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Biology of turnip moth, *Agrotis segetum* (Denis and Schiffermuller) on palak, *Beta vulgaris* var. *bengalensis* Hort.

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Abstract
The biology of turnip moth was studied on palak at UHS, College of Horticulture, Bagalkot. Duration from egg to adult emergence occupied 35.66 to 44 days. The moths laid eggs in groups on ventral surface of the tender leaves and the average fecundity was 250 ± 80.43. Incubation period was 3.5 ± 0.50 (3-5) days, the newly hatched larva was pale green colour with black head. The total larval period was 16.3± 3.92 (13 - 18) days. The grown up caterpillars pupated inside the webs and puapl period was 7-9 days. The moths lived for 7.0±1.08 (6- 9) days.

Keywords: Biology, palak, *Agrotis segetum* (Denis and Schiffermuller)

Introduction
Palak is one of the most common leafy vegetables of tropical and subtropical region. It is botanically called as *Beta vulgaris* var. *bengalensis* Hort. of the family Chenopodiaceae. It is a rich and cheap source of Vitamin A as compared to spinach and carrot. It contains high quantity of ascorbic acid and iron. A 100 g of leaves supply, as much as essential amino acids as 100 g of any non- vegetarian foods like meat and fish [11] and micronutrients [9]. The herbaceous parts of palak are mildly laxative besides other medicinal values. Palak is prone to attack by 37 insect pests of which turnip moth is the most serious, causing 24.50 per cent foliage loss [10]. Thus, Turnip moth, *Agrotis segetum* (Denis and Schiffermuller) has become an important pest on palak and considered to be the most serious pest of leafy vegetables as it occurs throughout the year and causes serious damage to the crop. The studies related to biology of the turnip moth are available on potato [2] and on turnip [7] but not on palak. Hence, the biology of the insect was studied in palak to know the weak links in its life cycle for devising the management strategies

Materials and Methods
The biology of turnip moth was carried out in the Department of Entomology, College of Horticulture, UHS, Bagalkot during 2014 under laboratory conditions. The weather parameters *viz.*, room temperature and relative humidity were recorded daily during the study period of April to May, 2014. The methodology followed by [8] for rearing tobacco caterpillar, *Spodoptera litura* (Fabricius) on castor, cabbage, cauliflower and potato and [12] for jatropa leaf webber was adopted for rearing turnip moth on palak.

Development and maintenance of stock culture
The culture of leaf eating caterpillar was developed by collecting the late instar larvae from palak field and rearing them in under those cages laboratory conditions. The culture was maintained in plastic cages of 28 cm x 21 cm x 12 cm and covered with muslin cloth held with the help of string. Once the larvae pupated, such pupae were collected and were kept in separate cages. The pupae were sexed based on presence of slit on either eighth or ninth abdominal sternite and used for further biological studies. Immediately after emergence five pairs of moths that emerged on the same day were enclosed separately in rearing cages for oviposition. A cotton swab dipped in ten per cent honey solution was provided as food for moths and tender shoots were also provided for oviposition. The tender leaves containing eggs laid on the same day were transferred to petriplates of size 20 cm x 5 cm which were sterilized with 4 per cent formalin.

On hatching, the larvae were transferred with the help of a soft camel hair brush to tender leaves. The food was changed whenever necessary.

Fecundity and incubation period

The numbers of eggs laid by a single female were counted and average was recorded as fecundity. Fifty eggs laid by a single moth on the tender leaves were placed in the petriplates of size 20 cm x 5 cm which were earlier sterilized with 4 per cent formalin. Duration from the day of egg laying to the day of hatching formed the incubation period.

Larva

Out of 50 larvae, twenty freshly hatched larvae were picked up with the help of a soft camel hair brush, transferred to the tender palak leaves kept on wet filter paper in clean petriplates of 20 cm x 5 cm separately for observation on instars. Food used for rearing was changed twice a day. Observations were made twice a day for possible moulting which was indicated by the presence of head capsule. From this, the number of instars passed through by the larva in the course of its development was determined. General morphological features associated with different stadia of larva were recorded. The grown up caterpillar were transferred to the plastic trays and given palak leaves.

Pupa

The grown up larvae pupated either on leaf debris in the petri plates. After pupation, twenty pupae were carefully separated from the leaf and placed in clean cages. They were kept individually till moth emergence to know the pupal period. When adult emergence commenced, the time of emergence was recorded.

