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Construction of age-specific survival and fertility life table of Rice Brown Plant Hopper, *Nilaparvata lugens* Stal under natural conditions

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Abstract

An investigation on "Construction age specific survival and fertility life-tables of Rice Brown Plant Hopper (Nilaparvata lugens Stal.) under natural condition" was carried out at White Grub Project Research Laboratory, Department of Entomology, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.) during Kharif 2017. Three types of life-tables viz. age specific, stage specific and age specific survival and fertility life-tables were constructed during the investigation. Age specific life -table was revealed that the Nilaparvata lugens Stal. was completed its generation in 30 days on Pusa Basmati-1, while it was completed generation in 29 days on Pant Dhan-12. Population growth was estimated from the fertility life-table using the parameters potential fecundity (Pf) 85.88, net reproductive rate (R_0) 24.46, Intrinsic rate of increase (r_m)0.1276, mean length of generation (T_c) 25.05, doubling time (DT) 54.432 and finite rate of increase (λ) 1.1372 was recorded on Pusa Basmati-1, while the data was observed on Pant Dhan-12, the fecundity (Pf) 85.48, net reproductive rate (R_0) 24.07, intrinsic rate of increase (r_m) 0.1278, mean length of generation (T_c) 24.89, doubling time (DT) 5.4236 and finite rate of increase (λ) 1.1372. The finite rate of increase was 1.1372 was observed on Pusa Basmati-1 and Pant Dhan-12.

Key words - Nilaparvata lugens Stal, Pusa Basmati-1 and Pant Dhan-12

Introduction

Rice (*Oryza sativa* Linn.) is a very important cereal crop belongs to the family Poaceae. It is one of the world's largest cereal crops providing the caloric need for millions of people. The rice crop plays a vital role in our national food security and is a means of livelihood of rural households. It covers 11 percent of world cropped area and is cultivated in more than 214 countries globally with production of 502.2 million tonnes worldwide. India is the world's second-largest rice producer and the largest exporter of rice, with production increasing from 53.6 million tons in 1980 to 120 million tons in 2020-21. In 2022-23, India's rice production was estimated at 1357.55 lakh tonnes. However, in February 2024, the government predicted that rice production would drop for the first time in eight years due to below average rainfall. **Anonymous, (2023)**. The consumption of rice is associated with diabetes mellitus due to its high glycemic index. In other hand, some of rice components namely rice bran and rice bran oil contained some minor components which are reported to have some biological effects. Rice can be contaminated by some toxic elements such as arsenic and mercury coming from water and land in which it grows. Rice bran will produce rice bran oil and defatted rice bran. Defatted rice

bran component consists a numbers of polysaccharide and dietary fibres that support in cancer and cardiovascular diet therapy. This review will cover some new research information on rice, rice bran and rice bran oil especially in the biological activities and nutritional aspects to human. Such biological activities which are related to rice and its products are decreasing low density lipoprotein level, lowering cholesterol, reducing blood pressure and preventing colorectal cancer.**(Rohman *et. al* ., 2013.)**

MATERIALS AND METHODS

For the present study entitled " Construction of age-specific survival and fertility life table of Rice Brown Plant Hopper, *Nilaparvata lugens* Stal under natural conditions" the experiment was conducted in the White Grub Project Research Laboratory, Department of Entomology, SardarVallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.) during *Kharif*, 2017. The Procedures adopted for computations of various life parameters were as specified by **Birch (1948), Southwood (1978)**

Ten females of different age group obtained from the rice BPH was paired separate in small plastic pots and covered with insect proof net till and observed till their death. Daily observations were made on fecundity and daily egg laying rates as well as adult mortality were recorded.

The observation for age specific survival of female and the number of hatched and un-hatched eggs was also recorded. From the above mentioned procedures, the age specific survival and fecundity table for female of *Nilaparvata lugens* Stal was constructed with the following assumptions.

(A) The survivorship rates were assumed to the same for the both sexes, as it was not possible to identify the sexes prior to the adult stage.

