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Spodoptera frugiperda J.E. SMITH (Lepidoptera: Noctuidae) on Local Rice Variety Kuriak Kusuik from West Sumatera Indonesia: Demographic Statistics and Biology

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ABSTRACT

Spodoptera frugiperda (Fall Armyworm/FAW) is a polyphagous invasive pest that has spread across various regions in Indonesia, posing a serious threat to staple crops, especially maize. However, the potential adaptation of FAW to rice plants, particularly local varieties from West Sumatra such as Kuriak Kusuik, has not been previously reported. This study aimed to examine the biological and demographic characteristics of *S. frugiperda* when fed with the Kuriak Kusuik rice variety. The results showed that FAW was able to complete its life cycle on this rice variety, with an average lifespan of 41.56 days. The survivorship curve was classified as Type III, characterized by high mortality in the early life stages. The net reproductive rate (Ro) was 46.75 individuals per generation, while the gross reproductive rate (GRR) reached 349 individuals. The intrinsic rate of increase (rm) was 0.10 individuals per female per day, with an average generation time (T) of 38.12 days and a population doubling time (DT) of 6.87 days. These findings indicate that although rice is not its primary host, *S. frugiperda* is capable of adapting and reproducing on the Kuriak Kusuik rice variety, suggesting that it may pose a potential threat to rice production systems in Indonesia.

KEYWORDS: *Spodoptera frugiperda*, Kuriak Kusuik, local rice, life cycle, life table, demography

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INTRODUCTION

The Fall Armyworm (FAW), *Spodoptera frugiperda* (J.E. Smith) (Lepidoptera: Noctuidae), is a highly destructive invasive pest and has been recognized as a serious threat by the Food and Agriculture Organization (FAO) of the United Nations. This species is native to tropical and subtropical regions of the Americas, including the United States, Argentina, and the Caribbean, such as Puerto Rico. In 2016, the presence of *S. frugiperda* was first detected outside its native range, with initial reports of its appearance in West and Central Africa (Goergen *et al.,* 2016). This pest began to spread into Asia in 2018 and was first detected in Indonesia in March 2019, specifically in West Pasaman Regency, West Sumatra (Nonci *et al.,* 2019). In May 2019, its presence was reported in Lampung (Trisyono *et al.,* 2019). In June 2019, Maharani *et al.* (2019) reported that this insect had already spread to the regions of Bandung, Garut, and Sumedang. Its rapid spread to various areas is attributed to its extremely high migratory ability, which allows it to travel up to 1.600 km in just 30 hours (Johnson, 1987).

S. frugiperda is a polyphagous insect with maize as its primary host plant. The host range of *S. frugiperda* includes approximately 353 plant species from 76 plant families, including Poaceae, Fabaceae, Solanaceae, Amaranthaceae, Brassicaceae, Caricaceae, Cyperaceae, Euphorbiaceae, and Cucurbitaceae (Montezano *et al.,* 2018). The level of *S. frugiperda* infestation on maize varies across different regions of Indonesia. In Lampung, damage has been recorded at between 26,50% and 70%. In West Sumatra, the pest has spread to almost all maize-growing areas, with infestation levels ranging from 12,78% to 41,25%. Meanwhile, in Bali, infestation has reached 47,84%. More severe conditions have been reported in East Nusa Tenggara (NTT), where damage levels range from 85% to 100% (Lestari *et al.,* 2020; Supartha *et al.,* 2021; Nelly *et al.,* 2021; Mukkun *et al.,* 2021).

S. frugiperda can damage crops at all growth stages, both vegetative and generative, with the most severe damage typically occurring during the vegetative phase (Trisyono *et al.,* 2019). Maize plants infested by *S. frugiperda* exhibit symptoms such as torn or perforated leaves, especially the young leaves. Damage to the whorl, leaves, and lower stem is easily identifiable due to the presence of larval secretions, which dry and resemble sawdust. The amount of this secretion depends on the number of larvae present within a single plant (Nelly *et al.,* 2021).

