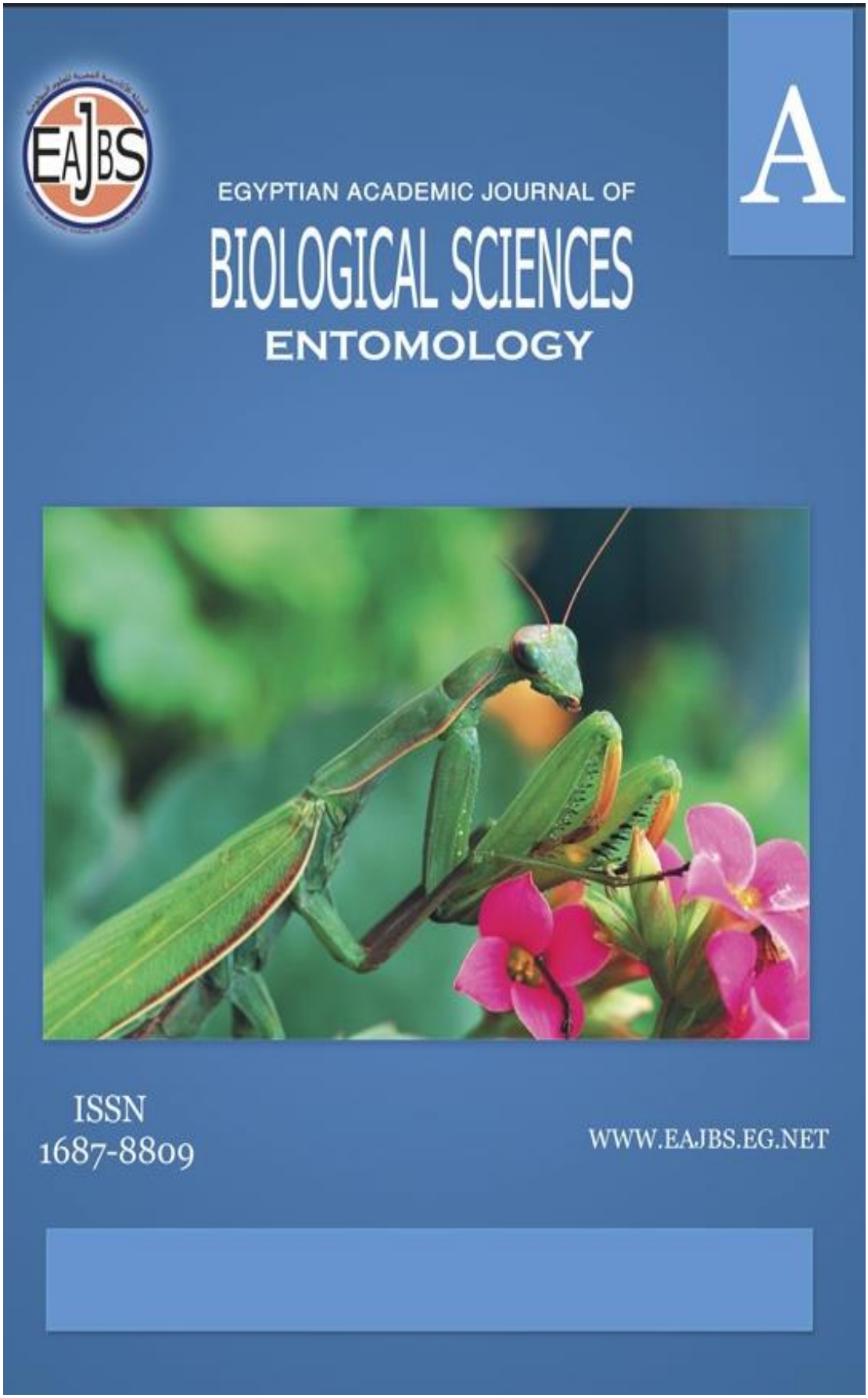

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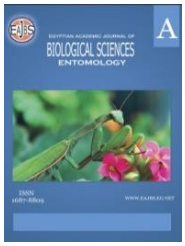