(B) The sex could not be identified at the egg stage, therefore, a sex ratio of 1:1 will be considered in each batch of eggs.

This table was constructed on the suggestions made by **(Birch, 1948)** which consists the following columns.

x = Pivotal age of the class in days.

l_x = Number of females alive at the beginning of the age interval x (as fraction of initial population of one).

m_x= Average number of female eggs laid per female in each age interval assuming 50:50 sex ratio and is computed as:

$$m_x = N_x/2$$

Where;

N_x =Total natality per female off-spring in each age. Besides 'm_x', total number i.e. female eggs laid in age interval x, ($l_x.m_x$) was also computed multiplying the column l_x with m_x. This is also termed as **"Reproductive expectation".** A number of parameters were computed from the age specific survival and fertility life-table of female which include the following:

1. **Net Reproductive or Replacement Rate (R_o)**

This is also referred to as the "carrying capacity" of the average insect under defined environmental conditions. The information on the multiplication rate of the population in one generation is obtained from it. It is denoted as,

$$R_o = l_x.m_x.$$

2. **Mean Length of Generation (T)**

It is defined as the mean period between the birth of the parent and the birth of their offspring's. This period is a weighed approximate value, since the progeny is produced over a period of time and not at a definite time; Calculations followed the method as suggested by **Dubin and Lotka(1925).**

$T = l_x m_x.X/l_x.m_x$

3. Intrinsic rate of increase (r)

It is also denoted by 'r' or 'r^m' or 'r^{max}' and referred to as 'biotic potential'. It is defined as the instantaneous rate of increase of a population in a unit of time under a set of ecological conditions (**Birch, 1948**). A rough estimate of the intrinsic rate of increase (r) can be calculated using the following equation;

$r = [\log_e Ro]/T$

Where, R_o represents net reproductive rate which is calculated by multiplying l_x and m_x

i.e. $R_o = l_x.M_x$.

'T' represents mean length of a generation for an accurate estimate of 'r' **(Birch, 1948)** introduced some approximation to the method of minimize the experimental errors in the formula as suggested by **(Dubin and Lotka, 1925)** and given as under;

$\sum e^{-rx} l_x m_x.d_x = 1$ (**Lotka, 1925)**

$\sum e^{-rx} l_x m_x = 1$ (**Birch, 1948)**

4. Finite rate of increase (λ)

It gives the information about the frequency of the population multiplication in a unit of time **(Birch, 1948).**

It denoted as $(\lambda) = e^r$. By multiplying with $\log_e$ to both sides, we get,

$\log_e = \log_e e^r$

$\lambda = \text{Antilog } e^r$

This was used for computing the rate of increase of population per year.

5. Potential Fecundity (pf)

It expresses the total number of eggs laid by on an average female in her life-span. It is obtained or calculated by adding up the age specific fecundity column.

$pf = \Sigma m_x$

6. Doubling Time (DT)

It is defined as the time requirement for the population to double and, which is calculated by the equation:

$$DT = \frac{\log_e 2}{r}$$

7. Annual rate of increase (ARI)

This can be calculated from the intrinsic rate of increase (r) or finite rate of increase (λ) or doubling time (DT) or the net reproductive rate (R_o), assuming that the rate of increase was constant throughout the year.

$$ARI = 365 = e^{365r} = 2^{365/DT} = R_0^{365/T}$$

RESULTS AND DISCUSSION

Data recorded on different observations during the present investigation according to the technical programme and methodology mentioned in previous chapter. In order to gauge the response of different rice variety responsible for fluctuation in the population build-up of *Nilaparvata lugens* Stal. an effort was made to construct life-table and computing various life parameters of this pest under natural conditions. The life-tables viz. age specific survival and fertility life-tables were formulated which have been summarized under the following heads.

