Stage and age specific Life-table for *Odoiporous longicollis* Oliver (Curculionidae: coleoptera) under Laboratory Conditions of Minimum Stress


*Biopesticide laboratory, ICAR- Central Tuber Crop Research Institute, Thiruvananthapuram, Kerala, India

*Corresponding author

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Abstract: Knowledge on life-table of agriculturally important insects are valuable since this can significantly contribute to the pest management strategies. The stage specific and age specific life-table of *Odoiporous longicollis* Oliver (Curculionidae: coleoptera) at minimum stress reveals that it took maximum period of 155.9±14.94 days to complete a generation at 28±2°C followed by 114±12.35 days at 20±2°C and 92±14.01 days at 35±2°C. The survivorship shows a retrogressive parabola pattern, whereas mortality curve represents a progressive parabola (J shaped) pattern. The life expectancy exhibited a continuous decline with advancement of age. The developmental stages from egg to first two stage adults of *O. longicollis* showed highest survivor fraction and lowest apparent mortality, survival ratio, indispensable mortality, and K-value is highest suggesting it as an R-strategist. Replacement rate and generation time clarify the status of *O. longicollis* as a pest.

Key words: Banana pseudostem weevil, life-table of banana weevil, minimum stress life-table of a coleopteran pest

Introduction

Life-table provides an important tool in understanding the agricultural pests during different developmental stages throughout their lifecycle. It is an especially useful approach in entomology, where developmental stages are discrete and mortality rates may vary widely from one life stage to another. It is very useful to analyse the mortality of insect population to determine key factors responsible for the highest mortality within population (Ali and Parvez, 2009).

The banana pseudostem weevil (BPW) (*Odoiporus longicollis* Oliver) is the most noxious pest of banana (Visalakshi *et al.*, 1989) and was a major issue ‘out of control’ for banana farmers (Fig. 1a and b). It is estimated that banana pseudostem borer causes 10-90% yield losses in banana fields were an active inoculum exist (Padmanaban and Sathiamoorthy, 2001).

Material and Methods

*Maintenance of test insect:* Samples of *O. longicollis* collected from the banana fields of Thiruvananthapuram district were
maintained in the laboratory at 26±3°C and RH 60 ± 10% and L:D 12:12. The pupae collected were maintained separately in 100 ml plastic container and its mouth was covered by muslin cloth. On emergence, the adults were transferred into one litre plastic container and they were provided pseudostem for feeding.

Life span: Three of the stock cultures were kept solely for life span study for almost one year and the stock starts with 20 individuals each in 2L stock bottles. The individuals were reared out synchronically from the selected eggs (90 nos.) laid by 130 adult females kept undisturbed individually for 48 hour. Equal amount of food and conditions were provided for the grub to obtain adults of uniform growth. From that successful and timely emerged 60 adults were selected. Sexes were segregated and ten numbers each of male and female were kept in a cage for life span study.

Life-table: Assessment was done by constructing both stage specific and age specific life-table of BPW following standard heads were recorded from the age specific life-table: \( x = \) Developmental stage of the insect, \( l = \) number surviving at the beginning of the stage \( x \), and \( d = \) mortality during the stage indicated in the column \( x \) (Arshad and Parvez, 2009; Kakde, 2014).

The data calculated through above assumptions were used for computing various life parameters as given below:

Apparent mortality \((q)\): It gives the information on number dying as percentage of number entering that stage and was calculated by using the formula:

\[
\text{Apparent mortality (q)} = \frac{d}{l}
\]

Where \( d = \) mortality during the stage indicated in column \( x \), and \( l = \) number surviving at the beginning of the stage \( x \)

Survival fraction \((S_x)\): Data obtained on apparent mortality was used for the calculation of the stage specific survival fraction \((S_x)\) of each stage by using the equation:

\[
S_x = \frac{l_{\text{subsequent stage}}}{l_{\text{particular stage}}}
\]

Mortality survivor ratio \((MSR)\): It is the increase in population that would have occurred if the mortality in the stage in question had not occurred and was calculated as follows:

\[
\text{MSR of particular stage} = \frac{d^*_{\text{particular stage}}}{l_{\text{subsequent stage}}}
\]

Where \( d^* = \) cumulative death for each stage

Indispensable mortality \((IM)\): This type of mortality would not be there in case the factor(s) causing it is not allowed to operate. However, the subsequent mortality factors operate. The equation is:

\[
\text{IM} = [\text{Number of new emergence observed}] \times \text{MSR of particular stage}
\]

\( K\)- value: It is the key factor, which is primarily responsible for increase or decrease in number from one generation to another and was computed as the difference between the successive values for “log l”. However, the total generation mortality was calculated by adding the \( k\)-values of different development stages of the insect, which is designated as “\( K\)”: 

\[
K = \sum k \text{ (Stages of O. longicollis)}
\]

In age specific life-table, observations on number of alive and dead, out of hundred larvae were recorded daily. The following assumptions were used in the construction of age specific life-table of O. longicollis.

