# Evaluating reproductive ability of the rice weevil (*Picia mesopotamica*) at different temperatures on rice

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**ABSTRACT**

Rice (*Oryza sativa* L.) is one of the most important grain crops in Iraq. This crop is plagued by several significant pests, including the rice weevil aquatic (*Picia mesopotamica*) which is a serious pest in rice fields. This study was conducted out to learn more about the biological and environmental factors that influence how this insect survives and poses a threat to rice crops in the field. The results of reproductive ability revealed that temperature seems to have a significant impact on females' life cycles and survival rates during the first reproduction. Female egg productivity rates were found to be regulated by temperature, with the lowest rate occurring later in the female's life cycle. Moreover, the average age at the first reproduction of the female was 21 and 10 days at temperature 30°C and the highest rate of 30 and 19 days at temperature 20°C respectively and the highest average number of eggs 294.20 eggs/female at the temperature was 30°C. Further, the lowest average age of the female at first reproduction was 10 days at 30°C and the highest was 19 days at 20°C. The results also indicated the apparent effect of the tested temperatures on the net compensation rates of the insect females with the lowest being 8.793 females/generation at 35°C with the highest112.68 females/generation at30°C and the lowest average generation length 57.68 days at temperature. The population grew at an exponential rate of 0.035 females per day at 30°C, while the population grew at the slowest pace of 0.008 females per day at 35°C. Despite of the effect of temperature on other biological aspects of rice weevils requires more research. We found that temperature has a clear effect on the rice weevil's reproductive activities on rice plants, and this research could be crucial in developing a successful pest management method.

**Key words:** rice weevil, *Picia mesopotamica*, rice, temperature factor

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## INTRODUCTION

The rice plant (*Oryza sativa* L.) is a semi-aquatic herbaceous plant in the Poaceae family with 20 species in the genus *Oryza* (Sunya *et al.,* 2022). The most common species is *sativa*, whereas perennial rice (*O. glaberrima* in Africa and *O. zizaniq* in the United States) is only grown in a few regions (Sun *et al.,* 2022). Rice is native to East Asia, and its cultivation has extended to the tropics; certain varieties are considered to be native to China (Villegas *et al.,* 2021). It is now grown in over 100 nations on every continent except Antarctica, with cultivation ranging from 50 degrees north to 40 degrees south and from sea level to 3000 meters (Civá *et al.,* 2019). Many pests, such as *Sesamina nonagrioides*, which feed on the stems of rice plants and induce welting of high sections of the shoot, damage rice production in Iraq. *Chilo suppressalis* is another prominent insect pest in Iraq; this bug caused dead heart phenomena in rice because of larvae eating on the inner content of plant stems, causing dry and dead leaves. *P. mesopotamica*, one of the most aggressive insect pests on rice crops, is the most common insect infected rice crop. *P. mesopotamica* was found attached to three species of certified grown rice and six types of weeds associated with rice fields in the provinces of Najaf and Qadisiyah in 2016, according to Mubasher (2019). Because of the economic importance of *P. mesopotamica* on the rice crop in Iraq, this study explored various biological characteristics and built reproductive ability tables, age groups, and specific age -specific fecundity tables of the insect in the laboratory. This research also determined the rate of internal growth in the population at different temperatures, which could aid in the development of a precise and effective control approach against the *P. mesopotamica* pest worldwide.

## MATERIALS AND METHODS

The experiments of reproductive ability of *P. mesopotamica* were carried out at temperatures 20, 25, 30 and 35 ± 2, relative humidity 70±5% and light duration 16 hours light: 8 hrs dark.

The insects were collected from some weeds accompany rice in rice planting fields at Muhanniyaharea/Qadisiyah province at central of Iraq. Adults and larvae of the first generation were collected to use in experiments later on spring season 2019. The insect was reared in wooden boxes on rice plants of the Jasmine variety. Pots were planted without mesh covered with cloth clip conical work to suit the shape of the plant in an incubator according to the above-mentioned temperatures degrees and were regularly changed. The pots were then placed in the incubator from the egg stage to the adult stage, with the number of adults out at each temperature and the fraction of total eggs used to calculate survival rates for incomplete roles. The rice plants were put in plastic pots (100mL) once the insect mating was completed, and each plant was separated by a cloth. Each plant received a new hatched male and female, as well as 10 replicates per temperature on the same host. The quantity of eggs laid by females and the number of live females were both recorded during the daily assessment. Plants were placed with fresh ones when needed to give adults insects with the proper plant food:

Age – specific survival rate and Age – specific fecundity rate According to (Stiling, 1996) equation where that :

