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Development of The Fall Armyworm, *Spodoptera frugiperda* (J. E. Smith) on Three Host Plants

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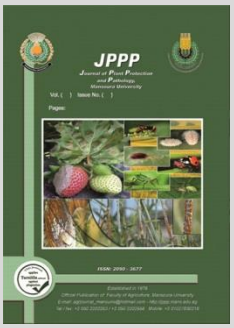

ABSTRACT

The present laboratory study is first attempt in Egypt which focused on studying the development of recent invasive insect pest "fall armyworm" *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) on three host plants, Castor oil, Corn and Lettuce. Study was conducted at Department of Zoology, Faculty of Science, South Valley University, Qena Governorate, Egypt. The fall armyworm, *S. frugiperda* is an economically important polyphagous. The pest has recently invaded Egypt causing unexpected damage to maize and other crops. The life history of *S. frugiperda* on three different host food resources, castor leaves, corn and lettuce was studied under laboratory conditions. Larval mortality percentage, larval duration, pupation percentage, pupal weight, pupal duration, pupal mortality percentage, adult emergence, sex ratio, male and female longevity, fecundity (No. of egg laying/female) and fertility % (egg hatchability) were evaluated. Obtained results showed that, average larval duration was 23.36, 23.58 and 22.8 days for castor leaves, corn and lettuce, respectively. The pupal duration was 10.52, 10.75 and 10.89 days respectively at the same three hosts. There were non-significant different between all pupal duration values. Fecundity (eggs laid by the females) was 2299.0, 1839.5 and 2116.0 egg/female at the same three hosts, respectively. Also results indicated that, post ovipostion periods were 2.4, 1.0 and 2.19 days, for castor leaves, maize and lettuce respectively. There were no preferences for any of tested plants which may be related to antixenosis/antibiosis. The fall armyworm *S. frugiperda* can easily reared in laboratory using uneconomic plants castor oil leaves.

Keywords: Life history, fall Armyworm, *Spodoptera frugiperda*, Castor oil, Corn oil, Lettuce.

INTRODUCTION

The fall armyworm, *Spodoptera frugiperda* (J.E. Smith) is a serious pest insect for economic crops. It is abundant pest; it has a very wide host range and recorded on more than 353 host plants (Casmuz Augusto *et al.*, 2010; CABI 2018; Montezano *et al.*, 2018).The pest has recently detected, it was reported in Egypt at 2019 (FAO, 2019) and caused a severe damage to maize and other crops. It occurs in several countries in South America, and USA (Prowell *et al.*, 2004; Bueno *et al.*, 2010; Padhee and Prasanna 2019). In Egypt, at May 2019 ,the Agricultural Pesticide Committee (APC) of the Ministry of Agriculture reported the first case of *S. frugiperda* presence in a maize field in a village in Kom Ombo city of Aswan Governorate, Upper Egypt (Dahi *et. al.*, 2020). According to Food and Agriculture Organization of the United Nations (FAO) facts, the fall armyworm landed in African via a ship or a plane in 2016, invading more than 40 African countries since then. Its large destructive impact could push 300 million people into hunger in Africa.

Because of its wide host range, *S. frugiperda* is one of the most aggressive insect pests with voracious feeding behavior attacking annual crops in tropical regions. Originally, *S. frugiperda* distribution was restricted in the American continent until 2016 when it became a global pest. Recently, it was recorded in Africa and Asia- Pacific. *S. frugiperda* outbreak in maize was recorded in African countries such as São Tomé, Nigeria, Bénin and Togo in 2016 (Goergen *et al.*, 2016). Subsequently, the pest has spread rapidly to over 43 countries in sub-Saharan Africa causing significant damage to crops like maize and sorghum Prasanna *et al.*, 2018; Rwomushana *et al.*, 2018). Also, it was reported in India (Ganiger *et al.*, 2018; Sharanabasappa *et al.*, 2018a and Shylesha *et al.*, 2018).

Polyphagous insects feed on a range of plant species, but may prefer or show stronger fitness on one particular host plant or a limited number of plant species Andrews, 1980; Via, 1991 and Clark *et. al.*, 2007.

