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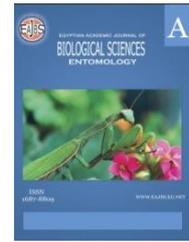
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Biomorphic Characters of Fall Armyworm, *Spodoptera frugiperda* (Lepidoptera: Noctuidae) on Maize in Pakistan

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ABSTRACT

Fall armyworm, *Spodoptera frugiperda* belongs to order Lepidoptera and family Noctuidae, is becoming a serious threat in maize growing areas of the world. Firstly, it was reported from African countries and caused significant economic crop losses. Recently the pest has been reported from various areas of Pakistan and knowledge of biomorphic characters was important. By keeping in view, the current study was conducted. The study resulted that complete metamorphosis was observed. The eggs were white to yellow in colour and dome in shape with 2-3 days of the incubation period. The egg width and thickness were recorded as 0.22 and 0.19 mm, respectively. Six larval instars were recorded. The pinacula of each seta was well recorded on all larval instar but more conspicuous in the last instar (6th) as compared to others. Inverted Y line was present on larvae head that mostly differentiates this species from other reported *Spodoptera* species. First, second, third, fourth, fifth and sixth larval head capsule width was 0.18±0.02, 0.29±0.00, 0.50±0.01, 0.76±0.47, 1.10±0.13 and 1.98±0.12 mm, respectively. The length and width of the 6th instar larva were 26.98±2.93 and 3.90±0.00 mm, respectively. The total larval period was 15-20 days on maize leaves. Obtect pupa was whitish green. Male was short-lived than female. The pre oviposition, oviposition and post oviposition periods were 2-5, 2-4 and 4-6 days, respectively. The study will be proved fruitful for coming researchers and farmers to control this pest.

INTRODUCTION

Maize (*Zea mays*) commonly known as the king of crops for silage, is the third most important cereal crop after wheat and rice in Pakistan. It is cultivated in all provinces (Punjab, Sindh, Khyber Pakhtunkhwa and Balochistan) of the country as multipurpose such as food for humans, silage for animal consumption, feed for poultry and raw materials for industrial products. It is cultivated on an area of 1.016 million hectares with an average

yield of 2,864 kg per hectare. Only 2-3% of maize grain comes from the province Balochistan and Sindh while 97% of total grain produced in KPK and Punjab. Maize is sown in spring and autumn but spring sowing was found most profitable in case of high yield in Pakistan (Tariq and Iqbal, 2010).

In Pakistan, maize production is low as compared to other countries due to various biotic and abiotic factors such as insect pests, diseases and the environment. Several insect pests attack the maize crop such as maize stem borer (*Chilo partellus*) and shoot fly (*Atherigona soccata*) which can reduce 10-30% yield (Ahmed et al. 2002; Naz et al. 2003; Ahmed et al. 2003). It was very difficult to control maize stem borer and many other reported insect pests in the country. Recently another most destructive maize pest, Fall armyworm (FAW), *Spodoptera frugiperda* has been recorded and identified from various regions of the world including Pakistan. It is considered an invasive alien species which has quickly spread in many countries (Pakistan, China, India, Africa, Taiwan, Philippines (Naeem-Ullah et al. 2019; CABI 2019; IPPC 2019; Navasero et al. 2019) due to high migrating power and high reproductive rate.

The attack of this voracious and invasive alien species had been reported on more than 353 host plants including maize, sorghum, rice, millet, sugarcane, soyabean, peanut, wheat, cotton, cabbage, cauliflower and different grasses (Levy et al. 2002; Montezano et al. 2018). Among reported host plants, maize is a major and preferable host for pest growth and development as reported by early researchers from various countries even Pakistan. Larvae consume all parts of maize such as reproductive and vegetative (Pogue 2002; Goergen et al. 2016).

For the last two years 2019-2020, the high infestation of FAW larvae was recorded on maize fields in the country (Pakistan). The different management practices are adopted against maize insect pests especially FAW and maize stem borer to minimize crop losses in many countries. It is a new emerging pest in Pakistan which caused high maize losses but still, no management practice has been adopted against it. Chemical control is extensively adopted against FAW in many countries except Pakistan.

