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Biology and Life Table Study of Rice Weevil *Sitophilus* Weevil in Milled Rice Grains Under Coastal Climatic Condition of Odisha

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ABSTRACT

An experiment on the study of biology and life table statistics of *Sitophilus oryzae* in milled rice grains was conducted under coastal climatic condition of Odisha indicated that the total life cycle from egg to adult as 59 to 70 days in males and 64 to 80 days in females during summer with 4 instars while 87 to 102 days in males and 98 to 109 days in females during winter with 3 instars. The stage-specific life table study revealed that the sex ratio was 0.94: 1.00 with a generation survival rate of 0.569. The age specific (female fecundity) life table study revealed the net reproductive rate (R_0) of 16.35 with the mean length of generation (T) of 36.65 days and the intrinsic rate of natural increase (r_m) of 0.076.

Keywords Biology, Milled rice grains, Reproductive rate, Age specific life table study, Stage -specific life table study.

INTRODUCTION

Among the several insects attacking stored grains, *Sitophilus oryzae* L. (Coleoptera : Curculionidae) has got economic importance. It is the most destructive insect pest of the stored raw cereal grains in the world (Champ and Dyte 1976). *Sitophilus oryzae* causes substantial losses to stored grain amounting 18.30% (Adams 1976). This species has a relatively short developmental period and a high population can easily be built up. Thus, unless control measures are taken, heavy infestation may take place. The female rice weevil oviposits directly into the seeds and completes larval development and emerge as adults.

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MATERIALS AND METHODS

Biology study of insect rice weevil, *Sitophilus oryzae* (L.)

Studies on the biology of the rice weevil, *S. oryzae* was carried out under laboratory condition in the test milled rice variety of Jyotirmayee. During the course of investigation the temperature and relative humidity were 23.42 ± 1.86 and 69.3 ± 1.8 during summer (May- July 2016) and 24.23 ± 1.78 and 69 ± 1.4 during winter (November 2016 – January 2017) respectively. The procedure followed to study the different stages of rice weevil were as follows.

Egg stage **:** Thirty rice weevils were enclosed with 50 g milled rice grains in each bottle and these bottles were kept under ambient conditions. Infested grains were replaced every morning with uninfested grains. Grains containing eggs were separated out by examining under microscope and were used for further study.

Incubation period **:** Milled rice grains with rice weevil eggs so obtained were maintained in a glass vials for incubation. Daily twenty grains from the day of oviposition to egg hatching were dissected to determine the incubation period.

Larval period **:** On hatching the grub of rice weevil were allowed to feed individually inside the grains in specimen tubes of 7.5 cm × 2.5 cm size having 5 gram of milled rice grains. Five grains per day were dissected out to see the different stages of the larvae. The dissection of grains was made up to the pupal stage. The period between egg hatching and pupation was observed as larval period.

Pupal period **:** The pupal period of the insect was studied by observing the same larvae for pupation-inside the grains. This was maintained and the observations were made till the adult emergence. The period between formation of pupae till the adult emergence was noted as pupal period.

Ovipositional studies **:** A pair of emerged weevils was collected in a specimen tube (7.5 × 2.5 cm) and likewise ten specimen tubes were maintained. The weevils were allowed to mate. Mating period and premating period were recorded.

Adult longevity **:** The ability of the adults of *S. oryzae* to live in the presence or absence of food was determined by enclosing male and female adults obtained from the culture separately. Ten such vials were maintained for each of the male and female with and without food.

Life table study of *Sitophilus oryzae* (L.)