Lx = survival rate x

Nx = number of individuals at the end of the age group x

N0 = Average number of individuals at the beginning of the age group x

According to Stein (1998), mx values for all age ranges were divided by (2) to extract the average number of females produced at each age since the sex ratio of *P. mesopotamica* at constant temperatures is approximately 1:1 (Meeri, 2019; Bai *et al.*, 2005), By knowing the survival rates and the productivity rates, the extracted the net reproductive rete, Mean generation time and Intrinsic rate of increase according to the equations set by Birch and the following:

Ro = ∑ Lxmx ………………….. (1)

Ro = net compensation rate (number of females produced/females / generation)

∑Lxmx=the sum of times the female survival rates multiplied by age productivity rates

$$T = \frac{\sum X\ Lxmx}{\sum Ixmx} \ldots\ldots\ldots\ldots (2)$$

T = average generation duration

∑X Ixmx = the sum of Lxmx times the age x

∑ Ixmx = net compensation rate

$$rm = \frac{Log\ Ro}{T} \ldots\ldots\ldots\ldots (3)$$

rm = rate of internal increase in population

Loge Ro = inverse logarithm of the net compensation rate

T = average generation duration

## RESULTS AND DISCUSSION

In general, consistent temperatures of 20, 25, 30 , and 35ºC in laboratory circumstances affected the lives of *P. mesopotamica* and the rates of fe male egg output (Tables 1-4). It was found that the average life cycle of females was (30, 29, 21and 21) days at 20, 25, 30 and 35°C on rice yield of jasmine cultivar respectively. The average age of females at first breeding (19, 15, 10 and 12) days at the same temperature respectively, and the average number of eggs laid by the female insect was (71.22, 242.73, 294.20 and 59.9) eggs respectively at the same temperature degrees.

Measures of growth and reproduction derived from production and survival tables, such as the net compensation rate (Ro), the rate of generation length (T), and the rate of internal increase (Ri), are used to explain the nature of population fluctuation in insects (rm). The

**Table 1.** Reproducibility of *P. mesopotamica* at 20°C on Jasmine Rice. 

| Age in days (x) | Survival rate (lx)±SD | Average number of total eggs (mx) ±SD | Average number of females produced (mx) ±SD | Expected productivity (LXMX) ±SD | (xlxmx) ±SD |
|---|---|---|---|---|---|
| 1 – 6 | Incomplete roles | | | | |
| 63 – 82 | Duration before laying eggs | | | | |
| 83 | 0.57±0.12 | 5.30±1.12 | 3.72±1.06 | 2.12±0.52 | 175.96±23.62 |
| 84 | 0.57±0.11 | 7.55±1.30 | 4.61±1.63 | 2.62±0.59 | 220.08±32.55 |
| 85 | 0.49±0.09 | 10.27±2.17 | 6.13±3.20 | 3.00±1.99 | 255.00±33.21 |
| 86 | 0.36±0.08 | 11.84±2.69 | 7.42±1.25 | 2.67±0.42 | 229.62±36.21 |
| 87 | 0.25±0.07 | 13.20±3.55 | 7.65±1.84 | 1.91±0.36 | 166.17±26.32 |
| 88 | 0.19±0.05 | 10.15±2.09 | 6.11±2.99 | 1.16±0.21 | 102.08±29.25 |
| 89 | 0.13±0.05 | 7.29±1.25 | 3.75±1.69 | 0.49±0.11 | 43.61±18.54 |
| 90 | 0.10±0.02 | 5.38±1.03 | 2.52±1.01 | 0.25±0.09 | 22.50±5.21 |
| 91 | 0.09±0.01 | 0.19±0.06 | 1.62±0.58 | 0.15±0.02 | 13.65±2.36 |
| 92 | 0.05±0.01 | 0.05±0.01 | 0.90±0.21 | 0.05±0.01 | 4.60±0.52 |
| 93 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 |
| | | 71.22 Average numberof eggs per female | Grr= 44.44 | ∑lxmx 14.42 | ∑Xlxmx1633.27 |
| L.S.D. 0.05 | 0.153 | 3.268 | 1.632 | 1.039 | 26.591 |

