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Comparative biology of *Spodoptera litura* (Fab.) on different host plants under laboratory condition

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Abstract
The present studies were undertaken at Department of Entomology, College of Agriculture, Dapoli (M.S.) during 2017-18 to know the biology of *Spodoptera litura* (Fab.) on different host plants under laboratory condition. The data on comparative biology of *S. litura* on different hosts inferred that, the minimum larval development period of 11.67 days was noticed on castor, whereas, it was maximum (17.33 days) on tapioca. The minimum pre-pupal (2.00 days) and pupal period (7.33 days) were recorded on castor, while were maximum (3.00 days pre-pupal and 11.67 days pupal period) on tapioca. The pupal weight was maximum on castor *i.e*. 0.28 g and minimum on cowpea (0.19g). The maximum pupal success of 86.67 percent was observed in larvae fed on castor, whereas, it was significantly lowest on tapioca leaves (46.67%). Highest adult weight was found on tapioca leaves (0.20g) followed by groundnut (0.18g) and the lowest adult weights were recorded on Mulberry and cowpea (0.08g each). Among the eight hosts the adult longevity was recorded maximum on castor and sweet potato *i.e.*7.67 day's each and minimum on tapioca (5.33days). The larvae fed on sweet potato leaves supported highest adult success *i.e*. 73.81 percent and lowest mean adult success was observed on tapioca (35.00%). The total development period was significantly highest on tapioca (37.00 days) and it was found to be minimum on castor (28.33 days). The maximum mean fecundity was 3074.00 eggs per female on castor host, whereas, minimum with 622.00 eggs per female on tapioca host. The sex ratio of female to male was observed as 1:0.7, 1:0.5, 1:0.6, 1:0.8, 1:0.6, 1:0.5 and 1:0.7 on castor, mulberry, okra, sweet potato, taro, groundnut and tapioca, respectively. The male biased ratio was only observed on cowpea (1:1.2).

Keywords: Biology, *Spodoptera litura* (Fab.), fecundity, adult success, sex ratio etc.

Introduction
The *Spodoptera litura* Fab. (Lepidoptera : Noctuidae) is a serious polyphagous insect causing immense damage to field crops like vegetables, oilseeds, pulses, throughout the Country (Gargav and Katiyar, 1971) [8]. This insect has been reported causing extensive damage to a wide range of crops such as oilseeds, pulses, fodders, fiber crops, fruit trees, weeds, medicinal and ornamental plants. (Singh and Singh, 1993) [19]. It was found to cause 26-100 percent yield loss in groundnut (Dhir *et al*. 1992) [5].

Host plant is a key determinant of the establishment, growth, survival and fecundity of herbivorous insects. Though many host plants were reported for *S. litura*, every host does not support the pest in the same way. There have been a number of studies on the biological parameters of S. *litura* on different host plants under different environmental conditions, particularly, in India (Patel *et al.*1986) [16], Pakistan (Ahmad *et al.*, 2007) [1], China (Zhu *et al.* 2000) [26] Korea (Bae and Park, 1999) [2] and other Asian countries (Etman and Hooper, 1979) [6] where S. *litura* has been an important pest on various crops.

Mathur (1962) [13] reported its several host plants like cotton, jute, sunhemp, castor, linseed, sesame, pigeonpea, black gram, horse gram, green gram, pea, cowpea, soybean, potato, sweet potato, maize, sorghum, groundnut, tobacco and also *Albezzia* sp., *Antemisia vulgaris* L, *Asparagus officinalis* L, *Cannabis sativa* L., *Chenopodium ambrosioides* L. and *Chrysanthemum* sp. (Nagia *et al.*1991, Singh and Sehgal, 1992) [14, 20].

The objective of this study was to determine the best host that support the development of *S. litura* and can be used for mass rearing of *S. litura*. Similarly, the information of life history parameters of *S. litura* on different host plant species will help to make efficient strategies to control this economic pest (Greenberg *et al.* 2001) [9].

Moreover, evaluation of the effectiveness and efficiency of control technology require the presence of the appropriate stage, quantity and quality of insect. Therefore, mass breeding technology using high quality of feed, easy to get, and affordable is needed in order to provide insect described as above. Even though this pest feed on various crops, the differences in morphological and chemical substance between host plants may likely interfere in the biology and behavior of pest. Therefore, the present investigation was carried out to study the comparative biology of *Spodoptera litura* (Fab.) on different host plants under laboratory condition.

