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A review article on the biology of the stored grain pest, the rice weevil *Sitophilus oryzae*

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Abstract
One of the most damaging major pests of stored cereals is the rice weevil, *Sitophilus oryzae*. Numerous common stored grains, such as wheat, rice, maize, bajra, jowar, and split beans are attacked by it. According to the present paper which is a review article on the biology of *S. oryzae*, different developmental phases exhibit differences based on seasonal fluctuations and food availability. Regardless of food and season, it was found that the females' life cycle was consistently longer than the males.

Keywords: Sitophilus oryzae, Rice weevil, Stored grain pest, Cereal pest, Insect biology, Life cycle, Seasonal

Introduction

One of the most significant pests is the rice weevil, *Sitophilus oryzae* Linn. (*Coleoptera*, *Curculionidae*), which most likely started in the Indian subcontinent and spread throughout the world via commerce (Koehler and Kern, 1998) [18]. The rice weevils, which Linnaeus originally named *Curculio oryza* in 1763 (Dobie et al., 1984) [13], were collected from Surinam. Oryza's specific name was chosen because of its ability to breed in rice. In warm areas, where it breeds constantly and quickly using all exposed grain, this bug is especially prevalent. Though they only occur in temperate regions, these species, despite their name, can infest a wide variety of cereal grains and spread through cereal commodities from tropical and sub-tropical countries (Cotton, 1960; Hill, 1978) [9, 16]. From granaries or other grain supplies, the adult weevil can fly actively to corn, wheat, and rice fields. Once the grain has been harvested, the infestation can be disastrous. In and around elevators, brans, and granaries, these weevils are common. When fresh grain is kept in warehouses, farm bins, and line or terminal elevators, the infestation begins. Therefore, the most frequent and dangerous pests on commercial grain shipments are these main pests of stored grains. A wide range of grains are consumed in large quantities by both adults and larvae. Early infestation identification is challenging because the larvae are stationary and feed indiscriminately inside the grain. Their uneven exit pores, which are between 1 and 1½ mm in diameter, allow for the discovery of infection. Only the grain's outer, perforated portion is left in areas with significant infestation.

In cereals that are stored, the rice weevil is a major pest that results in weight loss and quality degradation, which can lead to the establishment of cryptogramic infections (Cotton, 1960; Appert, 1987) [4, 9]. Throughout the tropics and warm temperate regions, this bug is common. It infests rice, husked and unhusked maize, wheat, and sorghum, especially during the monsoon season. *S. oryzae* can infest grains both in the field and in storage because to its broad host range, high biotic potential, and large penetration capability of grain mass (Loeck, 2002) [23].

Since every stage of the pest's life cycle occurs inside the grain, controlling it is challenging. Using a proboscis, the female *S. oryzae* makes a hole in a grain kernel, deposits an egg, and then covers the opening with an egg plug—a gelatinous substance. Although it is nearly undetectable to the unaided eye, the egg plug—the only outward sign that a grain has been infested—can be made apparent with the right staining methods (Frakenfeld, 1948; Sharifi, 1972) [14, 30].

Both larvae and adults are responsible for the damage to the grain. Larvae preferentially consume the grain's germ, eliminating a significant portion of the proteins and vitamins, while adults mostly consume the endosperm, which lowers the carbohydrate level.

Observations

Biology of the Sitophilus oryzae

The Life Cycle of *S. oryzae* is complete and shows four stages- Egg, Larva, Pupa and Adult.

EGG

Wille (1923) [40] noted that *S. oryzae* eggs on wheat were 6 to 9 days old during the summer, while Okuni (1924) [28] noted that the incubation period was 3 to 4 days under typical circumstances. According to Wenholz (1927) [38], the average egg stage required three days in warm, humid conditions. Five to six days after oviposition, the *S. oryzae* egg deposited on maize hatched (Anonymous, 1933) [2]. For six to seven days, unpolished rice was incubated at 27 to 28 degrees Celsius and 90 to 95% relative humidity (Treiman, 1937) [37]. According to Lefevre (1953) [20], the average incubation period in a lab was 2.65 days. The female's age also affected the hatchability and incubation time of the *S. oryzae* egg (Anand Prakash, 1980) [1].

The biology of *S. oryzae* on sorghum was thoroughly studied by Sattigi (1982) [29], who reported that the newly placed eggs were oval and white in shape and turned pink and opaque before hatching. The length of the incubation phase varied from five to nine days and the egg's width, which were measured on average at 0.46 and 0.11 mm. According to Bheemanna (1986) [7], eggs were placed inside the scooped grains one at a time. Usually, there is just one egg inside the grain. The dimensions of the eggs were 0.151 mm to 0.189 mm in diameter and 0.341 mm to 0.0379 mm in length. At 23 to 30 degrees Celsius and 79 to 87% relative humidity, rice weevils were seen to incubate for 5 to 8 days on the CSH-5, Sorghum cultivar, and for a

comparable amount of time on maize (Bhuiyah *et al*., 1990) [8]. While Yevoor (2003) [41] noted 5 days of incubation on maize at 14 to 34ºC and 55 to 88% moisture, Barbuiya (2002) reported 5 to 7 days on rice. Devi et al. (2017) [12] found that when *Sitophilus oryzae* were raised on wheat at 24–30°C and 70–80% relative humidity, they reached the egg stage in 5.5 days. Singh (2017) [32] found an incubation period of six to seven days.

