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BIOLOGY AND LIFETABLE OF WHITEBACKED PLANTHOPPER *SOGATELLA FURCIFERA* (HORVATH) ON RICE

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ABSTRACT

Whitebacked planthopper *Sogatella furcifera* (Horvath) is an important insect pest causing economic damage to rice. Studies on its biology in West Bengal revealed that the fecundity was 197± 13.37 eggs/ female. The incubation period was 7.6± 0.69 days in October, with nymphal duration being 16.2± 0.85 days; and longevity of male macropterous ones was 9.5± 2.06, while for brachypterous it was 7.3± 1.33 days; and female brachypterous lived for 13.50± 1.08 days. The net fecundity rate, intrinsic rate of increase, gross reproductive rate, generation time, doubling time, finite rate of increase and net reproductive rate were 31.30, 0.122, 108.60, 29.29, 5.68 days, 1.129 and 64.91, respectively. The seasonal abundance when studied on rice in rainy season revealed that slight incidence occurred at 60 days, and its peak was at 32.00 and 34.20/ hill at 120 DAT during second week of November. Then it disappeared from the third week of November with the onset of winter during 2019 and 2020.

Key words: *Sogatella furcifera*, bionomics, population dynamics, temperature, humidity, seasonal incidence, peak, winter, macropterous, brachypterous, fecundity, longevity

Whitebacked planthopper *Sogatella furcifera* (Horvath) (Homoptera: Delphacidae) is a major insect pest of rice in eastern India. It was first reported from Japan in1899 and from India in 1903 (Chaudhury et al., 1968; Dale, 1994). Its outbreak was also reported in Bangladesh, Indonesia, Malaysia, Nepal, Pakistan and Vietnam (Mochida et al., 1979). Later *S.furcifera* gradually spread to other countries like Myanmar, China, Hong Kong, Japan, Kampuchea, Laos, Philippines, Ryukyu Islands, Taiwan, Thailand, USSR, Australasia and Pacific Islands, Australia, Caroline Islands, Fiji, Irian Jaya, Marianas Island and Marshal Island (Dale, 1994). Khan and Misra (2003) reported that its population usually peaked in October in Uttar Pradesh, while Vijaykumar and Patil (2004) reported that it appeared from September to December in Karnataka. Katti et al. (2005) recorded it during rainy and summer seasons in Andhra Pradesh. The maximum occurrence of *S. furcifera* was observed during 2nd week of November and 3rd week of September in Odisha (Sarkar et al., 2018). Kumar et al. (2015) studied the biology of *S. furcifera* on basmati rice under agroclimatic conditions of Haryana and found that its fecundity was 132.8 eggs/ female in a cluster of 5 to 30 eggs. The effect of temperatures on its biology was studied in Punjab (Sandhu and Suri, 2018). To evaluate natality and reproduction of an insect population the analysis of lifetables is the most suitable method (Southwood, 1966; Price, 1997). Chi (1988) prepared the lifetable of brown planthopper *Nilaparvata lugens* (Stal.). The fecundity of *S. furcifera* gained prominence in Asia over the last few decades due to high levels of adoption by Asian farmers of hybrid rice varieties, particularly those with a cytoplasmic male sterile lineage, that are highly susceptible. It is also possible that gradual changes in global temperatures/ climate might have contributed to this (Horgan et al., 2016). There is still lack of information on the lifetable of *S. furcifera* on rice crop in eastern India, and hence, the present study.

MATERIALS AND METHODS

A field experiment was conducted for two wet seasons during July to October of 2019 and 2020 at the Regional Research Station, Chakdaha, Bidhan Chandra Krishi Viswavidyalaya (20.50^0- 24.50^0N, 86.00- 89.00^oE, 9.75 masl). Long duration pest susceptible variety MTU 7029 was transplanted in 0.40 ha on 3rd July, with 20x15cm spacing following normal agronomic practices. Incidence of *S. furcifera* was recorded at weekly intervals starting from 15 days after transplanting. It was done by trapping both nymph and adult from 30 randomly selected plants using 30x 20 cm enamel tray containing small quantity of soap

