Life cycle of *Spodoptera frugiperda* J. E. Smith FED with *Pennisetum purpureum* Schumach and *Paspalum conjugatum* PJ Bergius leaves

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Abstract. *Spodoptera frugiperda* is a pest that entered Indonesia and attacks corn plants. This pest can use other plants to complete its life cycle. This study aims to analyze the growth and life cycle of *S. frugiperda* with three different food treatments. Parameters observed in this study were life cycle length, larval head diameter, larval length, larval weight, pupa length, and pupa weight. The research began with searching for *S. frugiperda* larvae in corn fields in Bantul Regency, Yogyakarta. Feeding treatments and observations of the *S. frugiperda* life cycle were conducted in the laboratory. Data analysis used was Kruskal-Wallis non-parametric test. The results showed that *S. frugiperda* on *Zea mays* leaves (control) had a life cycle length of 44 days, *Pennisetum purpureum* leaves 46 days, and *Paspalum conjugatum* leaves 49 days. Head diameter, length, and weight of *S. frugiperda* larvae at instar 3 and instar 4 were highest in corn leaf feed, but when entering instar 5 and instar 6 the highest values were found in the feed treatment with *Paspalum conjugatum* leaves. The coslusion of this research were *Pennisetum purpureum* leaves and *Paspalum conjugatum* leaves can be an alternative feed for breeding *S. frugiperda* in the laboratory.

1 Introduction

Spodoptera frugiperda J.E. Smith is a pest that was found in Indonesia in 2019 in the Pasaman area, West Sumatra, which originated from the Americas [1,2]. Until now, *S. frugiperda* has been reported to spread to various provinces in Indonesia, including South Sumatra [3], Bengkulu [4], Lampung [5], Sulawesi [6], West Java [1], Central Java [7], Yogyakarta [8,9], East Java [10], Bali [11] and

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West Nusa Tenggara [12,13]. The main host of this pest is corn (*Zea mays* L.) and damaged corn plants during the larval phase by eating the leaves, stems, flowers and fruits of *Z. mays* [14,15,16].

Apart from maize, this pest is known to attack other crops of the Poaceae Family [16]. These include rice, sugarcane, and grasses [17,18,19,20]. Grass species that have been used as hosts by S. frugiperda are *Pennisetum purpureum* and *Paspalum conjugatum* [14,16]. Based on previous research, *S. frugiperda* has been bred in the laboratory by feeding food plants, such as lettuce (*Lactuca sativa* L.), pakcoy (*Brassica rapa* L.), kale (*Ipomea reptans* Poir), leeks (*Allium fistulosum* L.); as well as green thorn spinach and green pull spinach [21,22,23]. In the study of Montezano et al. [14], *S. frugiperda* was found to attack *P. conjugatum*. However, research on the life cycle of *S. frugiperda* feeding on *P. purpureum* and *P. conjugatum* leaves has not been conducted. This study was conducted to be used as an estimate or description of the population increase of *S. frugiperda* on plants other than corn. And can be used as a supply of *S. frugiperda* as experimental animals for further research. Therefore, this study is important to determine the life cycle of *S. frugiperda* in the laboratory by feeding *P. purpureum* and *P. conjugatum* leaves.

2 Material and Methods

2.1. Collection of *S. frugiperda* larvae from corn fields

a. Maize plants infested with *S. frugiperda* were characterized by the presence of graze marks in the form of coarse powder resembling sawdust on the upper surface of the leaves and around the tops of the maize plants.

b. *Spodoptera frugiperda* larvae attacking maize plants are characterized by four black dots on the penultimate abdomen that form a rectangle.

c. *Spodoptera frugiperda* larvae were collected by unrolling young leaves, then the larvae were put into a plastic aquarium and fed with young corn leaves.

2.2. Breeding process of *S. frugiperda* in the laboratory

a. *Spodoptera frugiperda* larvae collected from the field were brought to the laboratory for rearing. The temperature during rearing in the laboratory is conditioned around 25^{o} - 29^{o}C [24].

b. Each 3rd instar of *S. frugiperda* larva was placed into a different plastic cup with a tissue on the inside surface. The tissue was then sprinkled with tap water to maintain humidity in the glass.

c. The plastic cup is then covered using organdy cloth and glued with a rubber band. The larvae in the plastic cups were then fed with corn leaves that had been cleaned using food grade laundry soap.

d. Feed was washed thoroughly using tap water using food grade dish soap and changed every 3 days, starting from 3rd instar feed was changed every day.

e. Larvae that have become pupae were transferred into a clean 5 L jar, the inner surface of the bottom of the jar is given a tissue first with a little splash of tap water to maintain humidity. The jar is closed with a modified jar lid with a hole in the top and an organdy cloth is placed inside the jar lid, so that air circulation and oxygen can enter the jar. Then the jar was put into a black plastic bag, so that the mating process can run well, and the plastic bag is loosely tied so that air circulation remains stable.

f. After the pupa hatches into imago, the imago was then fed by dripping honey solution that has been dissolved with water in a ratio of 1: 1 on cotton and hung on the lid of the jar.
g. Oil paper was placed during the pupal phase at the bottom of the jar for the imago to lay eggs, and the jar is covered with a black cloth. Every day, the honey solution was checked and honey solution was re-dripped if dry. The wax paper in the jar was also checked for eggs.