Mortality rate at the age interval ‘\( x \)’ was calculated by using formula:

\[
Q_x = \text{average of q between the subsequent and particular developmental stage}
\]
*Life expectancy:* Life expectation was calculated using the equation: \( Ex = \frac{T}{lx} \)

Where, \( Ex \) = Expectation of life or mean life remaining for individuals of age \( x \) and \( T \) = the total number of individual of age units beyond the age \( x \) and \( lx \) = probable survivorship at each stage.

Total number of individual of \( x \) age units beyond the age \( x \): \( T = lx + (lx +1) + (lx +2) \ldots +lz \), were ‘lz’ is the last stage interval.

*Replacement rate:* The ratio of exponential production possibility can be ascertained by ‘Replacement rate’ and this can be calculated by using the formula, \( R = \frac{m^*}{M^*} \), where \( m^* \) is the number, of female in the \( F_1 \) generation and \( M^* \), that of \( F_2 \) generation. If the replacement rate is a value above ‘1’, it is considered that the growth of the population is exponential, while if it is below to that the population is going to extinct. Replacement rate is significant over stage by stage assessment (Wayne and Mark, 1982).

*Net reproductive rate:* Is an additive value of replacement assessment and it is calculated by using the formula, \( R_0 = \sum lx \cdot mx \), differing from a stage by stage assessment net reproductive rate access the population growth in general (Wittmeyer and Coudron, 2001).

Where, \( mx \) = Probable no. of newly emerged individuals at each stage.

*Average time of generation:* By calculating the mean time of generation one can easily ascertain the mean required time demanded by the insect to duplicate to the next generation (Wittmeyer and Coudron, 2001).

Mean time of generation= \( \frac{\sum lx \cdot mx \cdot tx}{R_0} \)

Where, \( tx \) = probable time of living specific to each stage.

**Result and Discussion**

*Life span:* Before the construction of a life-table the life span and the span related behaviour were studied (Table 1). The egg stage of BPW take 4.5±0.71 days for hatching to the first instar grub, and 4.8±0.79 days to moult into a second instar grub. The upcoming 2\(^{nd}\) and 3\(^{rd}\) instar larvae were the major stages that cause severe damage and loss of crop. Both the stages together in almost two week (5.2±0.42 days and 6.4±0.52 days respectively) contribute 3/4\(^{th}\) of causality. The fourth instar is comparatively lethargic to cause serious damage due to the massive body size, being a pre-pupa for almost 6.9±0.74 days. The pupal stage requires 7.2±0.79 days for complete metamorphose to an adult. Adults apart from sex live to an average of 120.9±14.94 days i.e.; almost 4 months. The females live longer (139.1±12.41 days) than males (102.7±17.47 days). Almost a month long, life expectancy of female weevil in comparison to males positively contributes over the status of the species as a major pest.

*Life table:* A life table in both age specific and stage specific were worked out (Table 2) and the following results were obtained:

**Apparent mortality curve** \( (q = d/l) \): From the Fig. 2a, the apparent mortality curve clearly gives the idea that the chance of mortality is high for the insect only due to ageing. A clear ‘J’ curve states BPW exhibit low mortality in its active stage/age.

**Survival fraction curve** \( (Sx = l/l_{n+1}) \): The survivalship curve (Fig. 2b) gives a clear idea on the extent of adaptation that the insect hold to thrive under experimental condition of minimum stress as a population. The chance of survival is found to be decreasing only due to aging.

**Mortality survivor ratio** \( (d^* \text{ in particular stage}) / (l \text{ of subsequent stage}) \), (MSR): It is maximum at adult insect in 3\(^{rd}\) and 4\(^{th}\) month of growth stage and minimum at pupa and adult in 1\(^{st}\) and 2\(^{nd}\) stage of growth.
Indispensable mortality curve (IM curve): This gives the minimum expectable mortality which is indispensable to each class or group and it is more significant than a mortality curve in a population, though the trend will be unique. The current study IM curve (Fig. 2c) shows the maximum mortality was on the last two classes as adult on 3rd and 4th month, respectively.

‘K- Value’ position for each stage: By analysing the ‘K- value’ position for each stage of *O. longicollis*, the high degree of survivorship from egg to adult indicates that the insect is an ‘R strategist’.

Replacement rate: The ratio of exponential production possibility (replacement rate) in this life table is above 1 over all the stages and thus the population of *O. longicollis* is considered to be ‘exponential’.

Net reproductive rate: The net reproductive rate value is also supporting the exponential population growth of *O. longicollis* since, $R_0 = 1.2$.

Mean time of generation: The mean time of generation calculated from the life table of *O. longicollis* suggests that the whole population of the species is duplicating in a mean time of 30.35 days until and unless there will be no interferences from any possible biotic and abiotic factors.