1. Age specific survival and fertility life-table of *N. lugens* Stal. on Pusa Basmati-1

Life and fecundity table for female was constructed to determine the survivorship of female (l_x) and age specific fecundity (m_x) close perusal of data (table-5) indicated that the immature stage period ranged from 0.5 to 17.5 and pre-oviposition period ranged from 18.5 to 21.5 days. Female survivalship (lx) was highest at the beginning of 22.5 pivotal age and after gradually decreased and 21.5 day after emergence i.e. total pivotal age was 3 days, the female continued to lay eggs throughout the life as in case of *Nilaparvata lugens* Stal. started laying eggs on 22.5th day. Maximum eggs (17.98) and minimum eggs (5.90.00) were laid on 23.5th day and 22.5th day.

2. Age specific survival and fertility life-table of *N. lugens* Stal. on Pant Dhan-12

Life and fecundity table for female was constructed to determine the survivorship of female (l_x) and age specific fecundity (m_x) close perusal of data (table-6) indicated that the immature stage period ranged from 0.5 to 17.5 and pre-oviposition period ranged from 18.5 to 21.5 days. Female survivalship (lx) was high at the beginning of 22.5 pivotal age and after gradually decreased and 21.5 day after emergence i.e. total pivotal age was 3 days, the female continued to lay eggs throughout the life as in case of *Nilaparvata lugens* Stal. started laying eggs on 22.5th day. Maximum eggs (18.45) and minimum eggs (6.30) were laid on 23.5th day and 22.5th day.

Table - 1. Age specific survival and fertility life table of *Nilaparvata lugens* Stal. on Pusa Basmati -1.

Pivotal age (Day) **X**	**Age specific female survivorship** **lx**	**Fecundity/ Natality rate** **mx**	**Net reproductive rate** **lx.mx**	**lx.mx.X**	**Value of $e^{-rmx}I_x.m_x$** **Where,** **r_m= 0.1286023**	**% Constitution of each group towards** **'r'**
0.5-17.5 Immature stage						
18.5-21.5 Preoviposional periods						
22.5	0.37	5.90	2.18	49.12	0.12	12.09
23.5	0.34	17.98	6.11	143.66	0.30	29.77
24.5	0.33	16.00	5.28	129.36	0.23	22.61
25.5	0.32	15.00	4.80	122.40	0.18	18.07
26.5	0.22	10.00	2.20	58.30	0.07	7.28
27.5	0.20	8.00	1.60	44.00	0.05	4.66
28.5	0.18	7.00	1.26	35.91	0.03	3.23
29.5	0.17	6.00	1.02	30.09	0.02	2.30
Total		85.88	24.46	612.84	1.00	100.00

Table - 2. Age specific survival and fertility life table of *Nilaparvata lugens* Stal. on Pant Dhan -12.

Pivotal age (Day) **X**	**Age specific female survivorship** **lx**	**Fecundity/ Natality rate** **mx**	**Net reproductive rate** **lx.mx**	 **lx.mx.X**	**Value of $e^{-rmx}I_x.m_x$** **Where,** **r_m= 0.1286023**	**% Constitution of each group towards** **'r'**
0.5 -17.5 Immature stage						
18.5-21.5 Preoviposional periods						
22.5	0.36	6.30	2.27	51.03	0.13	12.56
23.5	0.33	18.45	6.09	143.08	0.30	29.65
24.5	0.32	16.50	5.28	129.36	0.23	22.61
25.5	0.31	16.39	5.08	129.56	0.19	19.13
26.5	0.21	10.84	2.28	60.32	0.08	7.54
27.5	0.19	9.50	1.81	49.64	0.05	5.25
28.5	0.17	7.50	1.28	36.34	0.03	3.26
Total		85.48	24.07	599.33	1.00	100.00

Summary of life parameters for *N.lugens* on Pusa Basmati–1 and Pant Dhan- 12

Life parameters were also computed, while constructing female fertility table, which have been observed. The parameters include as below-

1. Potential Fecundity (Pf=∑mx)

The data revealed a noticeable variability in the potential fecundity with respect to the female of *N. lugens* Stal on Pusa Basmati-1 and Pant Dhan-12. It can be observed . The potential fecundity (Pf) of *N. lugens* Stal was 85.88 on Pusa Basmati-1 followed by 85.48 potential fecundity recorded on Pant Dhan-12.

