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Life Cycle Dynamics of *Sitophilus oryzae* on Diverse Rice Varieties

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Abstract: Cereal rice, particularly *Oryza sativa*, is of paramount importance globally, serving as a staple food for over half of the world's population and providing essential calories and nutrients, especially in Asia. In this study life cycle of major pest of rice *Sitophilus oryzae* or rice weevil was comparatively studied on different six rice varieties- Basmati, Sona masoori, Pusa, Sita, Jaya and Padma. The study observed that upon emergence, adult weevils began mating immediately. Female weevils chose healthy grains for oviposition, laying one egg per grain. The pre-oviposition period ranged from 3.43 days on Pusa to 6.33 days on Jaya. Oviposition was shortest on Pusa (29 days) and longest on Jaya (56 days), with fecundity lowest on Pusa (83 eggs) and highest on Jaya (179 eggs). The incubation period varied, with Pusa taking 4 days and Jaya 3.37 days. Hatching rates ranged from 64% on Pusa to 92.33% on Jaya. The larval period was longest on Pusa (16.01 days) and shortest on Jaya (12.69 days). Pupation rates were highest on Jaya (81.53%) and lowest on Pusa (54%), with pupal periods of 7.67 days and 6.98 days, respectively. Adult emergence rates were highest on Jaya (93.33%) and lowest on Pusa (52.66%), correlating with varietal susceptibility. Male longevity ranged from 46.39 days (Pusa) to 52 days (Jaya), while females lived longer, from 67.33 days (Pusa) to 106 days (Jaya). The sex ratio favored females, peaking on Sita (1:1.83) and lowest on Pusa (1:1.32). The developmental period of *S. oryzae* ranged from 23.04 days on Jaya to 27.68 days on Pusa. Growth indices were lowest on Sita (2.003) and highest on Pusa (3.948). Annual generations varied: six on Jaya and Sona Masoori, four on Padma, Basmati, and Sita, and three on Pusa.

Keywords: Rice, *Sitophilus oryzae*, Life cycle, Basmati, Sona masoori, Pusa, Sita, Jaya, Padma, Oviposition, Fecundity, Longevity, Larval period, Pupa

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Introduction

Cereal rice, particularly *Oryza sativa*, is of paramount importance globally, serving as a staple food for over half of the world's population and providing essential calories and nutrients, especially in Asia. Economically, rice farming supports millions of farmers and contributes significantly to the livelihoods and economies of many developing countries. Beyond its economic impact, rice is deeply woven into the cultural fabric of numerous societies, playing vital roles in rituals, traditions, and cuisines. Nutritionally, it is a key source of carbohydrates and can be fortified to enhance dietary diversity. Furthermore, the cultivation of various rice varieties contributes to agricultural biodiversity, helping to maintain ecological balance and resilience against pests and diseases. The rice industry also generates employment opportunities in farming, processing, and distribution, fostering rural development. Additionally, rice is a major focus of agricultural research, leading to innovations in crop resilience and sustainable practices. Moreover, rice paddies play an important environmental role by providing habitats for diverse species, highlighting the multifaceted significance of this essential cereal crop. Basmati and Sona Masoori are two popular rice varieties with distinct characteristics. Basmati rice, primarily grown in the Indian subcontinent, is known for its long grains, aromatic fragrance, and fluffy texture, making it ideal for biryanis and pilafs. It has a lower glycemic index, appealing to health-conscious consumers. In contrast, Sona Masoori is a medium-grain rice favored in South India for its lightweight, digestible nature, and mild flavor. It is commonly used in everyday dishes like sambar rice and lemon rice, appreciated for its versatility and affordability. Both varieties play significant roles in regional cuisines and contribute to culinary diversity. Recent research in rice science covers several key areas including genetics, climate resilience, disease detection, and nutrition. Advances in gene-editing technologies like CRISPR have enabled scientists to develop improved rice varieties with better yield, disease resistance, and stress tolerance. Notably, India recently introduced its first genome-edited rice variety, DRR Dhan 100. Climate change has also become a major focus, with countries like Japan promoting heat-resistant rice varieties to adapt to rising temperatures, while machine learning models in India have shown high accuracy in predicting rice yields using environmental data. In terms of plant health, deep learning and image-based AI techniques are being used to detect diseases and pests early, offering efficient tools for farmers. Additionally, nutrition-oriented innovations include the development of rice with a lower glycemic index and higher protein content to address health issues such as diabetes. Researchers are also exploring sustainable uses of rice husks in industrial applications. This body of work highlights the global effort to improve rice production and sustainability.