S. frugiperda is a highly polyphagous pest attacks many important crops. Its larva eat early stages scrape the epidermis off the underside of the leaves and later, produce feeding holes in fruits and leaves. Symptoms are generic for most primarily foliage feeding Lepidoptera species (Smith *et al.*, 1997). *S. frugiperda* is a destructive invasive to Egypt. Rare studies have been done concerning its life stage or biology herein.

S. frugiperda has two genetically distinct but morphologically indistinguishable strains, the corn strain referred as (C- Strain) prefers to feed on maize, sorghum, and other large grasses and the rice strain (R- Strain) feed on rice, Bermuda grass and small grasses. Although each strain is reported to have host preferences, this could not be confirmed consistently in laboratory trials, while high rates of hybridization have been observed (Juárez *et al.*, 2012).

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Regardless the strain invaded Egypt, it is necessarily to study the biology of the *S. frugiperda* population invaded Egypt to have the knowledge about this invasive pest under Egyptian ecosystem conditions. So, The work aim to study the biology of *S. frugiperda* to pave the way to the specialist towered the integrated pest management under Egyptian ecosystem conditions and to determine the suitability of the three different host plans species for *S. frugiperda* mass rearing under laboratory condition.

MATERIALS AND METHODS

Rearing the fall armyworm, *S. frugiperda*:

Trials were performed in the Insect Ecology Laboratory, Zoology Department, Faculty of Science, South Valley University. A stock colony of *S. frugiperda* larvae was collected from maize fields at the farm of South Valley University, Egypt. The colony maintained under laboratory-controlled conditions (25 ± 2 °C, 65 ± 5 % RH) in incubator (Cooled incubator VLEP FOC 21SE, VELP Scientific Inc., NY, U.S). The three laboratory colonies was fed on three host plants: on castor leaves (the 1st colony), on pieces of corn stem in (V3) growth stage (the 2nd colony) and on lettuce (the 3rd colony).The colonies reared according to (Dahi *et al.*, 2020, Gamil, 2020) with some modifications.

The larvae were reared in plastic container (40×20×15 cm) with muslin cloth and secured with rubber band to facilitate aeration and provided with fresh castor leaves as food. Food was replaced at two-day intervals. Larvae were reared separately from the 3rd instar. This was done in small plastic containers (70mm in height × 20 mm in diameter) with fine muslin cloth and secured with rubber band. A thin layer of fine saw-dust was spread on the bottom of every glass-Jars to help the successful pupation. Larvae were kept in an incubator at 25.0°C ± 1 °C, 65.0 ± 5.5 % RH, and 14 L: 10 D photoperiod until pupation. Pupae kept in the same incubator. Pupae were observed daily until moths emerged. After the emergence of moths, single male-female were coupled and kept to oviposition glass cadge and incubator maintained at the temperature and conditions aforementioned. The moths were provided with food (a small piece of absorbent cotton wool hanging on the glass by rubber band previously soaked in 10% sucrose solution). Pieces of papers were put inside the cage as oviposition sits. The papers were inspected for egg batches every day. For strain establishment, the eggs were maintained at 25 ±1°C and 65 ± 5% R.H. until hatching. Egg- patches were separated in different rearing cage to perform the different experiments.

The experimental design:

The first instars larvae were divided to three trials. The first one was reared and fed on castor leaves, the second trial, the larvae reared and fed on pieces of corn stem in (V3) growth stage and the third trial was reared and fed on lettuce.

First instar larvae were caged individually with plant leaves which were replaced on a daily basis to avoid excessive water loss. Saw dust was placed at the base of each rearing cage to absorb excess humidity. Fresh clean castor oil leaves or pieces of maize or part of lettuce were placed in appropriate quantities provide a source of food for the larvae. Daily, larvae faces were removed as well as dried leaves, which were then replaced by fresh plants, always in sufficient amounts. Sometimes it was found necessary to remove larvae to a clean breeding cage to avoid larval overcrowding, and contamination especially when reaching the older instars.

Newly formed pupae were collected on the same day of pupation and placed in the glass tube (2.5×7.5cm) (one pupae/each tube) and plugged tightly with a piece of cotton. After emergence ten of newly emerged moths were transferred on the same day of emergence to a glass mating-cage as mentioned before, each has 2 single adult (♂+ ♀). Daily observations were made to record the adult survival, collect and count the number of deposited eggs. The eggs were incubated at the same conditions.