water. Data were also recorded on *S. furcifera* at 3 days interval using sweeping nets and light traps; 10 m^2 areas were selected at random and *S. furcifera* were collected by sweeping five times during the morning hours. The pooled data were retransformed before subjecting to statistical analysis. Simultaneously in another study, *S. furcifera* were reared in the laboratory on the potted rice plant cultivar MTU7029 at the research station RRSS, Chakdaha. Initially heavily infested plants were grown inside a cage to maintain a mass culture containing freshly emerged last instars nymph. After one or two days the mated females were transferred to another set of 10 potted plants covered with glass chimney. The potted plant was changed daily morning till the adults died. The experiment was repeated five times by introducing female of each cohort in the laboratory (25 to 30º, 80 to 85% RH). Daily observation was taken to study the biology till the start of subsequent generation. Observations were recorded on preoviposition and oviposition periods, period from emergence to death and the fecundity of female. After emergence of first instar nymphs the plants were cut longitudinally and total number of hatched egg and unhatched eggs were counted under microscope. Data were subjected to computation of lifetable as per Southwood (1966)

RESULTS AND DISCUSSION

Sogatella furcifera a was observed passing egg, nymph and adult stages, with both adult male and female observed immediately after emergence remaining together for at least 3 hr. The females vibrate their abdomen and the excited males either flutter their wing or dance before mating. The evening time was the best time for their mating. Although 2 to 3 males followed a single female but ultimately, they mate once with a single potential male and mating period lasted for 162±10.32 sec. Long et al.(2012) also reported that successful mating in *N. lugens* depended on the exchange of acoustic signals between male and female. As soon as mating was completed the female gave some vertical cut over the mid region of leaf sheath and inserted about 21 eggs in the first day and they laid total of 197±13.37 eggs in nearby 5 to 10 tillers within 8 to 10 days. The egg laying sites appeared as brownish streaks over the leaf sheath. The macropterous male survived up to 9.5±2.06 days whereas brachypterous male could not survive after 7.3±1.33 days; female survived up to 13.50±1.08 days and remained beside the slits till the first instar nymphs emerged out. The incubation period was 7.6±0.69 days, nymphal developmental period was 16.2±0.85 days. There were five instars requiring 2.55± 0.37, 2.45± 0.43, 2.72± 0.26, 3.55± 0.43 and 4.70± 0.67 days each. These results corroborate those of Kumar et al. (2015). The net fecundity rate, mean length of generation, finite rate of increase, mean generation time, weekly multiplication of the population and doubling time of the population were also measured. The net fecundity rate (*Ro*) and net reproductive rate (R_t) were 31.30 and 64.91, respectively (Table 1).

The present results corroborate with those of van Lenterenand Noldus (1990) who found that short developmental time and high reproduction rate on a host reflect suitability of the plant tested. Win et al. (2011) reported that the basic reproductive rate of BPH (*Ro*) was also 10.02; the population increased by a factor of 10. The study also showed that innate capacity (*rc*), intrinsic rate of increase(*rm*) and finite rate of increase (λm) were 0.117, 0.122 and 0.129, respectively during wet season in West Bengal. The intrinsic birth rate(2.79) and intrinsic deathrate (2.73) were equal and it took only 5.68 days for doubling up their population. Therefore *S. furcifera* population could not maintain its *rm* value over an indefinite period under a given set of environmental condition. The data supports the observation of Win et al. (2009) who recorded the innate capacity *(rc*) and intrinsic rate of natural increase *(rm*) for BPH as 0.117 and 0.122 respectively. The *rm*, T_c and DT are useful in dices of population growth of *S. furcifera* on one of the most susceptible variety MTU 7029 during wet season in West Bengal. The *rm* value of a life table data of a particular species provide insight into characteristic life patterns of different species (Satpute et al. 2005). The intrinsic birth rate and death rate varied with some biotic and abiotic factors.