There is a need to control this notorious pest in the country but before adopting any strategy, basic knowledge of the pest is necessary such as biology and morphology. By keeping in view, the current study was conducted to provide basic information to future experts for adopting the best and effective management approach against this pest in the country.

MATERIALS AND METHODS

Three to four number of FAW pupae were collected from different maize fields and kept in plastic containers for adult emergence. A pair of emerged adults (1:1) was shifted into a rearing cage with maize leaves for obtaining eggs on them. After one day of adults releasing, leaves were examined properly, eggs separated from leaves with the help of camel hairbrush and placed into petri dishes for hatching. After hatching, thirty-first instar larvae were collected and placed individually into a petri dish with maize leaves. The following biomorphic characters such as incubation period, developmental period of larvae (1st-6th instars), prepupal and pupal period, ovipositional period (pre-and post-period), both sex longevity, fecundity, the total time duration from egg to adult and width and length of all stages were observed and noted. The morphological parameters were also noted by using a microscope.

RESULTS AND DISCUSSION

Several *Spodoptera* species have been reported by many taxonomists around the globe especially in Pakistan. Another major one, Fall armyworm, *Spodoptera frugiperda* belongs to order Lepidoptera and family Noctuidae, is becoming a serious threat in maize growing areas of the world including Pakistan (Ramzan et al., 2021^a). Its larval stage is most destructive and vigorously feeds on the host's leaves such as sorghum, rice, maize, millet, cotton, soyabean and sugarcane (Clark et al. 2007; Cock et al. 2017). It has been reported that adults are nocturnal and fly up to 100 Km in a night.

The complete metamorphosis was found in *Spodoptera frugiperda*, a serious pest of maize crop in the globe. Eggs are laid in masses or groups on the upper or lower side of plant leaves. The eggs are white to yellow in colour and dome in shape. Eggs covered with cottony-gray scales and colour of eggs changed dark prior to hatch. The incubation period of the egg was 2 to 3 days (**Table 1**).

Table 1: Biological parameters of *Spodoptera frugiperda* under laboratory conditions.

Parameters	Mean \pm SD	Range (days)
Eggs		
Eggs	2.32 \pm 0.90	2.00 – 3.00
Larvae		
Larval period	16.19 \pm 1.50	15.00-20.00
First instar	2.45 \pm 0.65	2.00- 3.00
Second instar	2.12 \pm 0.87	2.00- 3.00
Third instar	2.03 \pm 0.18	2.00-3.00
Fourth instar	2.05 \pm 0.65	2.00-3.00
Fifth instar	2.37 \pm 0.39	3.00-4.00
Sixth instar	5.17 \pm 0.97	5.00-7.00
Pupae		
Pre-Pupa	1.00 \pm 0.00	1
Pupal period	12.12 \pm 1.18	10.00- 14.00
Pre oviposition period	2.90 \pm 0.56	2.00-5.00
Oviposition period	2.97 \pm 0.32	2.00-4.00
Post oviposition period	4.76 \pm 0.74	4.00-6.00
Fecundity	1004.65 \pm 110.00	820-1150
Egg hatchability (%)	92.45 \pm 1.24	93.00-95.00
Longevity		
Male adult	7.99 \pm 0.76	8.00-11.00
Female adult	9.54 \pm 0.76	10.00-13.00
Total life history (egg-adult)		
Male	35.32 \pm 4.02	36.02-40.00
Female	42.00 \pm 5.76	45.00-48.00

The egg width and thickness were recorded as 0.22 and 0.19 mm, respectively. Our findings are in line with previous researchers who had reported similar findings of eggs (Navasero and Navasero, 2020). The variation in width and thickness could be due to geographical location and feeding capacity of larvae to host plants.