This pest has evolved into two distinct strains: the C strain (also known as the Corn strain) and the R strain (also known as the Rice strain). These two strains cannot be distinguished morphologically but differ in host range, mating behavior (Schofl *et al.,* 2009), genetic characteristics, and pheromone components—both in natural populations and those reared in laboratory conditions (Dumas *et al.,* 2015). The distribution of these strains is asymmetrical and shows specific host preferences, which have been consistently observed across various regions. The C strain typically infests maize, cotton, and sorghum, whereas the R strain has a preference for rice and various grasses (Swamy *et al.,* 2018).

Rice is one of the staple crops in Indonesia, and in certain regions, including West Sumatra, local varieties such as Kuriak Kusuik are still widely cultivated by farmers due to their good environmental adaptability. People in this region grow rice as a primary agricultural commodity. This condition provides the potential for *S. frugiperda* to adapt and utilize rice as an alternative host, in addition to maize. However, information regarding the resistance of this variety to *S. frugiperda* infestation has not yet been reported. Research on the demographic and biological aspects of *S. frugiperda* on local rice varieties such as Kuriak Kusuik is essential to determine the suitability of rice as a host plant and to assess the potential threat to local rice production.

MATERIALS AND METHODS

Research site

S. frugiperda was collected from corn plantations in Kuranji District, Padang City, Indonesia. *S. frugiperda* rearing was conducted at the Insect Bioecology Laboratory, Faculty of Agriculture, Universitas Andalas.

Method

Provision of rice plants as feed plants

Rice seeds of the Kuriak Kusuik local variety were soaked in water until the entire surface of the seed was submerged with a water level of about ±2 cm. After soaking, the seeds were sown on 30 cm × 24 cm × 4 cm trays filled with soil. After two weeks, the rice seedlings were transferred into plastic containers (6 cm in diameter and 11.5 cm in height), then covered with a mica plastic tube and gauze. Each container contained five clumps of rice plants. Watering was done every two days (Figure 1).

Figure 1. Rice plants at 15 days after sowing (DAS) were used as feed for *Spodoptera frugiperda*

Provision of *S. frugiperda*

Larvae of *S. frugiperda* were collected from corn fields located in Kuranji Subdistrict, Padang City. The larvae were hand-collected, placed in plastic containers measuring 4 cm × 5.5 cm, and transported to the laboratory for further rearing. In the laboratory, each larva was individually transferred into a plastic cup containing five two-week-old rice plants.

As the larvae entered the prepupal stage, they burrowed into the soil to pupate. Once they reached the pupal stage and were one day old, they were moved into plastic containers (6 cm in diameter and 11.5 cm in height) equipped with lids to enable easier observation. Both male and female pupae were supplied with a 10% honey solution (prepared by mixing 10 ml of honey with 100 ml of water). The adults were maintained in the same container until mating and oviposition occurred. The resulting eggs were then incubated and reared until hatching.

Biology of *S. frugiperda*

Observations were carried out on five pairs of *S. frugiperda* adults originating from larvae that had been reared on rice plants. The eggs produced were counted and monitored until they hatched into larvae. The developmental duration of the larval, pupal, and adult stages was recorded to determine the complete lifespan of FAW. The observation period began from the adult stage and continued until the emergence of the next generation of adults. Daily monitoring was conducted to collect morphological data and other relevant parameters.

Life Table *S. frugiperda*

To determine the life table, observations were made on five pairs of 10 adult FAW individuals. The initial stage of testing and observation begins with the adult phase, followed by the larval and pupal stages, to produce adults again. Morphology in the stadia phase of *S. frugiperda* was observed daily using a binocular microscope and a loupe. Data from the observation of the life of *S. frugiperda* were then calculated by filling in the following parameters (Southwood, 1978):

x = age class (stage) (days)
ax = number of individuals alive at each observation age
lx = age specific survival rate (lx = ax/ao)
ao = number of individuals alive at the start of observation
dx = mortality during stage x
qx = proportion of deaths at each age (qx = dx/ax)
mx = age-specific fecundity
lxmx = Total number of female eggs laid by age class x.