**Table 2.** Reproducibility of *P. mesopotamica* at 25 ° C on Jasmine Rice.

| Age in days (x) | Survival rate (lx) ±SD | Average number of total eggs (mx) ±SD | Average number of females produced (mx) ±SD | Expected productivity (LXMX) ±SD | (xlxmx) ±SD |
|---|---|---|---|---|---|
| 1 – 48 | Incomplete roles | | | | |
| 49 – 64 | Duration before laying eggs | | | | |
| 65 | 0.75±0.24 | 8.0±1.31 | 6.92±1.30 | 5.19±2.32 | 337.35±38.21 |
| 66 | 0.75±0.21 | 10.4±2.15 | 8.28±3.02 | 6.21±0.36 | 409.86±41.26 |
| 67 | 0.75±0.23 | 12.10±3.28 | 8.43±3.33 | 6.32±2.62 | 423.58±42.68 |
| 68 | 0.73±0.12 | 12.12±1.68 | 11.05±1.20 | 8.06±3.33 | 548.49±53.21 |
| 69 | 0.73±0.36 | 14.10±3.05 | 13.60±2.69 | 9.92±2.59 | 685.04±25.69 |
| 70 | 0.70±0.39 | 18.06±4.25 | 16.003.69 | 11.20±6.85 | 784.00±36.58 |
| 71 | 0.69±0.21 | 35.77±5.69 | 17.45±7.26 | 12.04±6.21 | 854.84±45.95 |
| 72 | 0.63±0.22 | 33.10±9.52 | 19.32±9.95 | 12.17±3.25 | 876.32±85.26 |
| 73 | 0.51±0.29 | 32.80±8.26 | 13.10±5.69 | 6.69±1.54 | 488.37±38.97 |
| 74 | 0.33±0.11 | 28.40±7.68 | 8.00±2.30 | 2.64±0.29 | 195.36±20.68 |
| 75 | 0.25±0.09 | 25.14±9.95 | 5.12±3.69 | 1.28±0.04 | 96.00±10.69 |
| 76 | 0.11±0.03 | 9.6±3.52 | 2.000.59 | 0.22±0.03 | 16.72±2.95 |
| 77 | 0.08±0.01 | 2.0±0.67 | 1.500.24 | 0.12±0.01 | 9.24±1.15 |
| 78 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 |
| | | 242.73 Average number of eggs per female | Grr= 130.77 | ∑lxmx80.496 | ∑Xlxmx5725.17 |
| L.S.D. 0.05 | 0.129 | 4.261 | 2.694 | 2.009 | 36.261 |

**Table 3.** Reproducibility of *P. mesopotamica* at 30 ° C on Jasmine Rice. 

| **Age in days (x)** | **Survival rate (lx) ±SD** | **Average number of total eggs (mx) ±SD** | **Average number of females produced (mx) ±SD** | **Expected productivity (LXMX) ±SD** | **(xlxmx) ±SD** |
|---|---|---|---|---|---|
| 1 – 41 | Incomplete roles | | | | |
| 42 – 52 | Duration before laying eggs | | | | |
| 53 | 0.89±0.25 | 20.80±1.52 | 9.55±1.20 | 8.50±1.26 | 450.05±65.32 |
| 54 | 0.89±0.25 | 23.00±1.62 | 12.43±3.26 | 11.06±2.39 | 597.24±55.28 |
| 55 | 0.88±0.26 | 23.40±1.36 | 13.80±3.25 | 12.14±2.54 | 667.70±57.68 |
| 56 | 0.87±0.22 | 30.60±2.39 | 17.05±5.21 | 14.83±3.58 | 830.48±59.26 |
| 57 | 0.79±0.12 | 39.80±2.88 | 17.85±4.99 | 14.10±3.45 | 803.70±53.26 |
| 58 | 0.79±0.12 | 42.00±3.56 | 23.90±5.20 | 18.88±5.69 | 1095.04±106.9 |
| 59 | 0.79±0.16 | 41.60±3.24 | 25.00±6.24 | 19.50±3.57 | 115.50±29.56 |
| 60 | 0.51±0.02 | 39.00±3.09 | 21.40±2.24 | 10.91±2.61 | 654.60±68.95 |
| 61 | 0.23±0.05 | 22.20±5.26 | 10.65±1.33 | 2.45±1.06 | 149.45±27.36 |
| 62 | 0.09±0.01 | 11.80±3.26 | 3.44±1.19 | 0.31±0.01 | 19.22±1.62 |
| 63 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 |
| | | 242.73 Average number of eggs per female | Grr= 130.77 | ∑lxmx 80.496 | ∑Xlxmx5725.17 |
| L.S.D. 0.05 | 0.115 | 4.291 | 3.225 | 2.691 | 41.036 |