At the beginning of experiments (to synchronize the age of eggs) ten pairs of mated *S. oryzae* were transferred from the stock culture to the vials internally lined with dark colored crape paper for facilitating egg laying. After 12 h 100 laid eggs on crape paper were further investigated. The collected eggs were kept inside petridishes (10 cm diameter) which was covered with muslin cloth. The collected eggs were checked daily until the emergence of adults. Incubation and larval periods and their mortality were recorded. As the larvae were internal feeder, seeds were splitted out and each hatched larvae were carefully placed inside the grains using a fine camlin brush to observe the stage of development of insect after certain intervals. Duration of adult longevity was also recorded daily until death of last female. After emergence of adults, each female with one male was placed into each plastic case (10 cm diameter) containing milled rice grains. The duration of oviposition and post-oviposition periods as well as longevity, daily fecundity (eggs per reproduction day) and total fecundity (eggs during reproduction period) were recorded of two successive generations. After the end of the life table experiment the insects which failed to come out from the seeds were observed minutely by splitting the seeds under the binocular microscope and the stages of the dead insects were also recorded.

Age specific survival (l_x) and mortility (d_x) were used to construct the age specific survivorship life table. Age specific survival (l_x) and average number of female offspring (m_x) for each age interval (x) were used to construct age specific female fertility life tables. Observations on mortality during different stages from hatching of eggs till the emergence of adults were recorded daily which provided the values for life table (l_x). Life tables were constructed according to the method of Howe (1952), Atwal and Bains (1974). The sum total of products 'lxmx' is the net reproductive rate (RO). The innate capacity of increase (r_m), net reproductive rate (R_o) and mean generation time (T) were the basic parameters used to assess the population growth.

RESULTS AND DISCUSSION

Study of the biology of rice weevil

Biology of the *S. oryzae* on milled rice grains having 12.0% moisture content under laboratory condition at temperature and relative humidity of 23.42 ± 1.86^{0}C and 69.3 ± 1.8% during summer (May-July 2016) and 24.23 ± 1.78^{0}C and 69 ± 1.4% during winter (November 2016 – January 2017) respectively. The results along with description of brief biology of

Table 1. Biology of *S. oryzae* in milled rice grain.

Life stages		Summer (May – July 2016) Life span (days) ±SEm	Range (days)	Winter November – January (2017) Life span (days) ±SEm	Range (days)
Egg		5.8 ± 0.37	5 – 7	8.4 ± 0.51	7 – 10
Grub	1st instar	3.6 ± 0.51	2 – 5	8.0 ± 0.32	7 – 9
	2nd instar	5.2 ± 0.37	4 – 6	9.6 ± 0.40	9 – 11
	3rd instar	6.2 ± 0.20	6 – 7	10.6 ± 0.60	9 – 12
	4th instar	6.8 ± 0.37	6 – 8	- -	
	Total	21.8 ± 1.16	18 – 25	28.2 ± 0.86	26 – 31
Pupa		7.2 ± 0.58	6 – 9	11.8 ± 0.86	9 – 14
Adult (with food)	Male	30.8 ± 1.36	27 – 35	45.2 ± 1.85	43 – 51
	Female	38.2 ± 1.24	34 – 41	57.4 ± 1.21	54 –61
Adult (without food)	Male	4.2 ± 0.37	3 – 5	5.8 ± 0.37	5 – 7
	Female	8.0 ± 0.45	7 –9	9.8 ± 0.86	7 – 12
Pre mating period		3.0 ± 0.32	2 – 4	3.8 ± 0.37	3 – 5
Mating period (minutes)		33.6 ± 6.24	15 – 50 min	37.0 ± 6.04	20 – 55 min
Total life cycle	Male	65.6 ± 1.86	59 –70	93.6 ± 3.11	87 – 102
	Female	73.0 ± 2.86	64 – 80	105.8 ± 2.46	98 – 109

various developmental stages are presented as follows (Table 1).

Egg **:** Eggs were laid inside milled rice grains below the seed coat. The eggs were oval in shape. Freshly laid eggs were translucent and white and became opaque before hatching. During summer the egg period varied from 5 to 7 days with a mean of 5.8 ±0.37 days whereas in winter it ranged from 7 to 10 days with mean of 8.4 ± 0.51 days.