Demographic parameters of *S. frugiperda*

Life table parameters were used to study the suitability of *S. frugiperda* as a feed for rice plants. The parameters obtained on rice were compared to those of individuals fed on corn. Life table parameters are used to assess the suitability of S. frugiperda as a feed for rice plants. Based on the life table data of *S. frugiperda*, it can be continued by determining the demographic parameters (Birch, 1948):

1. Net reproductive rate (Ro) = ∑ lxmx
2. Gross Reproduction Rate (GRR) = ∑ mx
3. Intrinsic Rate of Increase (rm) = ∑ lxmxe-rx = 1, with initial r = ∑ ln(Ro) / T
4. Generation Time Average (T) = ∑xlxmx / ∑ lxmx
5. Doubling Time (DT = ln(2)/rm.

RESULTS AND DISCUSSION

Biology of *S. frugiperda*

Observations of the biology of *S. frugiperda* also include the morphology of individuals, which changes at each stage of their life cycle, including aspects of body shape and color. The morphology of *S. frugiperda* on the Kuriak Kusuik rice variety can be seen in

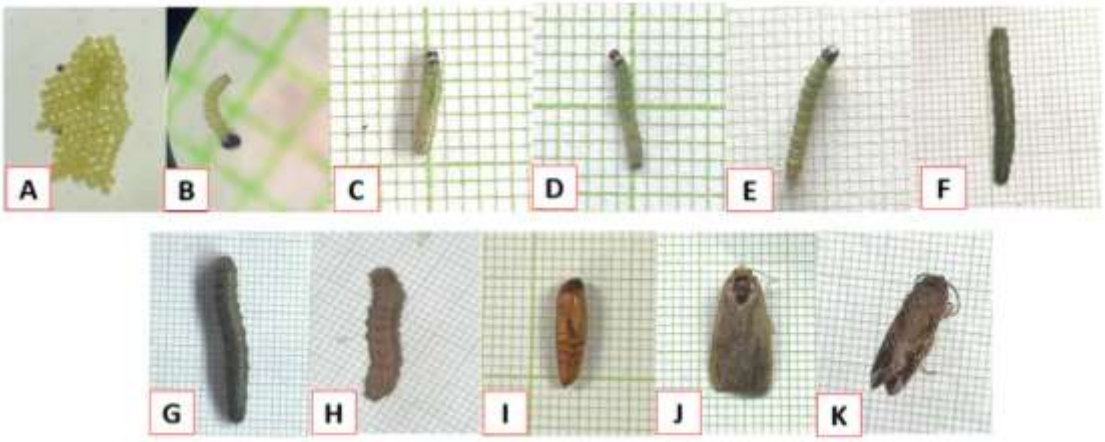

Figure 2. Morphology of *Spodoptera frugiperda*

A = eggs
B = I instar larvae
C = II instar larvae
D = III instar larvae
E = IV instar larvae
F = V instar larvae
G = VI instar larvae
H = Prepupae
I = Pupae
J = Female adult
K = Male adult

From Figure 2, it can be seen that *S. frugiperda* is an insect that undergoes complete metamorphosis (holometabolous), with four distinct developmental stages: egg, larva, pupa, and adult (imago). The eggs are round, cream-white to pale green in color, laid in clusters, and covered with female body scales that resemble a thin layer of cotton. The larva undergoes six instars, with body colors varying from light green to dark brown and longitudinal stripe patterns along the body. A distinctive feature of the larva is the inverted "Y"-shaped pattern on the head. The pupa is cylindrical, reddish-brown, and usually forms in the soil. The adult moth has a grayish-brown body; males have white spots on the forewings, while females tend to be darker and more uniformly colored. Overall, the morphology of *S. frugiperda* reared on either maize or rice does not show significant differences in body shape or coloration at any developmental stage.

The development of *S. frugiperda* was observed at each stage of development. The results of observations on the duration of each life stage, from egg to adult, on the Kuriak kusuik rice variety are presented in Table 1.