Larva

According to Wille (1923) [40], each grain contains a single *S. oryzae* grub, and the larval period varies from 12 to 17 days in the summer to 21 to 24 days with four moults in the winter (Okuni, 1924) [28]. Wenholz (1927) [38] noted three weeks of larval life on maize, while Newman (1927) noted 20 to 30 days on rice. According to Nakayama (1931) [26], the breadth of the head capsule can be used to identify various instars. Lopez-Cristobal (1953) [25] stated that the larval stages lasted somewhere between 10 and 30 days. Das Chaudhury *et al* (2014) [11] observed that *S. oryzae* had a larval duration of 22–29 days and a pupal period of 7-8 days at 30.7°C and 23.7°C, with 86 and 69% R. H. When rice weevils were raised on rice at 22.18°C to 32.8°C and 68% to 85% relative humidity, Singh (2017) [32] observed that the larval period lasted 21–27 days and the pupal period lasted 7-8 days.

Pupa

While Okuni (1924) [28] and Wenholz (1927) [38] reported pupal periods of 5 to 20 days and 3 to 4 days, respectively, Wille (1923) [40] recorded pupal periods of 7 to 11 days. The pupal stage lasts an average of 5.25 days, but can last up to 12 days (Anonymous, 1933) [2]. Treiman (1937) [37] noted that when *S. oryzae* were raised on unpolished rice, the pupal stage lasted 5–7 days. Lopez-Cristobal (1953) [25] believed that *S. oryzae* pupae had a duration of 6 to 16 days. Lin (1958) noted a prepupal time of one to two days and a pupal phase of three to thirteen days. In every way, the pupa is similar to the adult (Sattigi, 1982) [29].

The pre-pupal stage lasted 21 days, and the pupal period lasted 6 to 9 days on average. According to Yevoor (2003) [41], the pupal duration on maize was 8 to 9 days at temperatures between 14 and 34 degrees Celsius and relative humidity levels between 55 and 85%. There was significant seasonal fluctuation in the larval and pupal periods. Depending on the season, the pupal stage lasted 4.80 to 10.20 days, whereas the larval phase varied from 12.20 to 21.33 days.

Das Chaudhury *et al.* (2014) [11] observed that *S. oryzae* had a larval duration of 22–29 days and a pupal period of 7-8 days at 30.7°C and 23.7°C, with 86 and 69%.

When rice weevils were raised on rice at 22.18°C to 32.8°C and 68% to 85%, R.H. Singh (2017) [32] observed that the larval period lasted 21–27 days and the pupal period lasted 7-8 days. According to R.H. Wille (1923) [40], the larval phase lasted 12–17 days. The larval periods for rice and maize were found to be 16–20 days and 18–20 days, respectively, by Treiman (1937) [37] and Bhuiyan *et al.* (1990).

According to Okram and Ruth (2019), there were significant seasonal variations in the pupal and larval periods. Depending on the season, the pupal stage lasted 4.80 to 10.20 days, whereas the larval phase varied from 12.20 to 21.33 days. February and November had the longest larval and pupal durations, whereas August had the shortest larval stage and June the shortest pupal time.

Adult

In contrast to Okuni (1924) [28], who reported eight generations of *S. oryzae* in a year with an adult lifespan of roughly 160 days, Wille (1923) [40] documented the completion of one generation taking 45 days in the summer and 5 months in the chilly weather of autumn and winter. On sorghum grain with 11.80–12.3% moisture content, the adult *S. oryzae* lived for 12 months and produced 7–8 generations in a year, averaging about 54 days. According to Newman (1927), males lived for 12–122 days on average (70.2 days), while females lived for 51–122 days on average (83.9 days). When kept in an enclosure without food, the emerging male and female survived for 19 days (Lefevre, 1953) [20]. According to Lin (1958) [22], Formosa has eight generations annually.

The lifespan of the adult male was 12–130 days and 1–139 days, respectively. According to Bheemanna (1986) [7], adult longevity varied from 7 to 11 days with and without eating, and from 14 to 165 days. The male lived for 97.4 days, while the female survived for 115.8 days. Adult males and females lived for 7 to 32 days and 9 to 50 days without food, respectively (Yevoor, 2003) [41]. 97.86 and 116.33 days were documented by Narayana Swamy *et al.* (2014). One of the most significant pests, the rice weevil, Sitophilus oryzae Linn. (*Coleoptera, Curculionidae*), most likely started in the Indian subcontinent and expanded throughout the world via trade (Koehler and Kern, 1998) [18].