Grub **:** Four moults with five instars were observed during summer and three moults with four instars were observed during winter. The grub development took place inside the grain. Grub was apodous, short, stout, yellowish white brown colored head. The grub period ranged from 18 to 25 days with a mean of 21.8 + 1.16 days in summer and 26 to 31 days with a mean of 28.2 + 0.86 days in winter. The mean developmental periods were 3.6 + 0.51, 5.2 + 0.37, 6.2 + 0.20 and 6.8 + 0.37 days for 1st, 2nd, 3rd and 4th instar grub respectively in summer and 8.0 ± 0.32, 9.6 ± 0.40 and 10.6 ± 0.60 days for 1st, 2nd and 3rd instar respectively in winter.

Pupa **:** Pupa was white to yellowish white, exarate type with clearly visible head thorax and abdomen. Pupal period occupied 6-9 days with an average of 7.2 ± 0.58 days in summer and 9 to 14 days with an average of 11.8 ± 0.86 days in winter. Pupation took place in larval tunnel inside pupal case.

Adult **:** Newly emerged adults were reddish brown which gradually turned to black in due course of time. Adults were elongate sub-cylindrical with four orange colored patches on elytra. Externally both male and female look alike but on closer observation, the rostrum of the male was comparatively thick, closely punctured roughs curved, while in female it was elongate, slender smooth, shining slightly curved and sparsely punctured. During summer when the adults were provided with food, the male survived for 27 to 35 days and female for 34 to 41 days, but without food the adult male and female longevity were 3 to 5 and 7 to 9 days respectively. Similarly during winter when the adults were provided with food, the male lived for 43 to 51 days and female for 54 to 61 days, but without food the adult male and female longevity were 5 to 7 and 7 to 12 days respectively.

Pre mating periods **:** The pre mating period observed during present study ranged from 2 to 4 days with an average of 3.0 ± 0.32 days in summer and 3 to 5 days with an average of 3.8 ± 0.37 days in winter.

Table 2. Stage-specific life table study of *S. oryzae*. Note: X – Age in days, lx – no. of insects alive at the beginning of age interval X, dx – no. of insects dead at age interval X, dxf – key mortality factors, 100qx – death rate , Sx– Survival index.

x	Lx	Dxf	Dx	100qx	Sx
Egg	100	Egg sterility, Low temperature (24.1±1.06^{0}C)	14	14.00	0.86
Viable eggs	86	–	–	–	–
1st instar (N_1)	86	Low temperature (25.1±1.26^{0}C) & RH (55± 2.0%)	7	8.14	0.92
2nd instar	79	Low temperature (27.0±1.13^{0}C) & RH (52± 2.5%)	6	8.69	0.91
3rd instar	73	Low temperature (25.5±1.32^{0}C) & RH (49± 1.9%)	6	8.22	0.92
4th instar	67	Low temperature (26.1±1.22^{0}C) & RH (54± 2.5%)	5	7.46	0.93
Pupa	62	Low temperature (24.2±1.27^{0}C) & RH (53± 2.8%)	13	20.97	0.79
Adult (N_3)	49	–	–	–	–
Female	25	–	–	–	–
Sex ratio		0.94:1.00			
Generation survival (N_3/N_1)		0.569			

Mating period **:** The mating of the weevil ranged from 15 to 50 minutes with an average of 33.6±6.24 minutes during summer and 20 to 55 minutes with an average of 37.0 ± 6.04 minutes during winter.

Total life cycle **:** The total life cycle from egg to adult occupied 59 to 70 days with an average of 65.6±1.86 days in males and 64 to 80 days with an average of 73.0 ± 2.86 in females during summer while it occupied 87 to 102 days with an average of 93.6 ± 3.11 days in males and 98 to 109 days with an average of 105.8 ± 2.46 in females during winter.