Adult

The moths that emerged on the same day were allowed to pair by enclosing a pair each in five rearing cages separately provided with cotton swab dipped in ten per cent honey solution as adult food. Tender palak leaves were wrapped in wet cotton provided as oviposition substratum for studying the pre- oviposition, oviposition, fecundity periods and adult longevity. Leaves were changed daily with fresh ones after counting the eggs laid if any. The eggs laid on tender leaves were collected daily until both the individuals died and were maintained separately for further observations.

Results and Discussion

Egg

The freshly laid eggs were spherical shape (0.5-0.6 mm in diameter) and costate surface, colour was white and later turned to reddish pattern. Eggs were laid either in groups or singly on ventral surface of the tender leaves (Plate 1). Oviposition was observed during the late evening hours 6.30 pm onwards. Similar oviposition pattern was observed by [4, 3] [1]. The average incubation period was 3.5 ± 0.70 (3-5 days) (Table 1). Similarly, [12] oviposition pattern was observed by [13] and [3] reported incubation period in *Agrotis* species ranging from 3 to 6 days. But [1] reported the incubation period in *Agrotis* species ranging from 5 to 11 days. The difference may be due to difference in the species and host plant.

Larva

The larval eclosion took place either during morning hours (6.30 am) or evening hours (7.00 pm). On the same day the larvae started moving all over the cage in the laboratory in search of food. Once the larvae reached the food, they started feeding by scraping the leaf surface and later instars fed on the entire leaves (Plate 2). The larvae moulted on the surface of leaf. There were five larval instars and the total larval period occupied 16.3± 3.92 (13 -18) days (Table 1).

Plate 1: Egg mass

Plate 2: Hatching of larvae from the egg mass

Plate 3: First instar larvae

Plate 4: Second instar larvae

Larva developed through five instars undergoing four moults. Which was in conformity with earlier report of [2] on potato contrary to this, [3] observed six instars but on maize.

First instar

The newly hatched larva was pale green in colour. The head capsule was black in colour (Plate 2 & 3). On an average, the first instar occupied 2 days (Table 1).

Second instar
The newly hatched second instar larva was also pale green in colour (Plate 4). On an average, second instar occupied the duration of 2.6±0.48 (2-3 days) (Table 1).

Third instar
The third instar larva was green to grey. The head capsule was black (Plate 5). The third instar larva on an average occupied 3.8 ± 0.51 (3-4) days (Table 1).

Fourth instar
The larva was dark green to grey with black head capsule (Plate 5). The average duration of fourth instar larva was 4.0 ± 0.47 (3-5) days (Table 1).

Fifth instar
Larva was glossy dark-gray with dark stripes extending along dorsal and lateral sides with black head capsule (Plate 5). The duration occupied by fifth instar was 3.9 ± 0.39 (3-4 days) (Table 1). The grown up larva measured (40-50 mm) and head capsule measured (6.5 - 2.3 mm).
The first larval instar duration was 2 days, the second instar lasted for 2.3±0.48 days, third instar occupied 3.34±0.51 days, fourth instar occupied 4.00±0.47 days and the fifth instar lasted for the 3.9±0.31 days during the present study. [3] reported the duration of 6.0, 5.0, 4.6, 4.3, 5.6 and 5 days, respectively for first to sixth instars, in the case *A. ipsilon*. The variations may be due to differences in the species, geographical area, climatic conditions and host of the insect on which it fed.

Prepupa
The fully grown larva became sluggish and stopped feeding. The colour of larva turned to brownish to red-brown. Body length was 16 to 20 mm. As soon as it stopped feeding gradually shrunk in size and remained straight with the legs stretched forward. It started to construct pupa by using the bits of leaves remained after feeding faecal pellets (Plate 5). The prepupal duration was 1.3±0.61 (1-2) days during April to May (Table 1). These observations are more or less in agreement with the results of [2] who reported prepupal duration of 2 to 3 days.

Pupa
The exuvium and head capsule of last larval instar remained intact with pupal case constructed by the last instar larva. The pupa was obtect type; the freshly formed pupa was brown in colour and later turned to deep reddish brown colour just before adult emergence (Plate 5, 6 & 7). The pupa measured 19 to 20 mm width. In the case of female pupa, the genital opening was slit like and was situated on the posterior margin of the eighth abdominal sternite and in the case of male pupa the genital opening was located on the posterior margin of ninth abdominal sternite just in front of the ninth and tenth abdominal sternite. The duration of the pupal period was 7-9 (7.8 ± 1.80) days (Table 1). According to [2] pupal period was slightly more i.e, for 12 to 15 days and the pupa was obtect type, brown in colour when freshly formed and later turned to deep brown in colour. The slight variation was observed in the pupal duration which may be due to the variation in day length, temperature and relative humidity.