Measurements

Larval mortality %, larval duration (day), pupation %, pupal weight (gm), pupal duration (day), pupal mortality %, Adult emergence %, sex ratio, male and female longevity (day), Fecundity (No. of egg laying/female) and Fertility % (Egg hatchability).

Egg Stage:

Eggs were collected from the breeding cages at 12 hrs. intervals, in order to standardize the egg age. The collected eggs were transferred to glass vials (2.0 × 7.5 cm), subsequently; the incubation took place under the required combination of temperature and relative humidity. Four replicates of 25 eggs/each were used for testing. Observations were made daily to record the time of hatching and the incubation period (in days) during this experiment.

Larval Stage:

To study the larval development of *S. frugiperda*, 100 newly hatched larvae were transferred, each in a separate glass tube (7.5 × 2.5 cm.) which covered with cotton and containing fresh pieces of the three host plants under investigation (25 larvae/replicate). The larvae were left in the vials (contain a thin layer of fine saw-dust) until pupation. Daily, the pupated larvae were counted and the larval duration were calculated.

Pupal Stage:

Newly formed pupae were collected on the same day of pupation, weighted and placed in labeled glass tube (2.0 × 7.5 cm.) (One pupae/ each tube) and plugged tightly with a piece of cotton. Four replicates (each of 25 pupae) were placed at the same condition of temperature and RH% and observed daily till adult emergence. Pupal duration were calculated.

Adult Stage:

Ten of newly emerged moths were transferred on the same day of emergence to a glass mating-cage as mentioned before and also held on the aforementioned conditions. Five replicates, each has 2 adult (1♂ +1♀). Daily observations were made to record adult longevity.

Statistical analysis

The duration of different stages (incubation period, larval duration, pupal duration, pre-oviposition period, oviposition period, post oviposition, pupal weight, adult longevity (male and female) and fecundity were calculated. Data obtained in the present study were subjected to data analysis by standard errors. Differences in each measured parameter were examined by one-way analysis of variance (ANOVA).

RESULTS AND DISCUSSION

This study aims to investigate the development of *S. frugiperda* using different food resources in the laboratory. Newly hatched larvae were fed castor leaves, Corn stem and lettuce. Larval mortality %, larval duration, pupation %, pupal weight, pupal duration, pupal mortality %, adult emergence %, sex ratio, male and female longevity, Fecundity (No. of egg laying/female) and Fertility % (egg hatchability) were evaluated.

Such investigations may throw a light to complete the picture on food preference of *S. frugiperda*.

Data arranged in Table (1) showed that after feeding 1st instar larvae of *S. frugiperda* with castor leaves, corn stem and lettuce, the average larval duration of *S. frugiperda* were 23.36, 23.58 and 22.8 days, respectively. There was no-significant difference between the values of three plants. Larval mortality % was 5, 15, and 11.2 %, respectively. Normal larvae percentage was 100% in the three plants and there was no malformation recorded. These results agree with the findings obtained by Gamil, (2020) reported that the average larval duration was 21.4 days at 26°C for fall armyworm larvae and the pupation % was 91.2 %, on the other hand, the larval mortality %, malformed larvae % and normal larvae % were 8.8, 0.0 and 100 %, respectively. The same trend of results found by Hannalene *et al.,* (2020) on 22°C and Perkins (1979), his study conducted all biological aspects for *S. frugiperda.*

Table 1. Effects of different three host plants on larval stage of *S. frugiperda.*

Biological parameters	Castor oil leaves	Corn	Lettuce	F	LSD 1%
Larval duration (days)	23.36 ± 0.35 a	23.58 ± 0.36 a	22.8 ± 0.45 a	NS	-
Larval mortality %	5.0	15.0	11.2		
Normal larvae %	100.0	100.0	100.0		
Malformed larvae %	0.0	0.0	0.0		

Means have the same letter as vertically are non-significant different.

