Life Table Parameters Of Ceroplastes Floridensis(Homoptera: Coccidae) At Different Temperatures

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Abstract

Survival data, development and reproduction period of Ceroplastes floridensis on Cucurbita moschata were collected at temperatures of 15, 20, 25, 30°C, Relative Humidity 65±5%, and photoperiod (8:16) s (L: D). The highest value of the Intrinsic rate of increase (r) was 1.078, the final increase rate (λ) 0.075, the shorter generation length (T) was 71.73 days, and the highest Fecundity value of the citrus wax scale 316.82 at 30° C. Temperatures led to an increase in the rate of female reproduction that was raised on the Cucurbita moschata. Therefore, the temperature of 30° C was the optimal rate for the development and growth of the citrus wax scale population within the tested temperature.

Keywords: *Life Table, Temperature, Development, Bootstrap, Ceroplastes floridensis.*

I. INTRODUCTION

Ceroplastes floridensis Comstock, 1881 is a major pest on *Citrus* spp. It also infests a wide range of variety of other plants: *Persa americana*, *Cedrus deodara*, *Elmus* spp, *Rhapiolepsis indica*, *Pinus taeda*, *Quercus* spp [5].The insect caused significant damage because of feeding the nymphs and adults on the plant tissues by sucking the juice. Severe infection causes a change in the color of the leaves. Because of the absorption of large quantities of plant juices, the nymphs produce a large amount of honeycomb, which later covered with black mold fungi [20].*Ceroplastes floridensis* occurs in the tropical region, and it has spread all over the world, including North America: the United States (including New York, Florida and New Mexico) [2] and is considered an important economic pest [6].

Temperatures plays a crucial role in the rate of development, survival rate, and reproduction in insects. Many studies and reports indicate that the rate of development of insects at different temperatures depends on a variety of models of rates of thermal developmental [25],[18],[23],[26].

LifeTable studies are much more comprehensive and are not limited to predicting the rate of development but also rates of survival of each stage of development, fecundity, and life expectancy of insect population [10],[21],[18]. The researchers were forced to ignore data from male subjects in their studies, use the sex ratio to calculate female egg-laying rate, exclude male individuals, and differentiate between stages. However, errors in analysis and interpretation of life tables resulted [27].

Reference [12],[14] developed life tables based on tow-sex, age-stage to take into consideration the rate of development of males and their population. To determine the rate of development, survival rate, and reproduction of *Ceroplastes floridensis*, primary data were collected from the history of life at different temperatures and analyzed using life tables based on tow-sex, age-stage.

II. MATERIALS AND METHODS

A. Insect Culture of Ceroplastes floridensis

The citrus wax scale was studied on *Cucurbita moschata* after obtaining the "infection phase" of females containing eggs from infected citrus trees in Lattakia, Syria.*Cucurbita moschata* was sterilized with ethyl alcohol (95%) to prevent the growth of fungus, then dried fruit,*Cucurbita moschata*infection was carried out in females containing eggs of *Ceroplastes floridensis*, nested in aluminum boxes with a ventilating net, and prevented insects from leaving in a breeding chamber at 25±1°C, relative humidity 65±5%, photoperiod(8:16) (L:D),The rearing process continued for five consecutive monthsto obtain laboratory generations used in the experiments. The rearing was followed at four temperatures (15, 20, 25, 30°C). The rearing was carried out under the same lighting and humidity conditions, and in isolated rearing chamber with controlled conditions.

B. Life table study

The fruit of the *Cucurbita moschata* was placed in Glass cage with soft mesh that allows ventilation and prevents the exit of the insects and transferred 100 eggs of the citrus wax scale at each temperature, then transferred to the rearing room. The period of growth of the different stages was monitored, survival and number of eggs recorded for each female [14].