Six larval instars were recorded. The pinacula of each seta was well recorded on all larval instar but more conspicuous in the last instar (6th) as compared to others. The color variations were recorded in *S. frugiperda*. The purplish-green was the most common color. 1st and 2nd instar larvae were greenish and greenish-brown while 3rd instars were brownish

with two to three whitish dorsal lines. The 4th to 6th instars were brownish-black having black tubercles on the body. Inverted Y line was present on larvae head that mostly differentiates this species from other reported *Spodoptera* species. First, second, third, fourth, fifth and sixth larval head capsule width was 0.18 ± 0.02 , 0.29 ± 0.00 , 0.50 ± 0.01 , 0.76 ± 0.47 , 1.10 ± 0.13 and 1.98 ± 0.12 mm, respectively. The length and width of the 6th instar larva were 26.98 ± 2.93 and 3.90 ± 0.00 mm, respectively (Table 2). The total larval period was 15-20 days on maize while 14-19 days as reported by Sharanabasappa *et al.* (2018). Larvae stopped their feeding near to pupation.

Table 2: Morphological parameters; Head capsule width, length and width of larval body, egg width and thickness.

Instar	Head capsule	Body	
	Width	Length	Width
	Mean \pm SD	Mean \pm SD	Mean \pm SD
1 st	0.18 ± 0.02	1.68 ± 0.00	0.14 ± 0.26
2 nd	0.29 ± 0.00	2.25 ± 0.29	0.26 ± 0.03
3 rd	0.50 ± 0.01	6.65 ± 0.34	0.67 ± 0.12
4 th	0.76 ± 0.47	13.98 ± 1.00	1.84 ± 0.15
5 th	1.10 ± 0.13	19.32 ± 1.65	2.87 ± 1.54
6 th	1.98 ± 0.12	26.98 ± 2.93	3.90 ± 0.00

The larva can live without feeding for one day which is called the pre-pupation stage. In the current study pupal period was lasted 10-14 days while Débora *et al.* (2017) had reported 8.54 days. The pupation was occurred in the maize stem or between the leaf-cutting or sides of petri dishes. Obtect pupa was whitish green. Our findings are in line with the previous scientists who had reported similar findings of the life cycle of *S. frugiperda* on maize crop. The space between the anal slot and genital opening was present which differentiate the male and female. It was observed that male pupal length and width were larger than female (Table 3).

Table 3: Male and female pupa length and width

Pupa length		Pupa width	
Male	Female	Male	Female
Mean \pm SD	Mean \pm SD	Mean \pm SD	Mean \pm SD
14.12 ± 0.38	14.00 ± 0.32	4.12 ± 0.12	4.00 ± 0.00

The developmental period of insects depends upon the quality and quantity of food fed by larval duration. The insects can obtain full length or width which feed on the quality food or leaves. Quality food availability is the main factor for insect growth and development (Ramzan *et al.*, 2019). Our current results are similar to many researchers' findings who give importance to food source or quality. Barros *et al.* (2010) had discussed similar results about food quality. Sexual dimorphism was found in the color marking of *S. frugiperda* adults. The pre oviposition, oviposition and post oviposition periods were 2-5, 2-4 and 4-6 days, respectively.

The current study findings are similar to many *S. frugiperda* rearing experts. The male adult body length of a male adult was longer than a female while the wing expanse was shorter (Table 4). Navasero (2019) and Ramzan *et al.* (2021^b) had reported similar findings of adult body length and wing expanse.

Table 4: Adult body length and wing expanse

Adult body length		Adult wing expanse	
Male	Female	Male	Female
Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
11.21±0.65	10.13±0.56	30.63±1.54	31.00±1.43

The different management practices such as monitoring, cultural, physical, chemical, biological and entomopathogenic fungi have been recommended by many experts (Murtaza et al., 2019; Ramzan et al., 2021^{a,b}) in the country which can be tested to control this noxious pest of agricultural crops in Pakistan (Ramzan et al., 2020). The pheromones trap as well as monitoring is the best way to control this destructive and emerging pest in the study area. The great variations were recorded in width and thickness of *S. frugiperda* eggs (Table 5).

Table 5: Egg width and thickness.

Width	Thickness
Mean ± SD	Mean ± SD
0.22±0.02	0.19±0.19

Conclusion:

The study concluded that the current pest has the potential to damage the various agricultural crops all over the world and high potential for reproduction as well as migration. The study could prove helpful for many scientists, researchers and farmers to control this pest and apply the best strategy against this pest to protect the agricultural and horticultural crops.

Competing interest:

Authors declare no competing interest.

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