Andrewartha and Birch (1954) reported that both birth and death rates remain constant in a population having stable age distribution when grown in unlimited space. Quantifying the birth and death rate could predict the growth and decline of WBPH population in future in a particular variety of rice crop. The study showed that survival potential (*lx*) of the female and the age specific fecundity rate (*mx*) were maximum during the second day and then gradually declined with advancement of its pivotal ages. The survival potential (*lx*) of WBPH showed that high mortality was found in early stage followed by a gradual decline in the population densities throughout its life span over the study period. Studies on seasonal incidence of *S. furcifera* indicated that it appeared with very small average population of 0.10 macropterous adult per hill at 60 DAT during first week of September. Nymphs appeared at 75DAT during

Table 1. Biology and reproductive parameters of *S. furcifera* on rice (2019 & 2020)

Stage	Life period in days at 25 to 30ºC, 80 to 85% rh	
	Days (hour/second)	References
(A)Adult stage		
(i) Premating period	3.4± 0.459	-
(ii) Mating period	162± 10.32 second	148 second (Ahmed et al., 2016)
(iii) Preoviposition period	5.3 days± 1.76 days	3 to 8 days (Dale, 1994) 3.7 ± 0.3 days (Kumar et al., 2015)
(iv) Oviposition period	5.6 days± 1.26 days	10.2 ± 0.51 (Kumar et al., 2015)
(vi) Adult longevity		
Male (Macropterous)	9.5± 2.06 days	14.4 days (Kumar et al., 2015), 12. 5 days (Ammar et al.,1980)
Male (Brachypterous)	7.3± 1.33	
Female (Brachypterous)	13.50± 1.08	15.9 days (Kumar et al., 2015) 18.7 days (Ammar et al., 1980)
(vii)Sex ratio(Female: Male)	1.2: 0.98	1.0 : 0.78 (Kumar et al., 2015) 0.512:0.488. (Win et al. 2009)
(B) Egg stage		
Fecundity	197± 13.37	164 eggs (Vaidya and Kalode, 1981), 300 to 350 (Suenaga, 1963), 119 to 158 eggs (Kumar et al., 2015) (129 to 198 eggs Sandhu and Suri, 2018)
Incubation Period	7.6± 0.69	8.6 ±0.24 (Kumar et al., 2015)
(C) Nymphal stage		
First instar	2.55± 0.37	2.05± 0.05 days (Kumar et al., 2015)
Second instar	2.45± 0.43	2.3± 0.12 days (Kumar et al., 2015)
Third instar	2.72± 0.26	2.6± 0.11 days (Kumar et al., 2015)
Fourth instar	3.55± 0.43	2.7± 0.10 days (Kumar et al., 2015)
Fifth instar	4.70± 0.67	2.95±0.11 days (Kumar et al., 2015)
Total nymphal developmental period	16.2± 0.85	17. 7 days (Sandhu and Suri, 2018)
(D) Total life cycle(from egg to adult)	24.5± 0.99	23 days (Dale, 1994)
(E)Approximate generation time (T_c)= $\sum xlxmx/ lxmx$	29.29 days	-
(F) Net fecundity rate (R_0)= $\sum lxmx$	31.30	-
(G) Innate capacity(rc)= $\ln R_0/ T_c$	0.117	-
(H) Intrinsic rate of natural increase(rm)= $\sum e^{-rm.X} lXmX = 1$	0.122	-
(I) Finite rate of increase (λm) = antilog e^{rm}	1.129	-
(J) Doubling time of population (DT) in days=ln2/rm	5.68 days	-
(K) Intrinsic birth rate(B)=1/ $\sum e^{-rmx} lx$	2.79	-
(L) Intrinsic death rate(D)= B- rm	2.738	-
(M) Gross reproductive rate= $\sum mx$	108.6	-
(N) Net reproductive rate(R_t)= $\sum lxtx$	64.91	-

Lifetable for female *S. furcifera* (25ºC, 85 % RH)

Pivotal age in days(x)	*lx*	*mx*	*lxmx*	*xlxmx*	*tx*	*lxtx*	*xlxtx*
0-25.5	-	-	-	-	-	-	-
26.5	-	-	-	-	-	-	-
27.5	0.36	8.00	2.88	79.20	18.00	6.48	178.20
28.5	0.34	32.00	10.88	310.00	70.00	23.8	678.30
29.5	0.32	41.00	13.12	389.4	80.00	25.6	755.20
30.5	0.30	9.00	2.70	82.35	20.00	6.00	183.00

(contd.)