Materials and methods

Mass rearing of *S. litura*

The larvae of *S. litura* were initially collected from the infested plants of *Palak* (*Spinacea oleracea* L.) leaves growing at the Horticulture farm of College of Agriculture, Dapoli (Maharashtra). Culture was maintained under laboratory conditions on castor *(Ricinus communis* L.) leaves at room temperature (27 ± 3°C) and relative humidity (70 ± 5%). Fresh food was provided daily, during experimental period. Proper hygienic conditions were maintained. Full-grown larvae were allowed to pupate in the glass bottles (18 cm height and 9 cm diameter). Pupae were separated and kept in a separate glass bottle. Emerging moths were used to build up subsequent culture. Adults were fed on 10 percent honey. A folded black paper sheet was placed in the jar to provide suitable sites for oviposition. Open end of bottle was covered with muslin cloth held tightly with the help of a rubber band. Eggs obtained from these moths were placed in glass bottle by cutting the paper strips along with the eggs. Newly hatched larvae were further used for different aspects of the study.

Experimental details

A statistically designed lab experiment using Completely Randomized Design (CRD) having replications and treatments was laid out at Department of Entomology laboratory, College of Agriculture, Dapoli to study comparative biology of *S. litura* on different host plants under laboratory condition. The details of experiment are given below:

Experimental details

Location: Department of Entomology laboratory, College of Agriculture, Dapoli.

Design: CRD

Replication: Three

No. of larvae per replication: Ten

Treatment: Eight (Different host plants as given below)

Treatments	Host plants
T_1	Castor, *Recinus communis* (L.)
T_2	Mulberry, *Morus alba* (L.)
T_3	Okra, *Abelmoschus esculentus* (L.)
T_4	Cowpea *Vigna unguiculata* (L.)
T_5	Taro, *Colocacia esculenta* (L.)
T_6	Tapioca, *Manihot esculenta (*L.)
T_7	Groundnut, *Arachis hypogaea* (L.)
T_8	Sweet potato, *Ipomoea batatas* (L.)

Biology of *S litura* on different hosts

The experiment was started with neonate larvae, (0-12 hour old) obtained from the nucleus culture. Respective hosts were collected from nearby area. The newly hatched larvae were released in individual glass bottles (18 cm height and 9 cm diameter) containing fresh leaves of castor, cow pea, mulberry, okra, taro, groundnut, sweet potato and tapioca. Uneaten leaves and faces were cleaned from the bottles daily. Fresh leaves of all food plants were given to larvae at 24 hours. During the experimental period the average room temperature was 27 ± 3°C and the relative humidity was 70 ± 5 percent. Each glass bottle was examined for recording of the following observations.

Observations recorded

Total larval period

Time taken from hatching to the formation of pre-pupa was taken as total larval period.

Larval weight

The weights of the last instar larvae were recorded with the help of electronic balance.

Larval survival

The number of larvae which successfully pupated provided the data on larval survival on each host plant

Pupal stage

The observations were recorded on pupal stage of the *S. litura* as under.

Pre-pupal period

Pre-pupal stage was characterized by the larva becoming sluggish, decreased in size and further feeding ceased, soon the body contracted longitudinally and insect became motionless. The observation of the pre-pupal stage was recorded based on the above symptoms of the larvae. Period taken from the formation of pre-pupa to pupa was considered as pre-pupal period.

Weight of pupa

The weight of pupa from respective treatment was recorded with the help of electronic balance.

Pupal success

The number of pre-pupae, which were formed at the end of larval stage and successfully entering the pupal stage, were recorded and expressed as percent pupal success.

Pupal period

The pupal period was calculated from the date of formation of the pupa to the date of emergence of adults. The pupae formed were transferred to another set of bottles for recording of the pupal period.

Adult stage

The male and female adults emerged from the respective hosts on the same day were paired by releasing them in mating chambers. 10 percent honey solution was provided as food.

Adult weight

The weight of adult emerged from each host was recorded with the help of electronic balance.

Adult longevity
The interval between the emergence of the adults and its death was taken as the adult longevity.

Percentage adult emergence
The number of adults emerged from the pupae were converted in percent to obtain the data on percentage adult emergence.

Sex ratio
The adults were sorted out to record the male and female individuals. To work out this, pupae from the culture on different hosts were observed for the emergence of adults.