C. Life table analysis

To calculate the variable rate of development among individuals, the life history data of the *Ceroplastes floridensis* were analysed on the basis of age-stage, tow-sex, where life tables were developed by [13],[15]. The following rates were calculated: The age-stage specific survival rate (S_{xj}), the probability that a newborn will survive to age x and stage j, the age-stage specific fecundity (f_{xj}), the age-specific survival rate (l_x),the age-specific fecundity (m_x), and the population parameters: the intrinsic rate of increase (r) the finite rate of increase (λ), the net reproductive rate (R_0), the mean generation time (T), The rates and indicators were calculated according to the following equations:

According to the age-stage specific survival rate of the [12]of life table according to the equation:

$lx = \sum_{j=1}^{k} S_{xj}$,k is the number of stages.

The age-specific fecundity is calculated as*:*

$$m_x = \frac{\sum_{j=1}^{k} S_{xj} f_{xj}}{\sum_{j=1}^{k} S_{xj}}$$

The intrinsic rate of increase can then be estimatedin a repetitive way from the following equation:

$\sum_{x=0}^{\infty} e^{-r(x+1)} l_x m_x$ =1,Starting with age zero[7].

The net reproductive rate is calculated as follows: $R_o = \sum_{x=0}^{\infty} lxmx$

The mean generation time (T) is defined as the period that population require to increase their numbers to R_0, where population become larger over time to the end of the life cycle. The mean generation time is calculated from equation:

$$T = \frac{lnRo}{r}$$

Use the TWOSEX-MSChart software available at http://140.120.197.173/ecology/ last accessed on 03/01/2019, (Chi, 2015). The values of SE were estimated for the period of development, fecundity, and Life table parametersusing the bootstrap technique [28],[11]. Using 100,000 recurrences, the average frequency (B = 100,000) is calculated as follows:

$s(.) = \frac{\sum_{b=1}^{B} s(x^{*b})}{B}$, where $s(x^{*b})$ is the parameter estimated from the b-the bootstrap sample.

The SE of the parameter is then calculated as:

$$SE_{boot} = \frac{\sqrt{\sum_{b=1}^{B} [s(x^{*b}) - s(.)]}}{B - 1}$$

III. RESULTS AND DISCUSSION

A. Development Time

Temperature is one of the most important factors that regulates the development, reproduction, mortality, survival, and seasonal occurrence of insect populations[18],[8],[9],[27],[3],[21].

Our results showed clearly that the study of life tables at different temperatures can show the effect of temperature on survival, development and Fecundity in the *Ceroplastes floridensis* Table. (1) and (2).The duration of the immature stages was significantly reduced when the temperature rise from 15° C to 30° C. In other words, the period of development of the different stages of the plant of the *Ceroplastes floridensis* decreased with temperature. These results are similar with [1] the different stages of the insect *Saissetia coffeae* (Walker) (Homoptera: Coccidae) vary according to the temperature tested, and decrease with high temperature. The Adult longevity(females) and total longevity decreased with temperatures rising from 25° C to 30° C and this explains the adverse effect of high temperatures on the survival of the *Ceroplastes floridensis*. The *Ceroplastes floridensis* needs at lower temperature for the longest period of development before it can produce offspring.

B. Fecundity(m_x)

At 25° C, females begin laying eggs on day 89. The fecundity period (m_x) ends on day 100 and this value is associated with the adult female stage. The fecundity curve (m_x) range between age 61-145 (Figure 1). The shorter duration of fecundity (m_x) was 19 days (61-80), At 30° C and the highest fecundity value of 316.82 at 30° C while the lowest fecundity value was 87.40 at 15° C (Table, 1).The highest age-specific fecundities (27, 37, 53, 76) at (15, 20, 25, 30° C) respectively **(**Figure 1). It is clear from the results that increased temperatures lead to an increase in the rate of female reproduction on *Ceroplastes floridensis*. This is in line with what [16] noted that the rate of insect reproduction increases with increases of temperatures. This is due to the abundance of energy spent in producing eggs for their ability to eat large amounts of food that coincides with the loss of body moisture evaporated through the wall of the body [24].

