange trees for the fecundity of *Parlatoria oleae* (Colvée) (Hemiptera: Diaspididae). The average number of offspring for *P. oleae* females was 35.4, 30.9, and 18.7 females on blood orange, lemon, and mandarin leaves, respectively (Abd El Kareim et al., 2012).

Figure 4. The reproductive value (*vₓj*) of *Pseudaulacaspis pentagona* on white mulberry (a) and black mulberry (b) at 7 different temperatures (°C).
The temperatures studied affected the intrinsic rate of increase ($r$), finite rate of increase ($\lambda$), net reproductive rate ($R_0$), and mean reproductive time ($T$), of *P. pentagona*. While the net reproductive rate increased, the mean reproductive time was shortened. Net reproductive rate and intrinsic rate of increase ($r$) of MS were always higher on white mulberry than on black mulberry at all temperatures except at 20.6 °C in which no difference in intrinsic rate of increase

**Figure 5.** Population size (age-specific stages) of *Pseudaulacaspis pentagona* on white mulberry (a) and black mulberry (b) at 7 different temperatures (°C).

**Figure 6.** Total population size of *Pseudaulacaspis pentagona* on white mulberry and black mulberry at 7 different temperatures (°C).
(r), was observed between different hosts (Table). As expected, the mean generation time (T) shortened as the temperatures increased from the lowest to the optimum (27.1 °C). Although there was no statistical difference between both mulberry species at 20.6 °C and 23.2 °C, it was observed that they gave offspring in a shorter time on white mulberry. MS individuals developed on black mulberry at 27.1 °C and 29.0 °C in a shorter time and completed their offspring than on white mulberry. However, since there are negative intrinsic rate of increase (r) values at 20.6, 30.6 and 31.3 °C, the population is expected to decline over time (Table). Similar results were recorded by Ball (1980) that the shortest generation time of 40.4 days at 26.4 °C and the longest was 110.8 days at 13.3 °C and 40.4 days at 26.4 °C on Irish potato tuber in laboratory conditions. Erkılıç and Uygun (1977) determined that the total longevity of MS was affected by the host, lasting 65 days on squash and potato but 110 days on peach. In addition, that intrinsic rate of increase (r) values of MS were higher on potatoes (0.059 d⁻¹) at 25 °C and peaches (0.052 d⁻¹) than squash (0.024 d⁻¹). This result supported that white mulberry is the most suitable host plant for MS because intrinsic rate of increase (r) values were higher (0.078 d⁻¹ and 0.066 d⁻¹ at 27.1 °C and 29 °C in our studies. Kuzmin et al. (2020) when *P. pentagona* females feeding on blackcurrent cultivar ‘Noir de Bourgogne’ were higher number, had a larger scale and body, and had less parasitization compared to when females feeding on ‘Royal de Naples’ at the same site. Zeng et al. (2023) showed that the genes involved in salicylic acid synthesis were expressed higher in the cultivar of kiwifruit ‘LC-04285’ k, which has stronger resistance to *P. pentagona*. Hill et al. (2008) found that *Hemiberlesia lataniae* (Signoret) (Hemiptera: Diaspididae) showed lower survival, fecundity, intrinsic rate of increase, and net reproductive rate when developing on a resistant genotype of kiwifruit than on the other two commercial kiwifruits genotypes. Unlike of *H. lataniae*, *Hemiberlesia rapax* (Comstock) (Hemiptera: Diaspididae) had good survival and reproduction on all four *Actinidia* genotypes. On the other hand, the responses of different insect species feeding on the same host may be different. According to Ataş and Kaydan (2014), *M. nigra* seems to be more likely susceptible to *Pseudococcus comstocki* (Kuwana) (Hemiptera: Pseudococcidae) than *M. alba* in each temperature because it displayed the highest performance on this host plant.

As temperature and host plant species are the most important factors affecting the insect, all activities are significantly accelerated within the best limits. The intrinsic rate of increase (r) of *Aulacaspis yasumatsui* Takagi (Hemiptera: Diaspididae) was 0.06, 0.07, 0.09, 0.10, and 0.08 d⁻¹, respectively under at 20, 23, 25, 28, and 31 °C. The highest net reproductive rate (*R₀*) was 96.08 eggs, and the shortest mean generation time (T) was 44.15 days at 28 °C. The performance of *A. yasumatsui* was better at warmer temperatures than at lower temperatures (Ravuiwasa et al., 2012).

4. Conclusions

In the present study, the population growth parameters of *P. pentagona* were examined across a wide range of temperatures, from 20.6 °C to 33.8 °C, utilizing two significant mulberry species as host plants. Results indicate that the life table parameters of *P. pentagona* are significantly affected by temperature and host plants. Especially at high temperatures, the MS developed almost twice as fast as at low temperatures. The intrinsic rate of increase (r) is a fundamental parameter in population biology that adequately summarizes the physiological capacity of a species to increase in number. According to the results of the study, *P. pentagona* was able to reach the highest intrinsic rate of increase value at 27.1 °C on both hosts among the tested temperatures and the optimum temperature for MS on both hosts is found as 27.1 °C. In addition, negative values were calculated at the lowest temperature of 20.6 °C and the highest temperatures of 30.6 °C and 31.3 °C for both hosts. According to these results, it can be concluded that the pest can live on both hosts on these temperature levels, but cannot increase its population, and its population may progressively decline and disappear completely. While preadult duration of MS was shorter at 27.1 °C than at other temperatures for white mulberry, it was shorter at 29.0 °C for Black mulberry. Other parameters including highest fecundity, finite rate of increase, and net reproductive rate (*R₀*) were estimated at 27.1 °C for both hosts. In addition, while the mean generation time (T) was shorter at 27.1 °C for white mulberry, it was much shorter at 27.1 °C and 29.0 °C for Black mulberry.

Using the results of this study, it was concluded that preferential growing of black mulberry in regions having mean temperatures between 23–29 °C and white mulberry in warmer areas (29 °C and above) would be more appropriate in controlling *P. pentagona*. In addition, the selection of natural enemies that adapt to the growth rate of the host *P. pentagona* or develop faster in the biological control of this species will increase the success of the control. With the data obtained, it would be possible to predict to which regions of Türkiye, *P. pentagona* will spread and generation number under the influence of global warming. According to the results of this estimation, it will help in undertaking agroregion-specific management strategies to *P. pentagona*.
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Conflict of interest
The authors declare that they have no conflict of interest.

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