Results and Discussion

Comparative biology of *S. litura* on different host plants

Total larval period
The larvae were observed for larval period on different host plants, the data are presented in Table 1. Data indicated that the mean larval period of *S. litura* was significantly maximum on tapioca (17.33d) followed by cowpea (15.67d) and mulberry (14.67d) which were at par. Further, mulberry was at par with okra (14.33d), groundnut (14.33d) and taro (13.67d) which also were further at par with sweet potato (13.33d). The mean larval period was significantly the lowest on castor leaves (11.67d) than all other hosts tested.
The larval period was longest on tapioca (17.33 d) and shortest on castor (11.67d). These variations may be due to either the variability of nutritional quality and quantity of the host plants consumed by the larvae. The differences in the larval period of *S. litura* feeding on host plants have been reported by many researchers. Das (1985) reported the mean larval period of *Spodoptera* on sweet potato (13.67d), cabbage (15.47d) and groundnut (17.73d) leaves. Farahani *et al.* (2011) [7] recorded the larval period of beet armyworm on different hosts like cotton (15.50d), maize (14.91d) and on soybean (13.10d). Yadav *et al.* (2014) [25] also recorded the larval period of *S. litura* to the tune of 17.33 and 17.03 days on castor and okra, respectively. Thus, the present findings are also in close accordance with these workers.

Pre-pupal Period
Data on pre-pupal period are given in Table 1. It was noticed that, the pre-pupal period ranged from 2 to 3 days. Mean pre-pupal period recorded was maximum on tapioca (3.00d) and minimum on castor leaves (2.00d).
These results are in close accordance with the results of Kaur (2011) [11] who reported pre-pupal period of *S. litura* on different cabbage cultivars like, pride of India (2.89d), KGMR-1 (2.78d), golden acre (2.32d) and pusa mukta (2.26d).

Pupal Period
Observations recorded on the pupal period are presented in Table 1. It indicated that the pupal period of *S. litura* was maximum on tapioca (11.67d) followed by mulberry (11.33d) which was at par with each other. While, remaining hosts to follow were okra (8.67d), taro (8.33d), groundnut (8.33d), cowpea (7.67d), castor (7.33d) and sweet potato (7.33d).
These results indicated that, the most suitable host plants for overall larval-pupal development were found to be castor and sweet potato while, tapioca and mulberry were found less suitable for larval-pupal development. These results on pupal duration was little similar with previous study reported by Bhalani (1989) [4] who observed a shortest pupal period on castor (8.05d) and green gram (8.38d) and the longest (9.05 days) on cotton. Kumar (1992) [12] observed the variation in pupal period from 7.47 to 9.74 days on *arvi*, 7.49 to 12.26 days on sunflower, 7.84 to 13.6 days on cotton and 7.18 to 25.56 days on cauliflower.

Pupal Weight
Weights of the pupae from the larvae fed on different host plants were recorded. Data are presented in Table 1. The castor leaves supported the higher pupal weight (0.28g) among all the hosts and was at par with groundnut (0.27 g). Further, groundnut was found at par with taro, tapioca, and mulberry all with 0.24g pupal weight and were further at par with okra and sweet potato (0.23g each). The mean pupal weight was significantly the lowest on cowpea *i.e.* 0.19g.
These results indicated that pupal weight was affected by host plants which might have differences in quality and quantity of nutrition. Also, they may be different in primary and secondary alkaloids. Earlier, references revealed that pupal weights of *S. litura* varied on different host plants. Sudhakar *et al.* (1993) [22] recorded pupal weights of *S. litura* as 0.40, 0.34, 0.34 and 0.20g on castor, green gram, and cotton, respectively. Bayu and Krishnawati (2016) [3] reported the pupal weights of *S. litura* on soybean (0.32g), castor (0.33g) and water spinach (0.35g).

Percentage of Pupal Success
Pupal success was indicated by number of larvae pupated from the total larvae reared. The data on pupal success are presented in Table 1. The maximum pupal success of 86.67 percent was observed in larvae fed on castor followed by mulberry 83.33 percent and both were at par. These were followed by cowpea (70.00%) and taro (66.67%) which were also at par with each other. Further taro was at par with sweet potato (60.33%) which further was at par with groundnut (60.00%), while groundnut was at par with okra (56.67%). Pupal success was significantly lowest on tapioca leaves (46.67%).
The present results are also somewhat comparable with the earlier results. Higher pupal success may be contributed with maximum host plants feeding and its utilization as indicated in ECI and ECD presented in Table 1 of digestibility indices aspect. Kumar (1992) [12] recorded pupal survival of *S. litura* to be 81.82, 86.36, 80.95, and 91.30 percent on *arvi* sunflower, cotton and cauliflower, respectively. Xue *et al.* (2010) [24] also reported high pupal success of *S. litura* 91.40 to 95.90 percent on different host plants *viz.*, tobacco, Chinese cabbage, cow pea, and potato.