Table 1. Developmental time (d) (Mean±SE) of life stages of *Ceroplastes floridensis* at four constant temperatures(15, 20, 25, and 30̊C) 65±5% RH, andaphotoperiod of 16:8 (L:D)h

Duration	15̊C	20̊C	25̊C	30̊C
Egg	0.11±33. 9	21.95±0.1	16.36±0.08	12.22± 0.07
N1	0.03±3.96	2.91± 0.03	2.61±0.05	1.42± 0.05
N2	0.25±36.68	33.24 ±0.15	27.45±0.15	22.4±0.14
N3	38.23 ±0.22	34.62 ±0.21	29.02±0.17	24.11± 0.16
Total immature	112.94±0.48	93±0.40	75.45±0.29	60.3±0.29
APOP (d)	25±0	16.98±0.02	14.15±0.06	10.89±0.0424
TPOP (d)	138.21±0.47	110.24±0.45	89.62±0.32	71.02±0.36
Reproductive period (d)	28±3.37	50±4.05	55±5.42	55±4.07
Adult longevity(d)	38.32± 0.67	34.85± 0.68	30.93±0.27	25.07±0.281
Total longevity(d)	76.83±5.559	105.44±2.98	78.09±3.48	72.87±2.14

APOP: adult prereproductive period, **TPOP**: total prereproductive period. The SEs were estimated by using100,000 bootstraps and compared by using paired bootstrap test based on CI of differences

C. *Survival rate (l_x)*

Figure (2)shows the average duration of each stage of the *Ceroplastes floridensis* at four different temperatures. The total length of the immature stages ranged from the shortest 60.3 days at 30°C to 112.94 days at 15°C. Total longevity was significantly affected by temperature, with the longest total duration of 105.44 days at 20°C while the shortest time was 72.87 days at 30°C (Table 1).The highest survival rate to adult stage of the *Ceroplastes floridensis* was 71% at 30°C, while the survival rate to adult stage of the *Ceroplastes floridensis* was 31% at 15°C (Table 2) . The female stage started at 30°C on day 56 and ended on day 91 if the female needed 35 days to complete her growth,