2. Net Reproductive Rate (lxmx)

The propensity was identical to that of potential fecundity. The reproductive rate to the tuned of 24.46 was recorded on Pusa Basmati-1and 24.07 on Pant Dhan-12.

3. Mean Length of Generation (T)

The range of mean length of generation expected by *N.lugens*Stal was highest 25.05 days on Pusa Basmati-1 and lowest 24.89 days on Pant Dhan-12.

4. Intrinsic Rate of Increase (r)

Also showed variation in the accurate intrinsic rate on Pusa Basmati-1 and Pant Dhan-12. Intrinsic rate of increase 0.1276 was observed on Pusa Basmati-1 and 0.1278 was noticed on Pant Dhan-12.

5. Finite Rate of Increase (λ)

The finite rate of increase as 1.1372 on Pusa Basmati-1 followed by 1.1372 observed on Pant Dhan-12.

6. Doubling time (DT)

As far as the doubling time was concerned, there was a variation of doubling time on Pusa Basmati-1 and Pant Dhan-12. The doubling time 5.4321 was recorded on Pusa Basmati-1 followed by 5.4236 observed on Pant Dhan-12

7. Annual rate of increase (ARI)

Variation in the values acquired for annual rate of increase of *N. lugens* Stal. was 1.814216658×10^{20} recorded on Pant Dhan-12 and was 1.702167151×10^{20} recorded on Pusa Basmati-1

The data related to age specific survival and fertility table unconcealed the age specific female survivorship (lx), fecundity rate, net reproductive rate of *N. lugens* Stal on Pusa Basmati-1 and Pant Dhan-12. The present finding of age specific survival and fertility life-table table are agreement with the finding of Satpathi *et al*.,(2011) and also agreement with the finding of Manikandan *et al*., (2015). The present study partially relationship with the finding of Zheng *et al*.,(2017), Win *et al*.,(2011) and Shibo *et al*.,(2012).

Table -3 Summary table of life parameters of *Nilaparvata lugens* Stal. on Pusa Basmati-1 and Pant Dhan-12

Life Parameter	Symbol/Equation	Pusa Basmati –1	Pant Dhan - 12
Potential fecundity	**$Pf = \sum mx$**	85.88	85.48
Net reproductive rate	**$Ro = \sum lx.mx$**	24.46	24.07
Hypothetical F_2 female	**$(Ro)^2$**	598.29	579.36
Mean length of generation	**$T = (\sum lx.mx.x)/\sum lx.mx$**	25.05	24.89
Intrinsic rate of increase 'r'	**$r = [\log_e Ro]/T$**	0.1276	0.1278
'r_m'(Accurate)	**$e^{-rx} lx.mx = 1$**	0.1286	0.1286
Doubling Time	**$DT = \log_e 2/r$**	5.4321	5.4236
Finite rate of increase	**$\lambda = \text{Anti} \log_e r_m$**	1.1372	1.1372
Annual rate of increase	**$ARI = Ro^{365/T}$**	1.702167151×10^{20}	1.814216658×10^{20}

SUMMARY AND CONCLUSION

The data obtained for age specific survival and fertility life-table revealed that the females of *Nilaparvata lugens* Stal. exhibited highest potential fecundity was 85.88 on Pusa Basmati-1, while lowest 85.48 on Pant Dhan-12. The intrinsic rate of increase highest was 0.1278 on Pant Dhan-12, while lowest 0.1276 on Pusa Basmati-1. The finite rate of increase was 1.1372 observed on Pusa Basmati-1 and Pant Dhan-12. The highest doubling time 5.4321 was recorded on Pusa Basmati-1, while lowest 5.4236 on Pant Dhan-12. The highest annual rate of increase 1.814216658×10^{20} was recorded on Pant Dhan-12, while lowest 1.702167151×10^{20} on Pusa Basmati-1. The highest mean length of generation was found 25.05 days on Pusa Basmati-1, while lowest 24.89 days on Pant Dhan-12

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