Adult weight
Weight of adults emerged from larvae fed on different host plants were recorded and presented in Table 1. Highest adult weight was found on tapioca leaves (0.20g) which was at par with groundnut (0.18g) which further was at par with castor (0.17g) and castor was at par with taro (0.15g). Further taro, okra (0.14g) and sweet potato (0.14g) were also found at par. Mulberry and cowpea recorded the lowest adult weights (0.08g each) and remained at par.
Hwang *et al.* (2008) [10] reported adult weight of *S. litura* on cabbage and on cauliflower to be 0.72g and 0.68g, respectively. Present finding are also in line with the above even though the weight of the adults were low as compared to above ones.

Adult Success

The observations recorded on adult success are presented in Table 1. Adult success ranged between 35 and 73.81 percent. The larvae fed on sweet potato leaves supported highest adult success *i.e.* 73.81 percent which was at par with taro (69.54%), castor (68.33%) and okra (65.33%). Cow pea (52.38%) and mulberry (42.59%) were found at par with each other. Further, mulberry was at par with groundnut (39.33%) and tapioca (35.00%). The lowest adult success was observed on tapioca (35.00%).

The present results are in line with findings of Yadav *et al.* (2014) [25] who also reported adult success of *S. litura* on cauliflower (74.66%), castor (62.66%) and okra (61.33%). Naik *et al.* (2017) [15] also reported highest adult emergence of *S. litura* on vegetable soybean (75.00%) and lowest on grain soybean (68.00%).

Adult Longevity

The longevity of adults obtained from larvae reared on different hosts varied from 5.33 to 7.67 days. Maximum adult longevity (7.67d) was observed on castor and sweet potato. Okra and taro (7.33d each) both were at par with each other. Next adult longevity was recorded on cow pea (6.33d) which was at par with groundnut (6.00d) and mulberry (5.67d). Minimum adult longevity was recorded on tapioca (5.33d).

Soni *et al.* (2001) [21] recorded maximum longevity of female and male moth on cabbage as 8.20 and 7.0 days, respectively. Whereas a minimum of 6.09 and 5.60 days was observed on castor. Shahout *et al.* (2011) [17] recorded adult longevity of *S. litura* on sweet potato (6.92d) and cow pea (5.64d). Thus, present findings are also in line with the above results.

Total Life Cycle

The total developmental period from hatching of larvae to emergence of adults was significantly longer on tapioca (37.00d) followed by mulberry (34.33d). Remaining host to follow were okra (32.67d), cow pea (32.00d), taro (31.67d), groundnut (31.33d) and sweet potato (30.67d). However, it was found to be shorter on castor (28.33d). These results indicated that, the unusual food quality of tapioca for *S. litura* might required prolong feeding relative to other hosts such as castor and sweet potato and hence might have longer total developmental period.

Sharma (1994) [18] reported that the total developmental period of *S. litura* was 32.67 days on germinating seeds of soybean and 43.72 days on linseed. Farahani *et al.* (2015) [7] reported the total developmental period of *S. exigua* on maize (38.93d), cotton (39.54d) and soybean (35.84d). The present findings are also supported by above research work.

Fecundity

Fecundity of females emerged from different hosts were recorded and presented in Table 1. Highest fecundity was recorded on castor (3074.00 eggs) which was significantly superior to other hosts. This was followed by sweet potato (2618.00 eggs) and taro (2556.00 eggs) which were at par with each other while in case of okra female laid 2040.00 eggs. Further, mulberry (1112.00 eggs) and groundnut (999.67 eggs) were found at par with each other. Also, groundnut was at par with cow pea (967.67 eggs). Significantly the lowest fecundity was observed on tapioca (622.00 eggs).

These results indicated that fecundity of female was affected by different host plants. Thomas and Bilapate (2007) [23] reported that fecundity of *S. litura* on KBSH–1 and on LS–11 cultivars of sunflower was 4586 and 3163.30 eggs, respectively. Xue *et al* (2010) [24] recorded number of eggs of *S. litura* female per egg mass to the tune of 283.5 on Chinese cabbage, 282.1 on sweet potato, 224.9 on cowpea and 233.6 on tobacco. Thus, present findings are also comparable with the earlier research work.

Sex Ratio

The sex ratio was also female biased and more female adults emerged when their larvae were fed with different host plants recorded in Table 1. Out of the eight hosts, male biased ratio was only observed on cow pea (1:1.2).