Fall Armyworm *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) Biological Aspects as A New Alien Invasive Pest in Egypt

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ABSTRACT

The present study may be the first attempt in Egypt which devoted to studying the biological aspects of fall armyworm, *Spodoptera frugiperda* (J.E. Smith). The study was conducted under laboratory conditions (26 ±1°C and 65 % R.H.) at the Department of Zoology, Faculty of Science, South Vally University, Qena Governorate, Egypt. The results included both hatchability (%) and incubation period (days) for egg stage; larval duration (days), pupation %, larval mortality %, malformed larvae %, and normal larvae % for the larval stage. While, the pupal duration, normal pupae %, malformed pupae %, pupal weight (gm), malformed pupae %, pupal mortality %, and emergence % for the pupal stage. Adult malformation %, sex ratio %, adult longevity (days), male longevity, female longevity, pre- oviposition period, oviposition period, post -oviposition period, fecundity (No. eggs/ ♂) and fertility % for the adult stage. The study of the biological aspects of the fall armyworm as a new invasive pest came to Egypt from the of South Africa countries is very important in order to determine the stages of life history to contribute to the planning IPM strategies for this dangerous pest in the absence of any local information about it.

INTRODUCTION

The Fall Armyworm (FAW) *Spodoptera frugiperda* (J. E. Smith) (Lepidoptera: Noctuidae) is a lepidopteran pest that feeds in large numbers on leaves and stems of more than 80 plant species, causing major damage to maize, rice, sorghum, sugarcane but also other vegetable crops and cotton.

The fall armyworm is one of the important invasive polyphagous pests. It is native to tropical and subtropical regions of the Americas. It occurs in several countries such as Brazil, Argentina, and the USA (Prowell *et al*., 2004; *Clark et al., 2*007), causing economic losses in a variety of crops such as maize, soybean, cotton, and beans (Pogue, 2002; Nagoshi, 2007; Bueno *et al.*, 2010) and number of field crops, such as rice, maize, and other grasses (Nabity *et al.*, 2011). Because of its wide host range, *S. frugiperda* is one of the harmful pests threatening annual crops in tropical regions (Andrews, 1980; Marenco *et al.*, 1992; Cruz *et al.*, 1999). Recently, the severe incidence of FAW was reported from African countries such as São Tomé, Nigeria, Bénin and Togo (Sharanabasappa *et. al.*, 2018 and Igyuve 2018 in Nigeria. The fall armyworm, *Spodoptera frugiperda* was first reported in Africa by Goergen *et. al.*, 2016).

A large area of South and Southeast Asia is highly suitable for the year-round occurrence of the fall armyworm. There are also important invasion routes from Africa into several countries in this region. The pest spread to various areas in 2018 and 2019 and was reported for example from India, Thailand, Myanmar, China, Republic of Korea, Japan, the Philippines, Indonesia, and recently also in Australia, FAO (2020) and ABC News (2020).In 2016 it was reported for the first time in Africa, where it is causing significant damage to maize crops and has great potential for further spread and economic damage. In Egypt, in May 2019, the Agricultural Pesticide Committee (APC) of the Ministry of Agriculture reported the first case of FAW presence in a maize field in a village in Kom Ombo city of Aswan Governorate, Upper Egypt. According to the 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. So, the biology study of FAW is important for identifying the life stages and also for planning IPM strategies. Hence, this study is the first study on the biology of FAW under laboratory conditions in Egypt.