Sitophilus oryzae, commonly known as the rice weevil, inflicts significant damage to rice through its feeding and reproductive habits (Chaudhary *et al*., 2025). Adult weevils burrow into whole grains to lay their eggs, and once the larvae hatch, they consume the grain from the inside, leading to internal degradation. This feeding creates small holes in the grains, which diminishes their quality and makes them unappetizing. Additionally, infested grains can lose weight due to moisture loss and feeding activity, impacting overall yield (Mehta *et al*., 2021; V Parisot *et al*., 2021). The presence of weevils and their frass can also contaminate the rice, rendering it unsuitable for consumption and reducing its market value. Moreover, the damage caused by rice weevils can attract secondary pests, exacerbating storage issues and leading to further losses. The study of the biology of *Sitophilus oryzae*, or the rice weevil, is essential for addressing agricultural challenges and ensuring food security (Koehler *et al*.,1999). As a major pest of stored rice, understanding its life cycle and feeding habits is crucial for developing effective pest management strategies, reducing economic losses for farmers (Selvapandian *et al*., 2023). Ultimately, studying rice weevils is vital for protecting rice crops and maintaining a stable food supply amid increasing global demands. This research focuses on the life cycle of *Sitophilus oryzae*, specifically examining its developmental dynamics on 6 rice varieties - Basmati, Sona masoori, Pusa, Sita, Jaya and Padma. By comparing the reproductive behaviors, larval growth, and overall pest viability on these six distinct rice types, the study aims to elucidate how varietal characteristics influence the biology of this significant pest (Narayana Swamy *et al*., 2014; Supriya Okram and Hath, 2019). Understanding the interactions between *Sitophilus oryzae* and different rice varieties is crucial for developing targeted pest management strategies and enhancing the resilience of rice crops. This research not only contributes to the body of knowledge regarding pest-rice interactions but also has practical implications for improving storage practices and reducing economic losses in the rice industry.

Materials and Methods

Site of experiment

The study was carried out at the Department of Zoology, A.N.D.N.N.M. Mahavidyalaya, Kanpur, India.

Rice collection and preparation

Whole and un-infested rice grains of all 6 varieties- Basmati, Sona masoori, Pusa, Sita, Jaya and Padma were collected from the cereal market, Kanpur, India. After the collection the seeds were heat sterilized to kill any hidden infesting stage and disinfected seeds were weighed using digital balance and then stored in cool and dried place for further work.

Insect Rearing

Mass rearing of *Sitophilus oryzae* was conducted under controlled laboratory conditions, maintaining a temperature of 22-32°C and a relative humidity between 68-85% (Khan *et al*., 1948). To initiate the experiment, a 500 ml glass container was filled with 250 g of sterilized healthy pigeon peas, into which 50 adult weevils (with a 1:1 male-to-female ratio) were introduced. The container's mouth was covered with muslin cloth and secured with a rubber band to ensure proper aeration. The culture was regularly monitored throughout the study period, taking care to avoid disturbances. Newly emerged insects were classified as the next generation for further analysis.

Biology and Life Cycle of Sitophilus oryzae

This study on the biology and life cycle of *Sitophilus oryzae* used three glass jars with 1 kg of rice each, introducing ten pairs of adult weevils per jar at 22-32°C and a relative humidity between 68-85%.. Oviposition was analyzed using 25 g of rice per tube, each with one female weevil, and fecundity was tested with 10 g of rice and five weevil pairs. Eggs were stained and counted for analysis, while microscopy examined egg traits. Developmental stages (egg to adult) were monitored under controlled conditions, documenting incubation, larval instars, pupation, and adult emergence (Fig. 1). Longevity and sex ratio were determined by tracking emergence, death, and sex of 50 adults (Sharifi *et al*., 1971; Singh, 2017).