The present findings are in close proximity to the earlier findings of Xue *et al.* (2010) [24] who observed sex ratio of *S. litura* on chinese cabbage 1:0.6, cow pea 1:0.7 and sweet potato 1:0.7. However, Kour (2011) [11] reported sex ratio (female: male) of *S. litura* as 1.22:1 on Pride of India and Pusa Drum Head, 1.35:1 on KGMR-1, 1.50:1 on Golden Acre, 1.86:1 on Pusa Mukta.

Conclusion

From the present studies, the comparative biology of *Spodoptera litura* (Fab.) is important for to know the best host that support the development of *S. litura* and can be used for mass rearing of *S. litura*. Similarly, the information of life history parameters of *S. litura* on different host plant species will help to make efficient strategies to control this economic pest. The comparative biology of *S. litura* on different hosts inferred that, the minimum larval development period of 11.67 days was noticed on castor, whereas, it was maximum (17.33 days) on tapioca. The minimum pre-pupal (2.00 days) and pupal period (7.33 days) were recorded on castor, while it was maximum (3.00 days pre-pupal and 11.67 days pupal period) on tapioca host. The pupal weight was maximum on castor *i.e*. 0.28 g and minimum on cowpea (0.19g). The maximum pupal success of 86.67 percent was observed in larvae fed on castor, whereas, it was significantly lowest on tapioca leaves (46.67%). Highest adult weight was found on tapioca leaves (0.20g) followed by groundnut (0.18g) and the lowest adult weights were recorded on Mulberry and cowpea (0.08g each). Among the eight hosts the adult longevity was recorded maximum on castor and sweet potato *i.e.*7.67 day's each and minimum on tapioca (5.33days). The larvae fed on sweet potato leaves supported highest adult success *i.e.* 73.81 percent and lowest mean adult success was observed on tapioca (35.00%). The total development period was significantly highest on tapioca (37.00 days) and it was found to be minimum on castor (28.33 days). The maximum mean fecundity was 3074.00 eggs per female on castor host, whereas, minimum with 622.00 eggs per female on tapioca host. The sex ratio of female to male was observed as 1:0.7, 1:05, 1:0.6, 1:08, 1:06, 1:05 and 1:07 on castor, mulberry, okra, sweet potato, taro, groundnut and tapioca, respectively. The male biased ratio was only observed on cowpea (1:1.2).

Table 1: Biology of *Spodoptera litura* (F.) on different host plants.

Host plants	Larval period (days)	Pre-pupal period (days)	Pupal period (days)	Pupal weight (gm)	Pupal success (%)	Adult weight (gm)	Adult longevity (days)	Adult success (%)	Life span (days)	Fecundity	Sex ratio (F:M)
Castor	11.67	2.00	7.33	0.28	86.67 (68.86)*	0.17	7.67	68.33 (56.33)	28.33	3074.00 (56.44)#	1:0.7
Cowpea	15.67	2.33	7.67	0.19	70.00 (56.79)	0.08	6.33	52.38 (46.37)	32.00	967.67 (31.12)	1:1.2
Mulberry	14.67	2.67	11.33	0.24	83.33 (66.14)	0.09	5.67	42.59 (40.59)	34.33	1112.00 (33.33)	1:05
Okra	14.33	2.33	8.67	0.23	56.67 (48.85)	0.14	7.33	65.33 (54.26)	32.67	2040.00 (45.16)	1:06
Sweet potato	13.33	2.33	7.33	0.23	63.3 (52.78)	0.14		73.81 (71.20)	30.67	2618.00 (51.13)	1:08
Taro	13.67	2.33	8.33	0.24	66.67 (54.74)	0.15	7.33	69.54 (56.74)	31.67	2556.00 (50.51)	1:06
Groundnut	14.33	2.67	8.33	0.27	60.00 (50.85)	0.18	6.00	39.33 (38.73)	31.33	999.67 (31.61)	1:05
Tapioca	17.33	3.00	11.67	0.24	46.67 (43.08)	0.20	5.33	35.00 (36.15)	37.00	622.00 (24.90)	1:07
S.E±	0.39	0.29	0.39	0.01	2.17	0.01	0.31	4.07	0.54	1.18	-
CD (5%)	1.17	0.87	1.17	0.03	6.49	0.02	0.93	12.15	1.62	3.58	-

*Figures in parenthesis are arcsine values

#Figures in parenthesis are $\sqrt{n+1}$ values.

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