2.3. Observation of Feeding Treatments on *S. frugiperda* Larvae

a. Eggs from the initial breeding that had hatched were put into three jars for each treatment with each jar containing 10 1st instar larvae because these instar larvae had not yet entered the cannibal phase [24].
b. The larvae in the jars were fed with 1 gram of food for each treatment in each jar. Then the jars were labelled according to the treatment given.
c. Changes in larval weight, larval length, and head diameter were observed daily and the number of days of change from instar 3 - 6 was calculated.
d. Feeding of 1st and 2nd instar larvae was done every 2 days. When the larvae have turned into 3rd instar, the larvae were separated into one larva per plastic cup [22].
e. The feed of elephant grass leaves, buffalo grass leaves, and corn leaves as control were checked daily. If the feed decreased, additional feed was given as much as 1 gram for each treatment in each plastic cup [23].
f. Larvae that had become pupae were transferred into a 5 L jar, the bottom surface of the inside of the jar was given a tissue with a little splash of tap water to maintain humidity. Then, each treatment was marked with label paper.

2.4. Data Analysis

Data analysis was carried out with a significance level of 5%, starting with the Shapiro-Wilk normality test for all parameters such as head diameter, larval length, and larval weight. The resulting data are normal and homogeneous using the Kruskal Wallis non-parametric test to get data there is a difference and there is no difference. Furthermore, the data continued with Dunnet's further test.

3 Results and Discussion

3.1. Life cycle of *Spodoptera frugiperda* fed with *Zea mays*, *Pennisetum purpureum* and *Paspalum conjugatum*

The results obtained the length of time to complete one life cycle of S. frugiperda on different feeds has a different length of time. The total length of time required to complete one life cycle of S. frugiperda. In insects, food can be used when the insect can continue its life to complete one cycle until it can produce eggs (Table 1).

The rapid development of S. frugiperda larvae depends on the nutrients contained in the feed given. According to Subiono [25], the length of time for insect development from larvae to adults to complete one life cycle is influenced by the nutritional content contained in the feed. According to Putra and Wulanda [23], the nutrients needed by S. frugiperda larvae for growth and development are proteins.

Table 1. Life cycle of S. frugiperda on Z. mays, P. purpureum and P. conjugatum in the laboratory

Phase	Instar	Duration (Days)		
		Corn leaves	***P. purpureum* leaves**	***P. conjugatum* leaves**
Larvae	3	5	5	5
	4	4	5	6
	5	5	6	6
	6	7	7	8
Pupae		9	9	10
Imago		14	14	14
Total		**44**	**46**	**49**

Feed with a high enough protein content in this study in addition to *Z. mays* leaves is *P. conjugatum* leaves. However, from the results of the research conducted, *S. frugiperda* which had the second fastest life cycle after *Z. mays* was larvae feed with *P. purpureum* leaves. This may be because *P. purpureum* leaves have nutritional content other than protein which is almost the same as *Z. mays* leaves. The similarity of these nutrients with its natural food makes the life cycle of *S. frugiperda* on *P. purpureum* leaves faster. This is in accordance with the statement from Putra and Martina [22], which states that *S. frugiperda* fed with food with nutritional content similar to or close to the nutritional content of the original food will have a longer time to complete its life cycle faster than the original food. This is what causes the life cycle of *S. frugiperda* on *P. purpureum* leaf feed to have the fastest time compared to the other 2 feeds.

3.2. Comparison of Head Diameter, Length, and Weight of *S. frugiperda* Larvae from Each Treatment

The results of this study obtained the highest head diameter, body length, and larval weight in different feeds. 3rd Instar and 4th instar larvae had the highest growth and development on *Z. mays* leaf feed, but when entering 5th and 6th instar larval development was highest on *P. conjugatum* leaf feed (Table 2).

Table 2. Mean values of head diameter, length, and weight of *S. frugiperda* instar 3-6 larvae on the three diets

Parameters	Instar	Feed		
		Zea mays	***Pennisetum purpureum***	***Paspalum conjugatum***
Head diameter	3	0.25 ± 0.01*	0.18 ± 0.00*	0.12 ± 0.03*
	4	0.31 ± 0.04*	0.21 ± 0.02	0.24 ± 0.00*
	5	0.34 ± 0.02	0.21 ± 0.05*	0.34 ± 0.00*
	6	0.34 ± 0.02	0.23 ± 0.08	0.35 ± 0.01
Larval length	3	1.59 ± 0.16	1.70 ± 0.04*	1.42 ± 0.05*
	4	2.23 ± 0.33	2.18 ± 0.12	2.41 ± 0.18
	5	2.59 ± 0.22	2.65 ± 0.17	2.68 ± 0.06
	6	2.89 ± 0.24	3.13 ± 0.05	3.12 ± 0.05
Larval weight	3	0.31 ± 0.02*	0.27 ± 0.01*	0.18 ± 0.02*
	4	0.36 ± 0.06	0.26 ± 0.02	0.31 ± 0.01
	5	0.46 ± 0.11	0.32 ± 0.01	0.37 ± 0.01
	6	0.52 ± 0.02*	0.34 ± 0.02*	0.41 ± 0.01*