Statistical analysis

Data collected from the laboratory experiments were statistically analyzed. Statistical design was Complete Randomized Design (CRD). Tabulated data was transformed into percentages (%) and analyzed. Final tables and graph were prepared using Microsoft Office Excel.

Results and Discussion

The study on the biology of *Sitophilus oryzae*, a primary pest of stored rice, provides crucial insights into its life cycle across six rice varieties: Basmati, Sona Masoori, Pusa, Sita, Jaya, and Padma, highlighting the interaction between pest biology and host susceptibility. The weevil lays eggs inside healthy rice grains, where larvae consume the endosperm, leading to significant storage losses. Adult *Sitophilus oryzae* weevils initiated mating immediately upon emergence, with females selecting healthy rice grains for oviposition, depositing one egg per grain. The pre-oviposition period varied among rice varieties, ranging from 3.43 days on Pusa to 6.33 days on Jaya. The oviposition phase was briefest on Pusa (29 days) and longest on Jaya (56 days), with fecundity ranging from 83 eggs on Pusa to 179 eggs on Jaya (Table 1, Fig. 2). The incubation period also differed, being 4 days on Pusa and 3.37

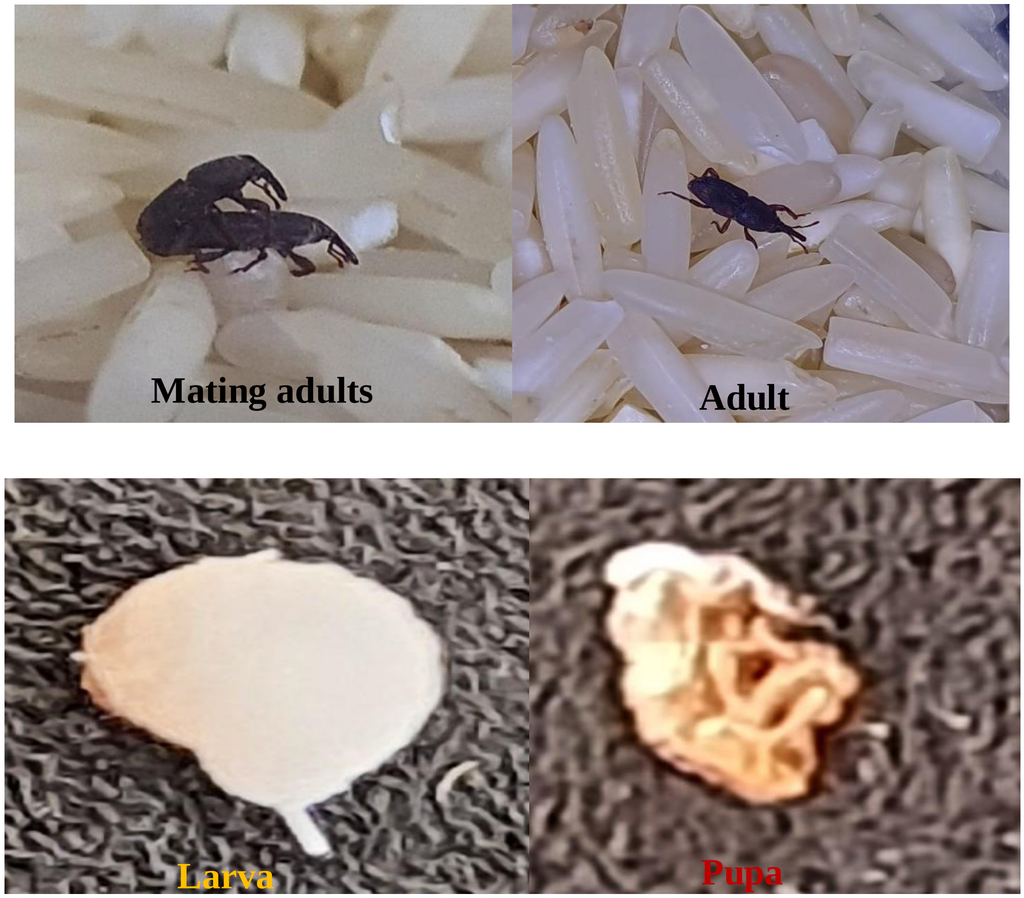

Fig. 1: Adult, larva and pupa of *Sitophilus oryzae.*

Table 1: Dynamics of life cycle of *Sitophilus oryzae* on different rice grains