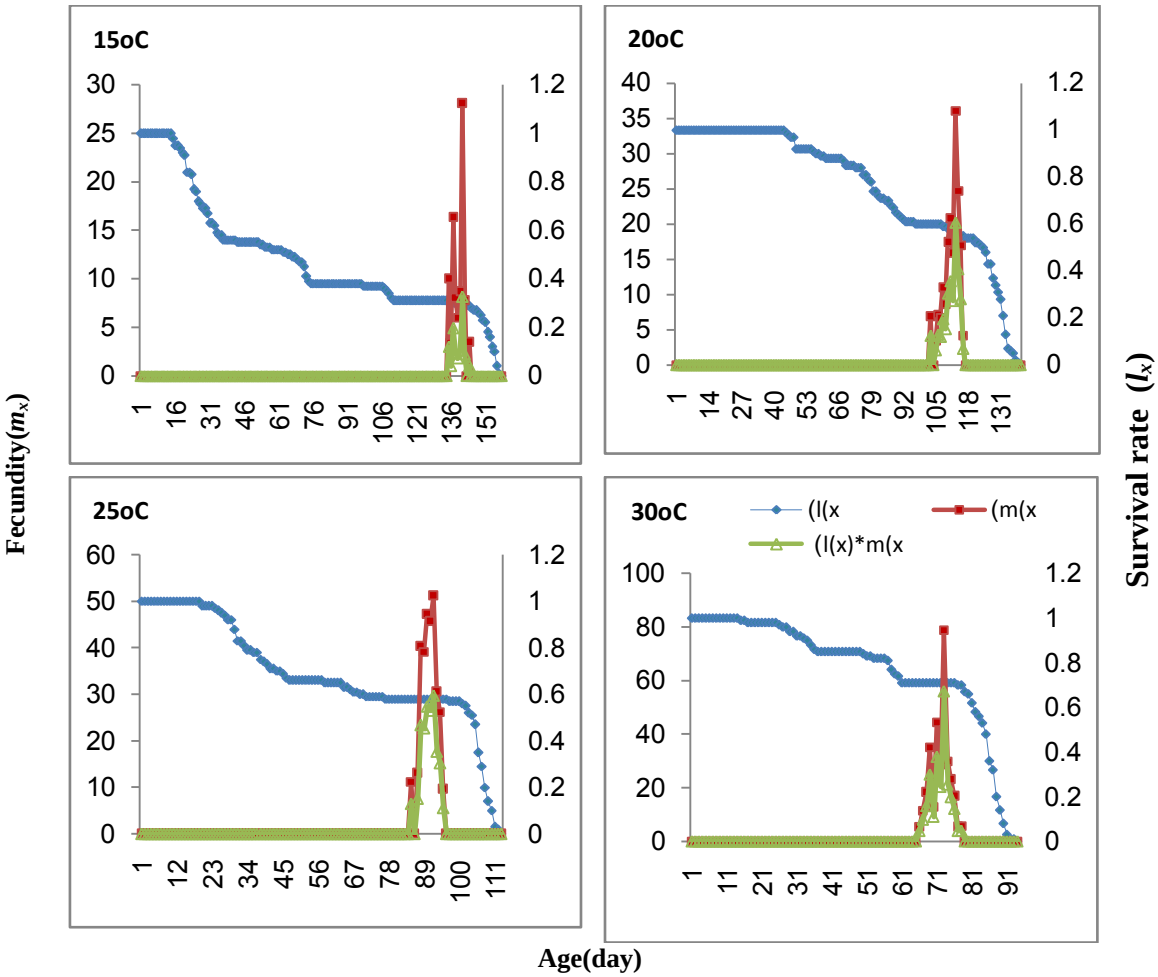

Figure (1) Age-specific survival rate (l_x),Fecundity(m_x), and Reproduction (l_x)*(m_x)of *Ceroplastes floridensis* reared on *Cucurbita moschata* at different temperatures (15, 20, 25, 30̊C).

while the female adult stage started at 15° C on 105 days and ended on day 157 if the female needed the longest period to complete her 49 days(Figure 2). The wax citrus insect started to produce eggs at 15°C at 138.21d. This period represented the TPOP period, while the *Ceroplastes floridensis* began to produce eggs at 25° C 89.62d. And at 30°C temperatures began toproduce eggs at 71.02d, which was well below its value at 15°C(Table 1).

D. PopulationParameters

The results shown in Table (2) indicate that the highest value of the net reproductive rate (R_0) was 20.49 at 30° C while the lowest was 4.43 at 15° C. The shortest T length was 71.73 days at 30° C while the longest duration of 139.06 days at 15° C where the length of the generation has decreased with temperatures rising from 15°C to 30°C, that is, the relationship between temperature and generation time is reversed.This agree of [17] where he noted that the generation of the *Coccus hesperidum* decreases as the temperature increases. The intrinsic rate of increase(r) and the finite rate of increase(λ), were the highest values at 30° C and were 1.078, 0.075 days respectively and the highest values were among the other three temperatures. Therefore, 30° C is the optimum degree for the development and growth of population *Ceroplastes floridensis* within the tested temperature. The lowest values were at 15° C were 1.023, 0.023 days respectively.