Life table study of rice weevil *S. oryzae*

Stage- specific life table study **:** The details of the data (Table 2) revealed that the stage- specific survival (lx) of *S. oryzae* decreased at a regular interval from the day after egg laying. A total of 100 eggs have been taken initially for the study and out of those only 86 eggs were found to be the viable eggs. A sharp decline in survival was recorded from the very beginning of starting of its life i.e. at egg stage 14% death rate was recorded with survival index of 0.86. But towards the 1st instar stage the survival index increased to 0.92 and it remained between 0.91 to 0.93 up to the 4th instar stage. At pupal stage the survival index was recorded to be 0.79 and out of that only 49 adults emerged with 25 females. The sex ratio was found to be 0.94 : 1.00 with generation survival rate of 0.569.

Agespecific (female fecundity) life table study **:** The reproductive period of the insect was recorded from 33.5 to 40.5 days. At the beginning of the egg laying the proportional survival of female (l_x) at age 'x' was 0.25. The natality rate (mx) i.e. the number of female offspring produced per female at the age 'x' was not similar during the whole length of reproductive period. At age 33.5 days the initial natality rate (mx) was 7.73 and it increased gradually at reached its peak of 12.37 at age 36.5 days. Then a declining was started in natality rate and at 40.5 days the lowest 'mx' of 3.61 was recorded.

The net reproductive rate (R_0) was estimated to be 16.35 while the mean length of generation (T) was 36.65 days. The potential fecundity was recorded to be 69.08 females per each female. The intrinsic rate of natural increase (rm) was recorded as 0.076.

Study of the biology of rice weevil under ambient conditions of temperature and relative humidity

Table 3. Age specific (female fecundity) life table study of *S. oryzae*. Note: X – Age in days, lx – survival fraction at age interval X (lx = total survival / 100; where 100 = total no. of eggs taken, mx = Nx/2 (where Nx – total natality at age x; when sex ratio 1:1), lx.mx = total female birth.

X	Lx	Mx	lx.mx	x.lx.mx
	Immature stages and pre-reproductive period = 0.5 to 32.5 days			
33.5	0.25	7.73	1.933	64.739
34.5	0.25	8.25	2.063	71.156
35.5	0.24	9.28	2.227	79.066
36.5	0.24	12.37	2.969	108.361
37.5	0.23	11.86	2.728	102.293
38.5	0.23	9.79	2.252	86.690
39.5	0.23	6.19	1.424	56.236
40.5	0.21	3.61	0.758	30.703
-	-	-	Σlx.mx = 16.352	Σx.lx.mx = 599.244
Net reproductive rate (R_0) = Σlx.mx			16.35	
Mean length of generation (T) = Σx.lx.mx / Σlx.mx			36.65 days	
Intrinsic rate of natural increase (rm) = Loge R_0 / T			0.076	
Potential fecundity (Pf) = Σmx			69.08 females/ female	

Biology of rice weevil

Under laboratory conditions during summer the egg period varied from 5 to 7 days with a mean of 5.8 +0.37 days and in winter it ranged from 7 to 10 days with mean of 8.4 +0.51 days. However Wille (1923) observed 6 to 9 days of egg stage in case of *Calandraoryzae* (L.) on husked rice during summer. But Treiman (1937) reared rice weevil in laboratory on unpolished rice at 27 to 28^{0}C and 90 to 95% relative humidity (RH) and recorded the egg period from 6 to 7 days which substantiates our findings.

In the present study four moults with five instars were observed during summer and three moults with four instars during winter. Urrelo and Wright (1989) observed four instars of *Sitophilus zeamais* (M.) on maize at 70% RH and 27^{0}C temperature which confirms our results. In the present study the grub period ranged from 18 to 25 days with a mean of 21.8 + 1.16 days in summer and 26 to 31 days with a mean of 28.2 + 0.86 days in winter. Bhuiyah *et al.* (1990) reported the larval period ranging from 16 to 20 days on maize grain at 23 to 35^{0}C and 79 to 87% RH which coincides with the present finding of summer. According to Sattigi (1982) the larval period ranged from 23 to 33 days with an average of 28 days during February to March and this corroborates with our findings of the winter season study of the biology of *S. oryzae.*

The pupal period occupied 6-9 days with an average of 7.2 ± 0.58 days in summer and 9 to 14 days with an average of 11.8 ± 0.86 days in winter. The findings of the summer season was confirmed by the findings of Sattigi (1982). Bheemanna (1986) recorded the pupal period of *S. oryzae* from 8 to 11 days which substantiates the present report of winter study of biology.