The rice weevils, which Linnaeus originally identified as *Curculio oryza* in 1763 (Dobie *et al.*, 1984) [13], were collected from Surinam. The reason oryza was given this particular name is because it breeds in rice. This insect breeds continually and quickly using all unprotected grain, and it is especially prevalent in warm countries. Despite being called "rice weevils," these species are only found in temperate regions, yet they can infest a wide variety of cereal grains and spread through cereal commodities from tropical and sub-tropical nations (Cotton, 1960; Hill, 1978) [9, 16].

The adult weevil can fly actively from grain granaries or other sources, including corn, wheat, and rice fields. Once the grain has been harvested, the infestation can be disastrous. These weevils are common in and near elevators, brans, and granaries. When fresh grain is kept in warehouses, farm bins, and line or terminal elevators, the infestation begins. As a result, the most frequent and dangerous pests on commercial grain shipments are these main stored grain pests. A wide range of grains are consumed in large quantities by both adults and larvae. Early infestation identification is challenging because the larvae are stationary and feed indiscriminately inside the grain.

Despite this, it exclusively occurs in temperate climates (Cotton, 1960; Hill, 1978) [9, 16].

Their uneven exit pores, which are between 1 and 1½ mm in diameter, allow for the discovery of infection. Only the grain's outer, perforated portion is left in areas with significant infestation. One of the most common pests in cereals that are stored is the rice weevil, which results in weight loss and quality degradation, which allows a cryptomic infection to spread (Cotton, 1960; Appert, 1987) [4, 9]. Infesting rice, husked and unhusked maize, wheat, and sorghum, especially during the monsoon season, this bug is

common in the tropics and warm temperate regions. *S. oryzae* can infest grains both in the field and in storage due to its broad host range, high biotic capability, and high penetration capacity. (Loeck, 2002) [23]. Since the grain contains all of the life cycle's developmental stages, controlling this pest is challenging. Using a proboscis, the female *S. oryzae* creates a hole in a grain kernel, deposits an egg, and then covers the opening with an egg plug—a gelatinous substance. Although it is nearly undetectable to the unaided eye, the egg plug—the only outward sign that a grain has been infested—can be made apparent with the right staining methods (Frakenfeld, 1948; Sharifi, 1972) [14, 30].

Both larvae and adults are responsible for the damage to the grain.

While larvae preferentially consume the grain's germ and eliminate a significant portion of its proteins and vitamins, adults mostly consume the endosperm, which lowers the carbohydrate level. This affects how long adult males and females live on food.

Devi *et al.* (2017) [12] found that when rice weevils were raised on wheat, the females lived longer (83.70 days) than the males (61.30 days) (male to female adult longevity ratio: 1:1.4). The extended duration of adult sexes in this study may be caused by differences in food and rearing conditions (raised at 70-80% R.H. and 24-30°C). Singh (2017) [32] also found that adult females lasted longer (81–105 days) than males (57–63 days).

In order to extend the lifespan of adult men and females with food, larvae preferentially eat on the grain's germ, eliminating a significant portion of the proteins and vitamins, while adults mostly consume the endosperm, which lowers the carbohydrate content. When weevils were raised on wheat, Devi *et al.* (2017) [12] found that the adult lifespan of females was longer (83.70 days) than that of males (61.30 days) (adult longevity ratio of male: female, 1:1.4). Variations in rearing conditions (raised at 24°C-30°C and 70-80% R.H.) and feeding may be the cause of the long duration of adult sexes in this study. Additionally, Singh (2017) [32] found that adult females had a longer duration (81-105 days) than males (57-63 days).

Male and female life cycles were calculated both with and without nourishment. The male life cycle was determined to be 96.09, 74.27, 65.23, 62.64, 77.57 days, and 50.35, 35.95, 27.97, 28.20, and 40.37 days, respectively, with and without nourishment in the months of February, April, June, August, and November. In a similar vein, the females' complete life cycles in February, April, June, August, and November were 114.61, 85.93, 84.33, 86.93, and 96.97 days with food and 51.84, 38.14, 30.69, 29.82, and 40.39 days without food. When food was provided, the total life cycle for males ranged from 62.64 to 96.09 days, while for females, it ranged from 84.33 to 114.61 days.

However, the life cycle ranged from 27.97 to 50.35 days and 29.82 to 51.84 days, respectively, when adults were not fed. Regardless of food or season, females consistently had a longer life cycle than males.

Wille (1923) [40] recorded varying life cycle durations, with 45 days in the summer and up to five months in the chilly autumn and winter.

According to Bheemanna (1986) [7], the rice weevil's life cycle on sorghum lasted between 38 and 53 days. Although Kavita Yadav (2006) obtained a complete life cycle of 35–46 days from egg to adult. Howe (1952) reported 25–46 days from egg to adult stage. Singh (2017) [32] and Narayana Swamy et al. (2014) reported that the life cycle of wheat and rice was 42 days, respectively.

Conclusion

It is clear from reading the aforementioned papers on *S. oryzae* biology studies that the different stages of the rice weevil's development differed with the seasons. The entire life cycle and the developmental period of the various stages (from egg to adult) were consistently longer in November and February than in April, June, and August. Regardless of food and season, females lived longer as adults than males.

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