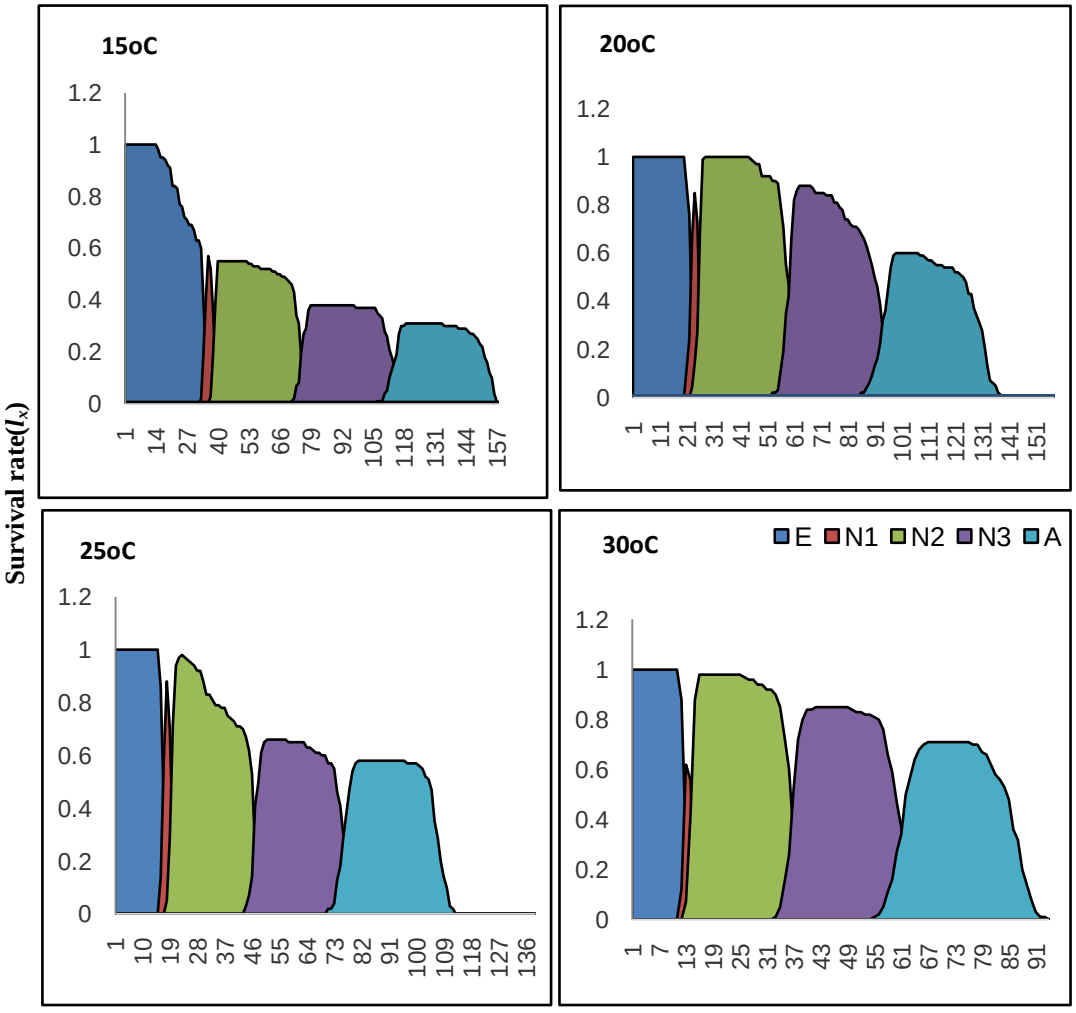

Figure (2) Survival rate(l_x)of *Ceroplastes floridensis* reared on *Cucurbita moschata* at different temperatures (15, 20, 25, 30°C).

Table (2) Parameters (Mean ± SE) for the life table of the *C.floridensis* on *Cucurbita moschate*at temperatures (15, 20, 25, 30°C), humidity 65±5%, the photoperiod(8:16) h.

Parameters	15°C	20°C	25°C	30°C
Cohort size (*N*)	100	100	100	100
Female adults (*Nf*)	31	60	58	71
Fecundity (*F*)(eggs)	87.46± 6.01	171.28±10.46	314.31±10.96	316.82±20.57
Generation time (*T*)(d)	139.06 ±0.476	110.94± 0.477	90.41±0.320	71.73±0.369
Net reproductive rate (R_0)(eggs)	27.10± 4.43	102.75± 10.49	182.27±16.66	224.92±20.49
Intrinsic rate of increase (*r*) (d^{-1})	0.023±0.012	0.0417± 0.095	0.0575± 0.0104	0.0754± 0.0135
Finite rate of increase (λ)(d^{-1})	1.023±0.0124	1.042±0.099	1.059±0.011	1.078±0.0145
Doubling time (DT)(d)	29.01	16.60	12.03	9.18

E. Life expectancy (e_{xj})and reproductive value (V_{xj})

The life expectancy and the reproductive value of age (*Vxj*)of the *Ceroplastes floridensis* shown in Figs. (3) and (4) was plotted. Due to the absence of other mortality factors under experimental conditions except insects Advanced in age, (*exj*) curves decreased with age and a fluctuation was observed at 15 C and the reproductive value of age (*Vxj*), which (expressed the contribution of individuals x and y Increased the number of members of the population), for the *Ceroplastes floridensis* (Fig. 3).The value of (*Vxj*) was clearly shown when the immature stages appeared and increased again when adult females began to produce eggs.