Table 1. Length of life of *Spodoptera frugiperda* at each stadia on the Kuriak kusuik rice variety

Developments stadia	Mean (days) ± SD	Range (days)	Sample size (n)
Egg period	2,84 ± 0,37	2-3	522
Instar I larvae	2,62 ± 0,49	2-3	495
Instar II larvae	3,12 ± 0,32	2-4	421
Instar III larvae	3,24 ± 0,43	3	351
Instar IV larvae	3,36 ± 0,48	2-4	321
Instar V larvae	3,20 ± 0,40	3-4	310
Instar VI larvae	4,00 ± 0,00	3-4	279
Prapupae	2,02 ± 0,31	2	23
Pupae	8,08 ± 0,56	8-9	160
Male adult	6,58 ± 0,70	6-7	72
Female adult	9,08 ± 0,89	9	75
Preoviposition period	3,26 ± 0,48	3-4	5
Oviposition period	2,28 ± 0,45	2-3	5
Pascaoviposition period	3,54 ± 0,54	3-4	5
Life cycle	41,56 ± 1,55	41-42	10

Table 1 shows that *S. frugiperda* can complete its life cycle when fed on the Kuriak Kusuik rice variety, from the egg stage through to the adult (imago) stage. The egg stage lasts an average of 2,84 ± 0,37 days, ranging from 2 to 3 days. After hatching, the larva undergoes six instars with varying durations. The first to sixth instars last an average of 2.62 ± 0.49 days, 3.12 ± 0.32 days, 3.24 ± 0.43 days, 3.36 ± 0.48 days, 3.20 ± 0.40 days, and 4.00 ± 0.00 days, respectively. The most extended duration occurs during the sixth instar, which is the final stage before the larva enters the prepupal phase. On average, *S. frugiperda* requires about 19 days to complete the larval stage on rice plants. Altaf *et al.* (2022) reported that *S. frugiperda* develops fastest during the larval stage (16 days) on maize, and slowest (32,74 days) on rice. The protein content greatly influences larval growth in the diet. Maize contains about 9,5% protein, higher than rice, which contains only about 7,1%. This difference in larval duration indicates that maize serves as a more optimal food source for *S. frugiperda* development compared to other host plants (Bhat & Bajracharya, 2022).

The prepupal stage lasts for an average of 2,02 ± 0,31 days, during which the larva stops feeding. This is followed by the pupal stage, which lasts an average of 8,08 ± 0,56 days. After emerging as adults, male insects have an average lifespan of 6,58 ± 0,70 days, while females live longer, averaging 9,08 ± 0,89 days. The reproductive period in females consists of three phases: a pre-oviposition phase lasting 3.26 ± 0.48 days, an oviposition phase of 2,28 ± 0,45 days, and a post-oviposition phase of 3,54 ± 0,54 days. Maharani *et al.* (2019) reported that the average duration of the pupal stage on maize plants is 8.35 days, whereas on rice it is 8,98 days. In this study, differences were observed in the developmental duration between female and male pupae. These results align with Montezano *et al.* (2018), who found that female pupae require less time to develop compared to male pupae.

The average life cycle of *S. frugiperda* on the Kuriak Kusuik rice variety is 41,56 days. This finding is consistent with research by Hutagalung *et al.* (2021), which reported that the life cycle of *S. frugiperda* on maize ranges from 38 to 45 days, with an average of 41,4 ± 1,73 days. The similarity in duration indicates that although rice is not the primary host plant, the Kuriak Kusuik variety is still able to support the complete development of *S. frugiperda* through all its life stages, comparable to its primary host, maize.

Life Table of *S. frugiperda*

The survival curve illustrates the proportion of individuals surviving at each stage (lx) as well as the average female fecundity (mx). The survival curve of *S. frugiperda* reared on the Kuriak Kusuik rice variety is shown in Figure 2.