(contd. Table 1)

31.5	0.12	6.00	0.72	22.68	12.00	1.44	45.36
32.5	0.10	5.00	0.50	16.25	8.00	0.80	26.00
33.5	0.08	4.00	0.32	10.72	6.00	0.48	16.08
34.5	0.06	3.00	0.18	6.21	5.00	0.30	10.35
35.5	0.01	0.6	0.006	0.201	1.00	0.01	0.355
Total		108.6	31.306	917.01		64.91	1892.84

Correlation coefficients- *S. furcifera* incidence vs. weather factors

Stages	Temperature				Relative humidity			
	2019		2020		2019		2020	
	Max	Min	Max	Min	Max	Min	Max	Min
Nymph	0.172	-0.168	0.156	-0.147	0.212	-0.179	0.173	-0.112
Adult	0.492	-0.547**	0.162	-0.172	0.682**	-0.248	0.562**	-0.219

Max= Maximum; Min = Minimum; ** Significant at p≤0.05

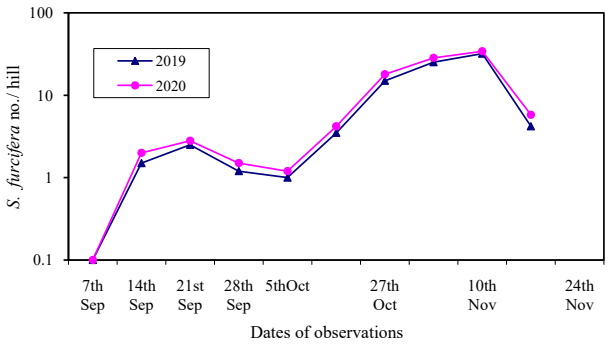

Fig. 1. Incidence of *S. furcifera* in West Bengal (2019 and 2020)

second week of September with an average population of 1.5 and 2.0/ hill during 2019 and 2020, respectively. The population increased when the second-generation nymphs emerged out averaging 3.5 and 4.2/ hill, respectively at 105 DAT during second week of October for subsequent 2 years of study (Table 1; Fig. 1).

Sogatella furcifera incidence peaked to 32.00 and 34.20/ hill at120 DAT during 2nd week of November followed by sudden disappearance from the 3rdweek of November with the onset of winter. The insect had the habit of clustering at the base of plant or on the under surface of leaf. Correlation coefficients of incidence with weather parameters showed a positive relationship with maximum (r= 0.172 to 0.492) temperature but had significantly negative association with minimum temperature (r= -0.168 to -0.547) during 2019. The trend was identical during 2020 with the correlation coefficient value of 0.156 to 0.162 and -0.147 to -0.172 for maximum and minimum temperature, respectively. A positive association was observed with maximum RH (r=0.212 to 0.682) but was negatively correlated (r=-0.179 to -0.248) with minimum RH; similar positive (r= 0.173 to 0.562) and negative(-0.112 to -0.219) correlations were also found during 2020 (Table 1). The present results are similar to those of Sarkar et al. (2018) as regards temperature with high relative humidity. Khan and Misra (2003) also reported a positive correlation with temperature and RH. The upper temperature tolerances for adult female was estimated as37-41°C (Ali et al. 2019).

The incidence of *S. furcifera* is gradually becoming to an alarming state in new Gangetic Alluvial Zones of West Bengal. Among the lifetable parameters the high net reproductive rate(R_0) and finite rate of increase (λm) with lower doubling time (DT) indicate that *S. furcifera* has a capacity for rapid buildup in a short period of time. The intrinsic birth rate and death rate may be regarded as the key factors for regulating its population. Therefore, based on lifetable study, a time-based management practices can be prepared including conservation of the natural enemies to reduce the negative impact on environment. The present study suggested that the key period for adoption of control measures is 2ndweek of October when the second-generation nymphs emerge out and the prevailing favourable climate is conducive to build up effective pest population in rice fields.

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