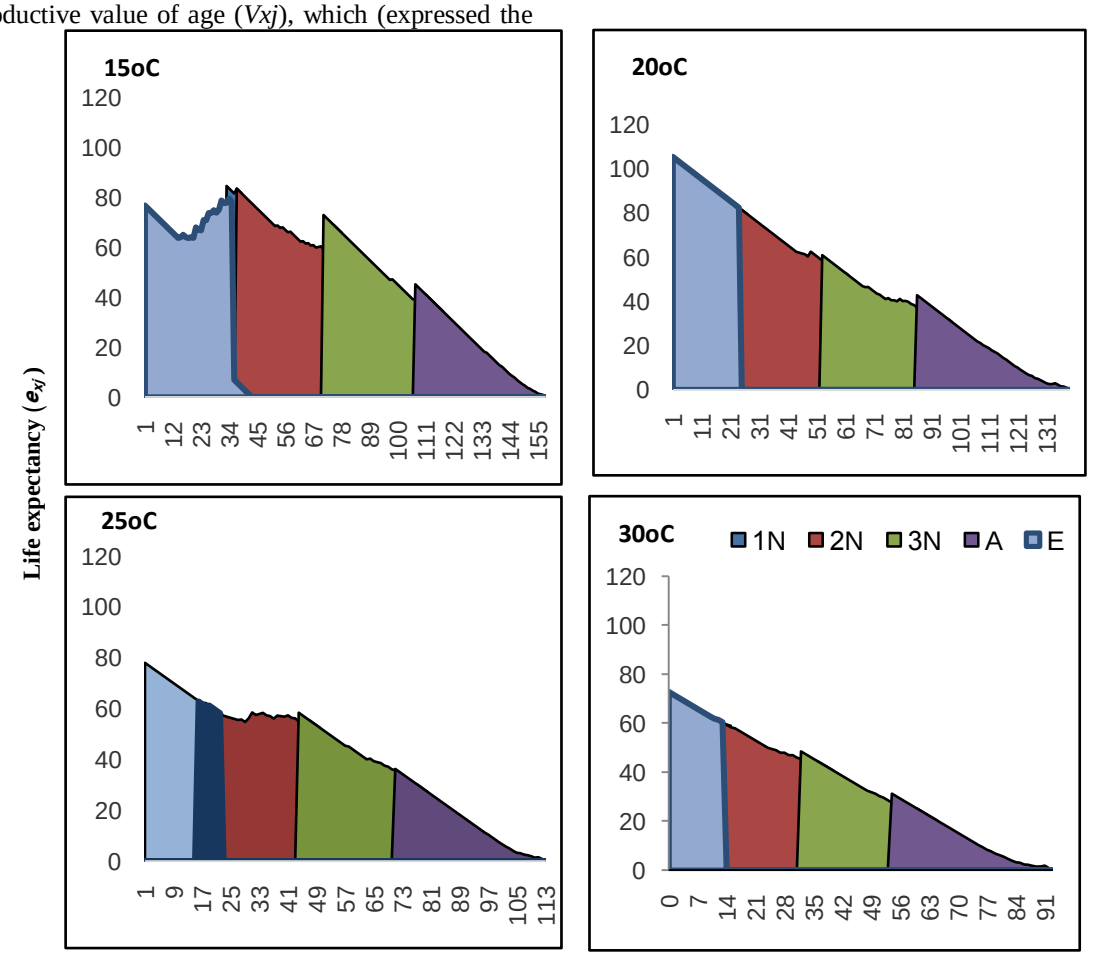

Figure (3) Life expectancy (e_{xj})of *Ceroplastes floridensis* reared on *Cucurbita moschata* at different temperatures (15, 20, 25, 30°C).