MATERIALS AND METHODS

A stock colony of *Spodoptera frugiperda* larvae (F0 generation) was collected from maize fields at the farm of South Valley University, Qena Governorate. This work was carried out at the Faculty of Science, South Valley University, Qena. These larvae were reared in plastic containers (40 × 20 × 15 cm) with aerated lids and provided with maize leaves as food. Food was replaced at three-day intervals. Larvae were reared separately from the 3rd instar onwards. This was done in small glass containers (70mm in height × 20 mm in diameter) with fine muslin. Larvae were kept in an incubator at 26°C ± 1 °C, 65 ± 5% RH, and 14L: 10D photoperiod until pupation. Pupae kept in the same incubator. Pupae were observed daily until moths emerged. After the emergence of moths, single male-female pairs were confined to oviposition glass cadge an incubator maintained at the temperature and conditions ascribed above. The cadge and methods used are according to those described by Kruger *et al*., 2012. A plastic bottle (22 cm in height and 10 cm in diameter) was cut open at the top and filled with small crusher stones up to a height of 5 cm. One maize stem, 18 cm in length, and 25–30 mm in diameter, with the whorl intact, was placed in an upright position inside the bottle. The stem was inserted 3–4 cm into the crusher stones to keep it upright. Water was added up to a level three-quarters of the height of the stones to provide humidity and to keep the plant parts fresh. The containers were covered with a fine muslin to prevent the moths from escaping. The maize leaves and stems were replaced every day and inspected for egg batches.

For strain establishment, the eggs were maintained at 26 ±1°C and 65 ± 5% R.H until hatching. Newly hatched larvae were transferred to clean 5-pound glass-Jars covered with muslin and secured with rubber bands. They were provided with fresh castor-oil leaves which were renewed daily until the larvae show the signs of pupation. A thin layer of fine saw-dust was spread on the bottom of every glass-Jars to help the successful pupation. Pupae were kept individually in a vial until moth emergence. Ten pairs of newly - emerged moths were confined into oviposition cages. Which consists of a conventional mating glass bells (16cm. high and 8cm.diam.) opened at each end. Each mating-glass bell was supplied with a small fresh branch of *Nerium oleander* to serve as an oviposition site and placed on its wide end on a half petri-dish. Tops of the glass bells were covered with muslin and secured with rubber bands. Cages were examined daily to replace *N. oleander* branches with new ones and renew the adult feeding solution (a small piece of absorbent cotton wool previously soaked in 10% sucrose solution). The cages were maintained at the same conditions of temperature and %

R.H. Deposited egg- masses were kept in petri-dishes, and then, were available to achieve the different experiments. Insect culture for fall armyworm reared in the laboratory for at least four generations (F4 generations) on the fresh leaves of castor oil plant to become a sensitive strain.

Experimental Design:

This work was carried out under controlled conditions (temperature and relative humidity). One incubator was used to provide a constant temperature of 26 ± 1°C. All stages (from egg to adults) were kept under the constant temperature and % R.H. to determine all the biological parameters of each stage.

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 x 7.5 cm), subsequently, the incubation took place under the required combination of temperature and relative humidity. Three replicates of 100 eggs/each were used for testing. Observations were made daily to record the time of hatchability 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 x 2.5 cm.) which covered with absorbent cotton and containing fresh pieces of castor oil plant leaves (25 larvae/replicate). The larvae were left in the vials (contain a thin layer of fine saw-dust) until pupation. Daily observations were made to count the pupated larvae. Larval development and duration were estimated.

Pupal Stage: newly formed pupae were collected on the same day of pupation and placed in the glass tube (2.0 × 7.5 cm.) (One pupa for 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, pupal weight, malformed pupae, and adult emergence % could also be considered.

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 same conditions of temperature and R.H. %. Five replicates, each has 2 adults (1♂ +1♀), were placed at tested temperature and RH %. 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 in order to calculate the fecundity, fertility, and adult longevity.

Duration of different stages, hatchability, pupation, adult emergence, sex ratio, pre-oviposition, oviposition, and post-oviposition periods, adult longevity, fecundity, and fertility were calculated. Data obtained in the present studies were subjected to data analysis by standard errors (Standard errors, were calculated using the equations provided by Campbell *et. al.*,1974)

RESULTS AND DISCUSSION

Egg Stage:

Data in Table (1) and Figure (1) show the incubation periods of fall armyworm egg in the laboratory at a constant temperature of 26 ± 1°C. The above-mentioned Table indicated that the required time for completion of fall armyworm embryogenesis. The mean incubation periods were 2.29 days. The same table indicate also to the percentage of *S. frugiperda* hatchability was 97.33 %. These results agree with the findings obtained by Igyuve1, *et al.*, (2018) and Sharanabasappa *et al., 2018* they reported the female covered a layer of scales on the egg mass and this gave moldy appearance. The incubation period ranged from 2-3 days with a mean of 2.50 days.