**Table4.** Reproducibility of *P. mesopotamica* at 35°C on Jasmine Rice

| **Age in days (x)** | **Survival rate (lx) ±SD** | **Average number of total eggs (mx) ±SD** | **Average number of females produced (mx) ±SD** | **Expected productivity (LXMX) ±SD** | **(xlxmx) ±SD** |
|---|---|---|---|---|---|
| 1-78 | Incomplete roles | | | | |
| 79-92 | Duration before laying eggs | | | | |
| 93 | 0.43±0.06 | 4.5±0.95 | 2.25±0.26 | 0.963±0.09 | 89.931±36.21 |
| 94 | 0.43±0.03 | 7.0±1.06 | 3.56±0.24 | 1.530±0.53 | 143.820±57.65 |
| 95 | 0.40±0.05 | 8.8±1.24 | 4.60±0.79 | 1.840±0.77 | 174.800±83.26 |
| 96 | 0.32±0.04 | 11.3±2.36 | 5.42±0.57 | 1.734±0.63 | 166.464±7532 |
| 97 | 0.25±0.03 | 8.2±1.53 | 7.0±0.36 | 1.750±0.14 | 169.750±74.39 |
| 98 | 0.13±0.05 | 8.0±1.09 | 4.80±1.26 | 0.624±0.02 | 61.152±21.32 |
| 99 | 0.03±0.01 | 5.4±1.37 | 3.21±0.88 | 0.288±0.02 | 28.512±7.62 |
| 100 | 0.03±0.01 | 3.7±0.36 | 2.13±0.92 | 0.064±0.01 | 6.400±1.63 |
| 101 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 | 0.00±0.00 |
| | | 56.9 Average number of eggs per female | Grr= 32.97 | ∑lxmx8.793 | ∑Xlxmx1010.293 |
| L.S.D. 0.05 | 0.109 | 2.154 | 1.697 | 0.889 | 42.421 |

**Table 5.** Values of net compensation rates (Ro) and rates of generation length (T) and rates of internal increase (rm) derived from the reproducibility tables of rice moth weevil *P. mesopotamica* at constant temperatures on rice crop Jasmine cultivar.

| Temperature ºC | Average life span of a female (day) | Average age of the female at first reproduction | Average number of eggs per female (egg) | Net Compensation Rate (Ro) | Generation Length (T) | Internal Increase Rate (rm) |
|---|---|---|---|---|---|---|
| 20 | 30±1.36 | 19±1.36 | 71.22±11.63 | 14.42±1.39 | 113.26±30.63 | 0.010±0.001 |
| 25 | 29±1.22 | 15±0.59 | 242.73±29.62 | 80.496±16.27 | 71.12±12.5 | 0.026±0.002 |
| 30 | 21±1.23 | 10±1.06 | 294.20±30.22 | 112.68±20.68 | 57.68±19.52 | 0.035±0.002 |
| 35 | 21±1.23 | 12±0.88 | 40.90±15.99 | 8.793±1.63 | 114.89±41.36 | 0.008±0.002 |

population of rice water weevil *P. mesopotamica* of the stable type was Ro (14.42, 80.496, 112.68 and 8.79) female/female/generation at the same temperature, based on the values of the net rate of compensation (Ro) per female at all tested temperatures (Table 5). It is noted that the highest value (Ro) was 112.68 females/female/generation at a temperature of 30ºC due to the high survival factors for insect growth roles at this degree, which amounted to 0.89 as well as the high ability of females to produce eggs. The highest rate was 294.20 eggs/females at the same temperature decreased to the lowest rate at 35°C at 40.40 eggs/female (Table 5). The results showed that the lowest value of (Ro) for females of insect was 8.793 females/females/generation at 35°C, which may be due to the low survival rates of insect growth roles as it reached 0.43 and decreased female productivity of eggs, which the lowest rate was 40.90 eggs/female.

From above data, the value of Ro increased with increasing temperatures up to 30ºC and then a sharp decreased in the value of Ro at 35ºC temperature, which decreased from 112.68 female/female/generation to 8.79 female/female / generation at temperatures of 30ºC and 35ºC, respectively (Table 5). This is in agreement with (Rockstein, 2013), who claims that the influence of temperature on productivity is similar to that of growth. If temperatures fall or rise within a given range, productivity is maximized and stabilized. T values were 113.26, 71.12, 57.68 and 114.89 days at 20, 25, 30 and 35 degrees Celsius, respectively (Table 5). Furthermore, as the temperature rose to 30°C, the average length of the generation dropped. It was greatly extended to 114.89 days at 35°C due to the velocity of insect growth at high temperatures until it reached a specific level. This means that the effect of greater temperatures than the ideal temperature was obvious, and incomplete roles in the insect's life cycle were clear (Mubasher, 2019). The lowering growth rate was found, which was represented in the lengthening of the phase and the lengthening of the generation. The optimal thermocouple for the development of their roles was (25ºC and 30ºC) and this range insect completed its life cycle with the least possible duration.

Population rate (rm) was increased by decreasing the generation length and the lowest value was 0.008 female/female/day at 35°C which may be due to a decreasing in Ro and T value at the same temperature degree. Further, the rate of internal increase (rm) was increased in the population of Colorado potato beetle *Leptinotarsa decemlineata* to high mortality in the population of rice mite weevil *P. mesopotamica* at a temperature of 35ºC and survival rates for incomplete roles (0.57, 0.75, 0.89 and 0.43) at the studied temperatures, respectively which indicated high mortality in incomplete roles of the insect. One of the good indicators is the value of (rm) of the mortality experienced by the population of the insect in nature. High values indicate the exposure of the population to high mortality rates and the insect has a certain adaptive means to compensate for the shortage in the population.

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