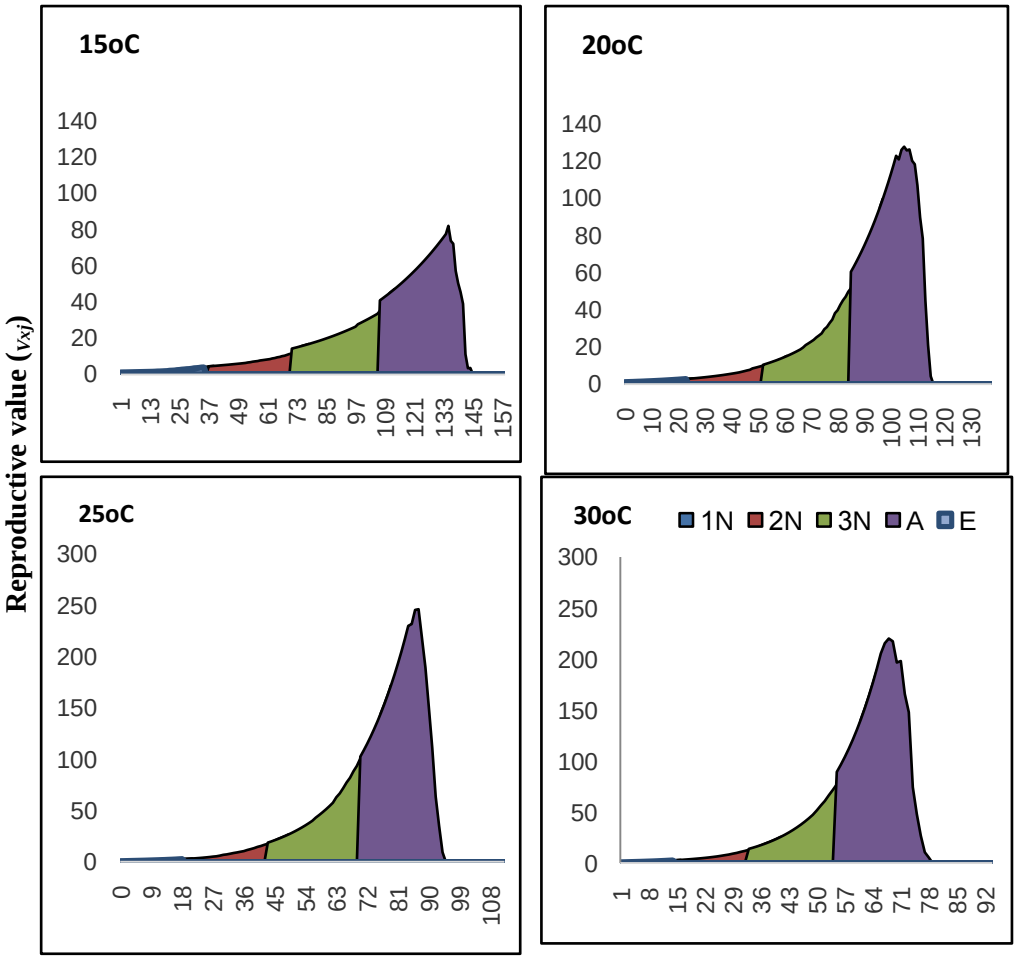

Figure (4) Reproductive value (V_{xj})of *Ceroplastes floridensis* reared on *Cucurbita moschata* at different temperatures (15, 20, 25, 30°C).

IV. CONCLUSIONS

The use of the age-stage, two-sex life table method to study *Ceroplastes floridensis* yielded considerably more accurate and useful data than would have been obtained by using the female-only age-specific life table .These life tables can be used for population growth, designing mass-rearing programs, and for pest management. We used the bootstrap method to estimate the variance of developmental time, fecundity, and longevity,because common statistical methods generally overestimate the variances and SEs of population means.

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