S. No.	LIFE CYCLE STATGES	Basmati	Pusa	Sona Masoori	Jaya	Sita	Padma
1	**Pre oviposition period**	4.32	3.43	5.29	6.33	3.67	4.39
2	**Oviposition period**	33	29	43	56	31	36
3	**Fecundity**	93	83	131	179	91	113
4	**Incubation period**	3.69	4.00	3.48	3.37	3.94	3.53
5	**Hatchability %**	71.33	64	89.33	92.33	69	74.33
6	**Larval period**	14.22	16.01	13.23	12.69	15.82	13.33
7	**Pupation %**	73.67	54	77.43	81.53	64.56	77.17
8	**Pupal period**	7.33	7.67	7.17	6.98	7.64	7.26
9	**Adult emergence %**	75	52.66	85	93.33	64.13	66.27
10	**Longitivity male**	48.33	46.39	49	52	51.66	51.37
11	**Longitivity female**	79.73	67.33	91	106	74.39	83
12	**Sex ratio**	1:1.51	1:1.32	1:1.45	1:1.62	1:1.83	1:1.59
13	**Developmental period**	25.24	27.68	23.88	23.04	27.4	24.12
14	**Growth index**	3.073	3.948	2.681	3.355	2.003	2.423

days on Jaya. Hatch rates were higher on Jaya (92.33%) and lower on Pusa (64%). Larval development spanned 16.01 days on Pusa and 12.69 days on Jaya. Pupation was more successful on Jaya (81.53%) compared to Pusa (54%), with pupal durations of 7.67 days and 6.98 days, respectively. Adult emergence mirrored these trends, being highest on Jaya (93.33%) and lowest on Pusa (52.66%), reflecting the varying susceptibility of the rice varieties. Males lived 46.39 to 52 days, while females exhibited greater longevity, from 67.33 days on Pusa to 106 days on