Data presented in Table (2) indicated that the pupation % was 95, 85 & 88.8 % for castor leaves, corn and lettuce, respectively. There were no malformed pupae reared on the three host plants. Moreover, the pupal duration was 10.52, 10.75 and 10.89 days when the *S. frugiperda* larvae feed on castor oil, corn and lettuce, respectively. There were no-significant difference between all pupal duration values. The pupal weights for the three host plants were 0.2740, 0.1913 and 0.2209 gm., respectively, with a significant difference between pupal weight value for castor oil and other values for corn and lettuce. For pupal mortality %, it was 5.88% when *S. frugiperda* fed on corn while there was no mortality when it was feed on castor oil leaves and lettuce. In Brazil Silva *et al.,* 2017 and in Egypt, Gamil, 2020 reported the same results for *S. frugiperda* biological aspects. Many authors study the fall armyworm biology among of them, Perkins, 1979, Pitre and Hogg (1983) and Ali and Luttrell (1990) and Barros, *et al.,* (2010). Hannalene *et al.,* (2020).

Table 2. Effects of different three host plants on pupal stage of *S. frugiperda.*

Biological aspects	Castor oil	Corn	Lettuce	F	LSD 1%
Pupation %	95.0	85.0	88.8		
Malformed pupae %	0.0	0.0	0.0		
Pupal duration (days)	10.52 ± 0.2 a	10.75 ± 0.25 a	10.89 ± 0.37 a	NS	
Normal pupae %	100.0	100.0	100.0		
Pupal weight (gm.)	0.2740 ± 0.016 a	0.1913 ± 0.003 b	0.2209 ± 0.013 b	S	0.074
Pupal mortality %	0.0	5.88	0.0		

Means have the same letter as vertically are non-significant different.

The obtained results in Table (3) indicated that the total emergence % was (100, 94.12 and 100%) for castor leaves, corn and lettuce, respectively. There was no malformation between adult stages. Statistically, there were no-significant differences between the three host plants. The sex ratio was affect with the different host plants. It were 42.1, 36.0 and 50.0% for (male) and 57.9, 64.0 and 50.0 % for (female) for castor leaves, corn and lettuce, respectively Table (3). Results showed that the adult longevity period for the fall armyworm, *S. frugiperda* at 26.0 °C was 11.8, 11.88 and 11.29 days for castor leaves, corn and lettuce, respectively. At the same time, the mean time required for maturation of the ovaries and starting to egg-laying (pre-oviposition period) was 4.6, 3.25 and 3.39 days. Meanwhile, the results indicated that oviposition periods were 4.0, 4.0 and 4.56 days, for castor leaves, corn and lettuce respectively. Statistically, there was no significant different between the values for the three host plants.

Table 3. Effects of different three host plants on adult stage of *S. frugiperda.*

Biological aspects	Castor oil	Corn	Lettuce	F	LSD 1%
Emergence %	100.0	94.12	100.0		
Adult malformation %	0.0	0.0	0.0		
Sex ratio % (♂:♀)	42.1: 57.9	36.0 : 64.0	50.0 : 50.0		
Adult longevity (days)	11.8 ± 0.75 a	11.88 ± 0.97 a	11.29 ± 0.43 a	NS	
Male longevity (days)	12.8 ± 0.66 a	14.5 ± 0.47 a	12.43 ± 0.38 a	NS	
Female longevity (days)	10.8 ± 0.59 a	9.25 ± 0.41 a	10.14 ± 0.27 a	NS	
Pre- oviposition period (days)	4.6 ± 0.58 a	3.25 ± 0.41 a	3.39 ± 0.16 a	NS	
oviposition period (days)	4.0 ± 0.4 a	4.0 ± 0.0 a	4.56 ± 0.18 a	NS	
Post oviposition period (days)	2.4 ± 0.54 a	1.0 ± 0.0 b	2.19 ± 0.16 a	S	1.16
Fecundity (No. eggs / female	2299.0 ± 117.0 a	1839.5 ± 260.8 a	2116.0 ± 50.0 a	NS	

Means have the same letter as vertically are non-significant different.

Also data showed that post oviposition periods were 2.4, 1.0 and 2.19 days, for castor leaves, corn and lettuce, respectively. Statistically, there were significant different between the values of three host plants. Many other investigators studied the biological aspects of different *S. frugiperda* stages including their immature stages, among of them, Silva *et. al*., 2017, the author studied the pre-pupal, pupal, and larva-adult period, pupal weight, sex ratio, survival, larva feeding preferences, oviposition preferences, and nutritional quality of different hosts. The authors found differences in the parameters and assured that the *S. frugiperda* tend to feed more in cereal crops.

The No. of eggs/ female (fecundity) laid by the females, which emerged under the constant temperature and R.H., the values was 2299.0, 1839.5 and 2116.0 egg /female for the three host plants under test, respectively. Statistically, there were no-significant differences between all values for all host plants.