Conclusion

This study was a pioneer of its kind on the banana pseudostem weevil (*O. longicollis*) that gives a general idea on the status of this insect as a pest. The sketch of mortality curve, survivorship curve and indispensable mortality curve gives an overview over how this insect adapt by its life stages for effective survival. Life expectancy, replacement rate, net reproductive rate and mean time of generation studies also visualise the possible extend to which the pest can extend under minimum possible stress or in a possible conducive environment.
Fig 2: Prediction curves of apparent mortality, survivorship and indispensable mortality of O. longicollis under minimum stress
Table 1: Life span of *O. longicollis* at different stages (Days ± SD)

<table>
<thead>
<tr>
<th>Stage/age group (x)</th>
<th>No. of Survivor</th>
<th>Average survivalship (Lx)</th>
<th>Average probability of l (Lx)</th>
<th>Relatively time of living with lx (T)</th>
<th>Life Expectancy (Ex= T/lx)</th>
<th>Time of living in each class (t)</th>
<th>Cumulative probability of t (tx)</th>
<th>Avera ge probability of t (Tx)</th>
<th>No. of death in each class (d)</th>
<th>Cumulative probability of d (dx)</th>
<th>Probability of death (dx)</th>
<th>Average probability of d (Dx)</th>
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<tbody>
<tr>
<td>Egg</td>
<td>62</td>
<td>0.95</td>
<td>7.36</td>
<td>4.5</td>
<td>0.02</td>
<td>6</td>
<td>0.09</td>
<td></td>
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</tr>
<tr>
<td>1st instar</td>
<td>56</td>
<td>0.90</td>
<td>6.36</td>
<td>4.8</td>
<td>0.06</td>
<td>6</td>
<td>0.18</td>
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<td>2nd instar</td>
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<td>5.2</td>
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<td>12</td>
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<tr>
<td>3rd instar</td>
<td>50</td>
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<td>4.56</td>
<td>5.6</td>
<td>0.13</td>
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<td>14</td>
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<td>4th instar</td>
<td>48</td>
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<td>Pupa</td>
<td>48</td>
<td>0.74</td>
<td>2.98</td>
<td>7.2</td>
<td>0.22</td>
<td>4</td>
<td>18</td>
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<tr>
<td>0-1 MAE</td>
<td>44</td>
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<td>3.11</td>
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<td>6</td>
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<tr>
<td>1-2 MAE</td>
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<td>2-3 MAE</td>
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<td>0.79</td>
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<td>3-4 MAE</td>
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<td>4-5 MAE</td>
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<td>0.00</td>
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<tr>
<td>TOTAL</td>
<td>155.9 ± 14.94</td>
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</tbody>
</table>

Table 2: Life table of *O. longicollis* Oliver

<table>
<thead>
<tr>
<th>Stage/age group (x)</th>
<th>Mortality rate (q)</th>
<th>Mortality rate in average (Qx)</th>
<th>Surviv al fraction (Sx)</th>
<th>MortalitySurvivor Ratio (MSR)</th>
<th>Indispensable mortality (IM= 62/M SR)</th>
<th>In lx (A)</th>
<th>lx+1 -ln (B)</th>
<th>A (k)</th>
<th>AB (k)</th>
<th>lnx x (M*)</th>
<th>No. of females in F0 (M*)</th>
<th>No. of females in F1 (M*)</th>
<th>Replacement rate = m*/M*</th>
<th>No. of egg/individual (mx)</th>
<th>lx.m x</th>
<th>lx.m.x.t x</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg</td>
<td>0.09</td>
<td>0.04</td>
<td>1.00</td>
<td>0.00</td>
<td>6.63</td>
<td>0</td>
<td>0</td>
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<td>0.00</td>
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<tr>
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</tr>
<tr>
<td>2nd instar</td>
<td>0.10</td>
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<td>0.11</td>
<td>6.5</td>
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<tr>
<td>3rd instar</td>
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<tr>
<td>4th instar</td>
<td>0.00</td>
<td>0.04</td>
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<tr>
<td>Pupa</td>
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<tr>
<td>0-1 MAE</td>
<td>0.00</td>
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<td>0.00</td>
<td>4</td>
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<tr>
<td>1-2 MAE</td>
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<tr>
<td>2-3 MAE</td>
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<tr>
<td>3-4 MAE</td>
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<td>12</td>
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</tr>
<tr>
<td>4-5 MAE</td>
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<td>NS</td>
<td>NS</td>
<td>NS</td>
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</tr>
</tbody>
</table>

NS. = Non Significant value, Sx.im= Sexually Immature, Uk.Sx = Unknown Sex, F0= Zero filial generation, F1= First filial generation
Disclosure Statement

The authors are not aware of any biases that might be perceived as affecting the objectivity of this research article.

Competing Interest

I declare that the authors have no competing interests as defined by this publishing group, or other interests that might be perceived to influence the results and/or discussion reported in this article.

Reference