During summer when the adults were provided with food, the male survived for 27 to 35 days and female for 34 to 41 days, but without food the adult male and female longevity were 3 to 5 and 7 to 9 days respectively. Similarly during winter when the adults were provided with food, the male lived for 43 to 51 days and female for 54 to 61 days, but without food the adult male and female longevity were 5 to 7 and 7 to 12 days respectively. Sattigi (1982) placed a recorded that in the absence of food the adult female lived for 9 to 17 days and male for 7 to 13 days as per the report placed on records which contradicts our results but the reports of Yevoor (2003) that female

lived for 9.50 days and male lived for 7.32 days without food confirms the present result and his reports of female longevity of 115.76 days and male of 97.42 days with food deviates from our findings. But the reports of Bheemanna (1986) that adult longevity of 14 to 165 days with food supports our results.

The total life cycle from egg to adult occupied 59 to 70 days in males and 64 to 80 days in females during summer while it occupied 87 to 102 days with in males and 98 to 109 days in females during winter. The findings contradicts the reports of Howe (1952) who reported 21 to 46 days and also these results do not agree with observation of Bheemanna (1986) who reported 38 to 53 days of total life cycle on sorghum hybrid CSH-5. The variation may be attributed to variation in genotype and different environment condition.

Life table study of rice weevil, *S. oryzae*

Stage specific life table study **:** The perusal of data of the Table 2 revealed that the stage- specific survival (lx) of *S. oryzae* decreased at a regular interval due to egg mortality and subsequent reduction in survival was observed due to the mortality of the larval instars. A sharp decline in survival was recorded from the very beginning of starting of its life i.e. at egg stage 14% death rate was recorded with survival index of 0.86. However Howe (1952) reported that *S. oryzae* lay around 90% fertile eggs which is in agreement with the present study. Towards the 1st instar stage the survival index increased to 0.92 and it remained between 0.91 to 0.93 up to the 4th instar stage as the larvae grew older. The sex ratio was found to be 0.94 : 1.00 with generation survival rate of 0.569. But Howe (1952) found the sex ratio is unity which substantiates the present findings. The key mortality factors at egg stage were due to sterility of the eggs and low temperature of 24.1 + 1.06^{0}C. From 1st instar up to pupal stage the low temperature and low relative humidity were found to be the key mortality factors. It has been reported that for stored product insects 25-30^{0}C optimal for growth and reproduction, at 13-25^{0}C or 33-35^{0}C they are unable to complete their development, which strengthens the present findings.

Age specific (female fecundity) life table study **:** The reproductive period of the insect was recorded from 33.5 to 40.5 days. In the present study the net reproductive rate (R_0) was estimated to be 16.35 while the mean length of generation (T) was 36.65 days. The potential fecundity was recorded to be 69.08 females per each female and the intrinsic rate of natural increase (rm) was recorded as 0.076. However Ryoo *et al.* (1988) reported the life table statistics of rice weevil *Sitophilus oryzae* and found that the intrinsic rate of increase and mean generation time were calculated to be 0.0052 + 0.0006 and 715.2 + 53.6 DD respectively. Choo and Ryoo (1988) reported the intrinsic rates of natural increase of the weevil and were estimated to be 0.6791, 0.4816 and 0.1898 on the brown rice, polished rice and rough rice, respectively which contradicts the recent findings. But the findings of Kangmontree (2005) that at temperature of 20°, 25° and 30°C the net reproductive rates (R_o) were 26.629, 32.748 and 32.140 with intrinsic rate of natural increase (r) being 0.052, 0.058 and 0.059 which is in partial agreement with our reports.

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