Table 1: Hatchability percent and Incubation period for *Spodoptera frugiperda* egg stage at constant conditions

Biological aspect	Mean ± SE
Hatchability (%)	97.33
Incubation Period (days)	2.9 ± 0.10

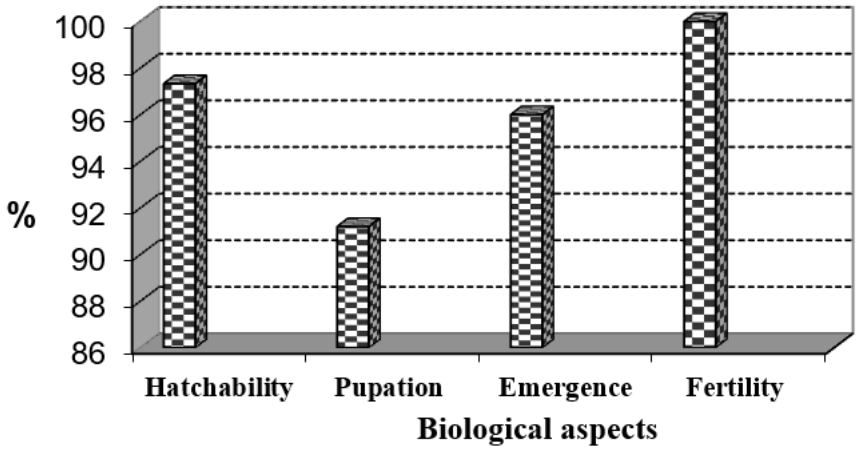

Fig.1: Egg Hachability, pupation, adult emergence, and fertility% of *Spodoptera frugiperda*

Larval Stage:

Table (2) and Figure (1) indicate 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. These results agree with the findings obtained by Hannalene *et al.*, (2020) on 22°C and Perkins (1979), his study conducted all biological aspects for fall armyworm.

Table 2: Biological aspects for *Spodoptera frugiperda* larval stage reread on castor oil leaves in the laboratory at constant conditions**.**

Biological aspect	Mean ± SE
Larval Duration (days)	21.4 ± 0.59
Pupation %	91.2
Larval mortality %	8.8
Malformed larvae %	0.0
Normal larvae %	100

Pupal Stage:

Concerning the pupal stage of *S. frugiperda*, the pupal duration was 9.56 days and the pupal weight was 0.3033 gm, while the normal pupae, malformed pupae, pupal mortality and emergence % were, 95.44, 4.56, 4.0, and 96.0 %, respectively as shown in Table (3) and Figure (1).In Brazil Silva *et al.*, 2017 reported the same results for *S. frugiperda* biological aspects.

Table 3: Biological aspects for *Spodoptera frugiperda* pupal stage in the laboratory at constant conditions.

Biological aspect	Mean ± SE
Pupal Duration (days)	9.56 ± 0.11
Normal pupae %	95.44
Malformed pupae %	4.56
Pupal weight (gm)	0.3033 ± 0.0027
Pupal mortality %	4.0
Emergence %	96.0

Adult Stage:

Data in Table (4) and Figure (1) show that the adult longevity period for the fall armyworm, *S. frugiperda* at laboratory condition (constant temperature 26 ± °C) was 12.11 days. At the same time, it is appreciably clear that the mean time required for maturation of the ovaries and starting to egg-laying (pre-oviposition period) was 3.50 days. Meanwhile, the results indicate that both oviposition and post-oviposition period were 5.11 and 2.61 days, respectively.

Regarding the fecundity (No. of eggs/ female) and egg fertility laid by the females, which emerged under the constant temperature and R.H., the data in the same table indicated it was 1787.5 eggs and 100.0 %, respectively.