Note: *asterisks indicate a significant difference between columns

Larval growth depends on the feed that is provided. Feed that was a natural host (*Z. mays*) of *S. frugiperda* will certainly be preferred and larvae will adapt more easily to the feed [26]. This is why the growth of larvae in 3rd and 4th instars was faster on corn leaf than other feeds. In line with larval growth, larvae fed with *P. purpureum* and *P. conjugatum* leaves can adapt to the food they were given. According to Subiono [25], the older the larval instar, the more adaptable it will be to its surroundings, including the provided feed. So that the larvae can maximize the nutrients from the food that provided, whether the food is their natural host or not. This is the reason why the growth of larvae in 5th and 6th instars was higher on *P. conjugatum* leaves than on *Z. mays* leaves. Although the development and growth of *S. frugiperda* larvae of 5th and 6th instars that feed on buffalo grass leaves was higher than on other leaves, the feeding preference of *S. frugiperda* larvae still favored its natural host. This is evidenced by the higher weight of larval feces on corn leaves compared to other feeds (Table 3).

Table 3. Mean of fecal weight of *S. frugiperda* larvae in each diets

Fecal weight of *S. frugiperda* (gr)		
Corn feed (average ± SD)	**Elephant grass feed (average ± SD)**	**Buffalo grass feed (Average ± SD)**
0.20 ± 0.03	0.08 ± 0.03	0.40 ± 0.15
0.25 ± 0.02	0.14 ± 0.01	0.23 ± 0.01
0.37 ± 0.03	0.14 ± 0.02	0.29 ± 0.01
0.35 ± 0.04	0.17 ± 0.06	0.26 ± 0.02

Supposedly with higher dung weights, larvae on *Z. mays* leaves can be higher in growth and development. However, the results of this study found that the highest growth and development of larvae on *Z. mays* leaves were only obtained in 3rd and 4th instars. Were 5th and 6th instars of *S. frugiperda* larvae were higher in growth and development on *P. conjugatum* leaves. This is because the *Z. mays* leaves used as feed wither easily, which can inhibit the consumption of *Z. mays* leaves by *S. frugiperda* larvae. This inhibition of feed consumption can affect larval growth and development [23]. According to Megasari et al. [24], reduced consumption of natural food for some reason can cause inhibition of growth and development of insect larvae.

Insect development depends on the food provided. The food provided must have certain criteria and suitability depending on the insects being reared. The more appropriate the feed criteria given, the better the growth and development of these insects will be. According to Hidayanti and Tri [27], nutrients that can support larval weight gain are carbohydrates and fats. This is supported by research from Putra and Wulanda [23], which obtained the highest weight average results obtained in *S. frugiperda* larvae fed with green spinach leaves and green thorn spinach leaves because they contain higher carbohydrates than the control feed with corn leaves. The higher the fat and carbohydrates contained in a feed, the heavier the insect's body weight [23]. This is in accordance with the results of this study where the heaviest weight of *S. frugiperda* larvae was higher that obtained on *Z. mays* leaves and *P. conjugatum* leaves which have higher carbohydrate and fat content than *P. purpureum*.

The results of the study were then further analysed to see whether there was a significant difference in the parameters of head diameter, body length, and body weight of *S. frugiperda* larvae in the three feeds given. Dunnet test results showed

that there were differences in head diameter, larval length, and larval weight. The differences between treatments can be due to the nutritional content of the feed and the resistance of the feed to senescence. According to Putra and Khotimah [21], the nutritional content of the host plant that is suitable for the growth and development of insects can cause the rapid growth and development of these insects.

4 Conclusion

Based on the results obtained, the conclusions that can be drawn are as follows: (1) The life cycle of *S. frugiperda* was the fastest in the treatment with *P. purpureum* leaf feed, and the longest was in the treatment with *P. conjugatum* leaf feed; (2) The largest head diameter, body length, and weight of *S. frugiperda* larvae were found in the treatments with *Z. mays* leaves and *P. conjugatum* leaves. While the smallest was found in the feeding treatment with *P. purpureum* leaves.

The authors confirm that the data supporting the findings of this study are available within the article.

Author contribution statement: L.F.M. performed the measurements of the larvae, I.L.I.P. were planning and supervised the work, I.L.I.P. and L.F.M. processed the experimental data, performed the analysis, drafted the manuscript. I.L.I.P. and L.F.M. discussed the results and commented on the manuscript.

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