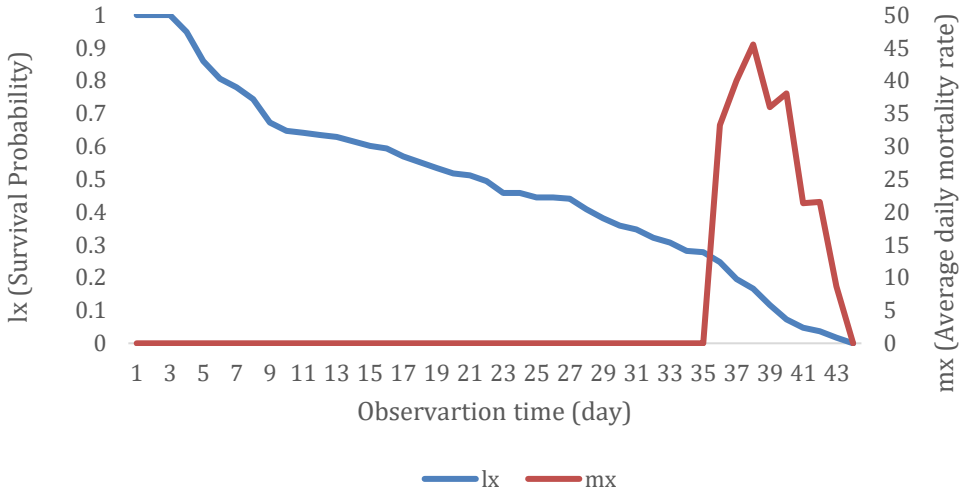

Figure 2. Survivorship curve of *Spodoptera frugiperda* on Kuriak kusuik rice variety

Figure 2 shows the survival pattern (lx) and average daily fecundity (mx) of *S. frugiperda* populations on the Kuriak Kusuik rice variety over a 43-day observation period. The lx curve, representing the probability of individual survival, gradually declines from a value of 1 on the first day to nearly zero by day 43, indicating that most individuals do not survive until the end of the observation period. Meanwhile, the mx curve, representing the daily reproduction rate, remains at zero from the beginning until around day 34, then sharply increases between days 35 and 41, reflecting the pest's active reproductive phase. After this period, mx declines back toward zero, indicating the end of the reproductive phase. This pattern illustrates that *S. frugiperda* on the Kuriak Kusuik rice variety experiences gradual mortality and has a relatively short reproductive period within a specific time frame. This information is important for understanding the pest's life cycle and can serve as a basis for developing more effective control strategies.

Life table data for *S. frugiperda* are presented in Table 2, which includes various biological parameters such as survival rates, developmental duration, and reproductive rates under specific conditions. This information is essential for understanding the population dynamics of this insect.

Table 2. Cohort life table of *Spodoptera frugiperda* on Kuriak kusuik rice variety

Parameters	Kuriak kusuik rice variety
GRR	349
RO	46,75
Rm	0,10
T	38,12
DT	6,87

Table 2 shows that the Gross Reproductive Rate (GRR) value of 349 indicates that a single female *S. frugiperda* has the potential to produce up to 349 female offspring throughout her lifetime, assuming all offspring survive to adulthood. However, after accounting for mortality rates at each developmental stage, the Net Reproductive Rate (Ro) decreases to 46,75, meaning that on average, one female produces about 47 female offspring that successfully develop into adults. Maharani *et al.* (2019) reported higher Ro and GRR values for *S. frugiperda* fed on rice, which were recorded at 398.87 and 563.35, respectively.

The intrinsic rate of increase (rm) was recorded at 0.10 individuals per female per day, reflecting a moderate population growth rate under favorable environmental conditions. The mean generation time (T) was 38,12 days, indicating that one complete life cycle—from egg to producing offspring—takes approximately 38 days. Meanwhile, the population doubling time (DT) was 6,87 days, meaning the *S. frugiperda* population could potentially double in less than a week if no control measures are implemented. This finding is consistent with Dono *et al.* (2024), who also reported an r_m value of 0,10 for *S. frugiperda* on rice plants. However, in their study, the generation time was longer, at 47,02 days, while the DT was slightly shorter at 6,74 days (Dono *et al.,* 2024). These results indicate that although the Kuriak Kusuik variety is not a primary host, *S. frugiperda* is still capable of growing and reproducing, albeit with lower reproductive potential compared to when feeding on regular rice leaves.

CONCLUSION

S. frugiperda is capable of adapting and reproducing on the Kuriak Kusuik rice variety. This is evidenced by its ability to complete its life cycle and produce offspring on this variety. The survival curve of *S. frugiperda* on this rice variety is classified as Type III. The life cycle of the pest on Kuriak Kusuik rice lasts 41.56 days. The net reproductive rate (R_0) on this variety reaches 46.75 individuals per generation, while the gross reproductive rate (GRR) is 376.45 individuals per generation.

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