Many other investigators studied the biological aspects of different *S. frugiperda* stages including their immature stages, among of them, Silva *et al.,* 2017, the Duration of pre-pupal, pupal, and larva-adult period, pupal weight, sex ratio, survival, larva feeding preferences, oviposition preferences, and nutritional quality of different hosts were evaluated. Concerning the mean male and female longevities were, 13.00 and 11.22 days, respectively. Table (4) show the sex ratio of fall armyworm at constant conditions in the laboratory was approximately 1:1(45.24 ♂:55.76♀). Many authors study the fall armyworm biology among them, Perkins (1979), Pitre and Hogg (1983) and Ali and Luttrell (1990) and Barros, *et al.*, (2010). Hannalene *et al.*, (2020) on 22°C.

Table 4: Biological aspects for *Spodoptera frugiperda* adult stage in the laboratory at constant conditions.

Biological aspect	Mean ± SE
Adult malformation %	1.8
Sex ratio %	45.24 ♂ :55.76♀
Adult longevity (days)	12.11 ± 0.41
Male longevity	13.00 ± 0.37
Female longevity	11.22 ± 0.33
Pre- Oviposition period	3.50 ± 0.17
Oviposition period	5.11 ± 0.21
Post -Oviposition period	2.61 ± 0.21
Fecundity (No. eggs/ female)	1787.5 ± 91.3
Fertility %	100.00

The Complete Generation:

The complete development of *Spodoptera frugiperda* generation required 35.97 days (from egg to adult longevity) in the laboratory under constant conditions as shown in Table (5).

Table 5: Duration of *Spodoptera frugiperda* generation in the laboratory at constant conditions.

Biological aspect	Mean ± SE
Incubation Period (days)	2.9 ± 0.10
Larval Duration (days)	21.4 ± 0.59
Pupal Duration (days)	9.56 ± 0.11
Adult longevity (days)	12.11 ± 0.41
Duration of generation (days)	35.97 ± 1.38

These results agree with findings by Pitre and Hogg (1983); Ali and Luttrell (1990); Barros, *et al.,* (2010); Silva *et al.,* 2017and Hannalene *et al.,* (2020).

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ARABIC SUMMARY

المظاهر البيولوجية لدودة الحشد الخريفية كآفة غازية جديدة في مصر

ولاء جميل إبراهيم
معهد بحوث وقاية النباتات- مركز البحوث الزراعية – الجيزة- مصر

قد تكون هذه الدراسة هي المحاولة الأولى في مصر التي كرست لدراسة الجوانب البيولوجية لدودة الحشد الخريفية . أجريت هذه الدراسة معمليا تحت ظروف الحرارة الثابتة 26 ± 1 درجة مئوية بقسم علم الحيوان، كلية العلوم، جامعة جنوب الوادي بمحافظة قنا بجمهورية مصر العربية وذلك التزاما بالشروط التي تفرضها اللجنة الاحترازية لدودة الحشد الخريفية بوزارة الزراعة. وشملت النتائج كلا من :النسبة المؤية لفقس البيض وفترة الحضانة لمرحلة البيض وكذلك مدة الطور اليرقي- النسبة المؤية للتعذير والنسبة المؤية لموت اليرقات والنسبة المؤية لليرقات المشوهة والسليمة وذلك لطور اليرقات اما بالنسبة لطور العذراء فتم دراسة كل من مدة الطور العذري – النسبة المؤية للعذاري السليمة – النسبة المؤية للعذاري المشوهة – متوسط وزن العذراء – النسبة المؤية لموت العذاري – النسبة المؤية لخروج الفراشات من العذاري. واخيرا بالنسبة للطور الكامل (الفراشات) تم دراسة كل من المظاهر التالية – طول عمر الحشرة الكاملة – طول عمر الذكر والانثي – طول فترة ماقبل وضع البيض وكذلك فترتي وضع البيض ومابعد وضع البيض – الخصوبة – النسبة المؤية للفراشات السليمة والمشوهة – النسبة الجنسية.حيث تعتبر دراسة المظاهر البيولوجية لدودة الحشد الخريفية كآفة غازية جديدة جاءت الي جمهورية مصر العربية من بلدان الجنوب أفريقيا امر في غاية الاهمية وذلك لتحديد مراحل الحياة بدقة للمساهمة في تخطيط استراتيجيات المكافحة المتكاملة لهذة الافة الخطيرة في ظل عدم توافر اي معلومات محلية عنها.