On the other hand, the egg fertility (Table. 4) were 92.0, 93.0 90.9 % for the three host plants under test, respectively. This results agreement with findings buy Pitre and Hogg (1983); Ali and Luttrell (1990); Barros, *et al.,* (2010); Silva *et al.,* (2017), Hannalene *et al.,* (2020) and Dahi *et. al.,* (2020) in Egypt.

Table 4. Effects of different three host plants on egg stage of *S. frugiperda.*

Biological aspects	Castor	Corn	Lettuce	F
Fertility %	92.0	93.0	90.9	
Incubation period (days)	3.11 ± 0.04 a	2.99 ± 0.008 a	3.24 ± 0.24 a	NS
Hatchability %	85.0	98.0	91.7	

Means have the same letter as vertically are non-significant different.

Data obtained in Table (4) indicated that, the hatchability % were 85, 98 and 91.7 % for castor leaves, corn and lettuce, respectively. The incubation periods were 3.11, 2.99 and 3.24 days for the three host plants, respectively. Statistically analysis, there are non-significant different between all values of incubation period for all host plants. These results agreed with many authors studied the fall armyworm biology among of them, Ali and Luttrell (1990), Barros, *et al.,* (2010), Dahi *et al.,* (2020), Gamil (2020), Hannalene *et al.,* (2020).

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نمو وتطور دودة الحشد الخريفية علي ثلاثة عوائل نباتية

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الدراسة المختبرية الحالية هي المحاولة الأولى في مصر والتي ركزت على دراسة نمو وتطور الآفة الحشرية الغازية الجديدة "دودة الحشد الخريفية" علي ثلاثة من العوائل النباتية وهم الخروع والذرة الشامية والخس وقد أجريت هذه الدراسة في قسم علم الحيوان، كلية العلوم، جامعة جنوب الوادي، بمحافظة قنا بجنوب البلاد، وذلك التزاماً بالشروط التي تفرضها اللجنة الوطنية للإجراءات الاحترازية لمجابهة دودة الحشد الخريفية بوزارة الزراعة المصرية. حيث تعتبر دودة الحشد الخريفية من الآفات الإقتصادية الهامة متعددة العوائل . وقد غزت هذه الآفة مصر مؤخراً مسببة أضراراً غير متوقعة لمحصول الذرة الشامية. ومن خلال هذا العمل تم دراسة تاريخ الحياة لهذه الآفة الحشرية على ثلاثة من العوائل النباتية المختلفة تحت ظروف المعمل، تم تقدير وحساب كل من نسبة موت اليرقات وطول مدة الطور اليرقي والنسبة المؤية لتكوين العذاري ووزن العذاري وطول مدة طور العذراء والنسبة المؤية لموت العذاري والنسبة المئوية لخروج الفراشات والنسبة الجنسية وطول مدة حياة الفراشات الذكور والاناث وعدد البيض لكل انثي والنسبة المؤية لفقس البيض وذلك علي العوائل الثلاثة تحت الدراسة. وأظهرت الدراسة أن متوسط مدة حياة اليرقات كان 23.36 و 23.58 و 22.8 يومًا علي اوراق الخروع والذرة الشامية والخس على التوالي ، وكانت مدة حياة طور العذراء 10.52 و 10.75 و 10.89 يوما على التوالي للعوائل الثلاثة تحت الدراسة وكان هناك اختلاف غير معنوي بين كافة قيم مدة حياة طور العذراء . بلغ عدد البيض 2299.0, 1839.5 و2116.0 بيضة/أنثى علي العوائل الثلاثة تحت الدراسة علي التوالي . وأظهرت النتائج أيضا أن فترات ما بعد وضع البيض كانت 2.4 و 1.0 و 2.19 يوماً، لعوائل الثلاثة على التوالي. لم تكن هناك تفضيلات لأي من العوائل النباتية الثلاثة المختبرة والتي قد تكون ذات صلة بصفة عدم التفضل او التضاد الحيوي لهذه الافة . وانتهت الدراسة الي ان دودة الحشد الخريفية يمكن تربيتها بسهولة في المعمل باستخدام أوراق الخروع وهو محصول غير اقتصادي ويمكن الحصول علية بسهولة.