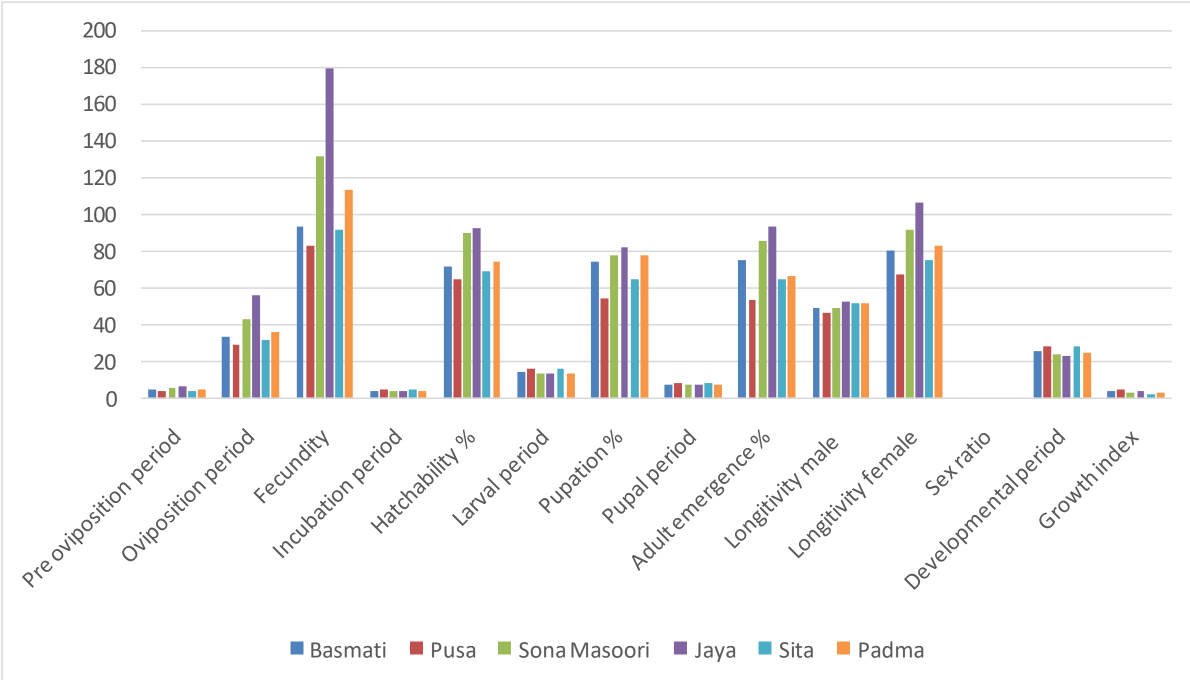

Fig. 2: Dynamics of life cycle of *Sitophilus oryzae* on different rice grains.

Jaya. The sex ratio consistently favored females, with the highest ratio on Sita (1:1.83) and the lowest on Pusa (1:1.32). The total development period ranged between 23.04 days on Jaya and 27.68 days on Pusa. Growth indices peaked on Pusa (3.948) and were lowest on Sita (2.003), with annual generations varying from six (Jaya and Sona Masoori) to three (Pusa) (Table 1, Fig. 2). The present study provides comprehensive insights into the biological performance of *Sitophilus oryzae.* The variation in the weevil's life cycle parameters clearly demonstrates how host plant characteristics influence pest development, fecundity, and survival, which is critical for formulating targeted pest management strategies. Among the tested varieties, Jaya consistently supported faster development, higher fecundity, better survival rates, and greater adult emergence of *S. oryzae*, indicating its higher susceptibility. In contrast, Pusa showed significantly delayed development, reduced egg laying, lower hatch rates, and decreased adult emergence, marking it as the most resistant variety in the study. The longer pre-oviposition period, shorter oviposition phase, and lower reproductive success observed in Pusa suggest inherent biochemical or structural traits that deter pest infestation or development. These traits may include harder grain texture, chemical deterrents, or less favorable nutrient profiles for larval growth. The observed differences in fecundity and survival parameters across the varieties—particularly the egg-to-adult success rate and pupation success—highlight the role of host suitability in modulating the pest's life history traits. The highest growth index recorded in Pusa, despite its lower reproductive output, suggests a more efficient conversion of developmental resources, potentially pointing to adaptive mechanisms in weevils under suboptimal host conditions. The female-biased sex ratio across all varieties, especially pronounced in Sita, aligns with known trends in stored grain weevils and may be linked to environmental cues or nutritional quality of the host. The increased longevity of females, particularly in Jaya, further underscores the enhanced reproductive potential afforded by more susceptible hosts. These findings underscore the importance of host selection in the population dynamics of *S. oryzae*. Varietal resistance, as seen in Pusa, can be a valuable tool in integrated pest management (IPM), particularly when combined with improved storage techniques and biological control measures. The identification of resistant varieties not only helps in reducing post-harvest losses but also limits the reliance on chemical insecticides, thereby supporting sustainable storage practices and food security. Furthermore, the study highlights the potential for using life table data to predict pest population build-up and optimize the timing of control interventions. With *S. oryzae* capable of completing multiple generations per year in varieties like Jaya and Sona Masoori, timely interventions become crucial to prevent exponential population growth.

Conclusion

This research reinforces the need for varietal screening as a foundational component of pest management strategies in stored grain systems. The biological plasticity of *S. oryzae* in response to host variation emphasizes the importance of continuous monitoring, particularly in the face of changing agricultural practices and climate conditions. Future studies could explore the physiological or molecular basis of resistance in varieties like Pusa, contributing to the development of rice lines that inherently deter pest establishment and damage. This research highlights the critical need to address the pest's impact on rice, given its role as a primary food source for millions worldwide.

Ethical Statement

The authors confirm that all ethical issues have been dealt with the research ethics guidelines provided by the

Author Contributions

Each author has contributed equally to the study's planning, analysis, writing, and editing. All authors have read and agreed to the published version of the manuscript.

Conflict of Interest

The authors declare no conflicts of interest.

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