Adult
Emergence
Emergence of adult from the pupal case was noticed during evening hours (6.30 to 7.30 pm). The adult moth was medium sized and uniformly grey in colour. The body length was 18 to 20 mm with 34-45 mm wingspan. The forewings were brown with a small white streak at the inner area of the base and hind wings white in colour with broad black marginal band narrowing towards anal side. Thorax was black and abdomen was brownish elongated and tapering posteriorly (Plate 8). Adults were ready for copulation a day after emergence. Copulation was noticed in the evening hours (6 - 7 pm). The oviposition was observed after two to three days of mating and continued up to 5 days. The moths laid eggs during night hours.

Plate 5: Different stages of *Agrotis segetum*

Plate 6: Pupae

Plate 7: Adults emergence from the pupae

Plate 8: Adults

Oviposition

Five pairs of moths were released separately for oviposition studies. The moths laid eggs during late evening and night hours. The eggs were laid singly as well as in clusters on under surface of the tender leaves of palak. The oviposition period was 4.2 ±0.63 (3-5) days (Table 1).

Fecundity and hatching

Total number of eggs laid by a female varied from 165 to 331 (250 ± 80.43). Egg hatching took place on different days (first day 73.68 ± 13.98, second day 15.04 ±1.18, third day 1.16 ±2.72and fourth day 0.66 ±1.04) and total per cent hatching was 90.54 ± 5.09 (Table 1). [3] opined that the female may deposit 1200 to 1900 eggs. Each female laid 200 to 2000 eggs depending on the local climatic conditions [6, 1] observed that the moth laid eggs singly or in clusters ranging from 600 to 800 eggs. The variation in the fecundity of the adult may be due to the prevailing weather conditions and host of the insect. Similar temperature dependent variation in the fecundity of the lady bird beetle *Micraspis discolors* (Fabricius) was reported by [5] the percentage of egg hatching in the present study was 94.59.

Sex ratio and adult longevity

The percentage of female to male ratio was (1.08: 1.0). The longevity of the adult was 7.5±1.80 days with food (10% honey solution) (Table 1). [13, 1] reported the imago life span of 5 to 25 days. The variation may be attributed to the differences in the climatic factors and nutritional status of the food provided. High temperature and low relative humidity prevailed during the present study.

Table 1: Duration of different stages of *Agrotis segetum* on Palak under laboratory conditions

Incubation period	Larval instars (Days)					Total larval period (Days)	Prepupal period (Days)	Pupal Period (Days)	Sex ratio
	I	II	III	IV	V				
3.5 ± 0.50 (3-5 days)	2± 00 (2)	2.6±0.48 (2-3)	3.8 ± 0.51 (3-4)	4.0-0.47 (3-5)	3.9 ± 0.39 (3-4)	16.3± 3.92 (13-18)	1.3±0.61 (1-2)	7.8± 1.80 (7-9)	1.08:1
Adult longevity (Days)	**Pre oviposition**	**Oviposition period**	**Post oviposition**	**Fecundity**	**Egg hatching percentage (Days)**				**Total percent of hatching**
					I	II	III	IV	
7.0±1.08 (6- 9 days)	1.6 ± 0.54 (1-2 days)	4.2±0.63 (3-5 days)	1.2 ±0.7 (1-2 days)	250 ± 80.43	73.68±13.98	15.04±1.18	1.16 ±2.72	0.66 ±1.04	90.54 ±5.09

Figures in parentheses are range values,
± indicates standard deviation
Mean temperature and relative humidity recorded during April- May was 32.8° C and 56 %.

4. Conclusion

The turnip moth is an important pest of palak. For effective management of this pest, the detailed biology is required. Hence, the studies on biology of turnip moth were undertaken under laboratory conditions using its natural host palak. The total life cycle occupied 35.66 to 44 days. The average fecundity was 250 eggs. The eggs hatched in 3 to 5 days. The larvae took 13 to 18 days to pupate and the adults emerged in 7 to 9 days. The moths lived for 6 to 9 days.

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