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Study on biology and physical measurements of shoot borer, *Leucinodes orbonalis* (Guenee) on the potato, *Solanum tuberosum* (L.) during *kharif* and *rabi* season

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Abstract
The present investigation on biology of shoot borer, *Leucinodes orbonalis* Guenee on potato during both the seasons (*kharif* 2016 and *rabi* 2016-17) revealed that the average pre-oviposition period was 1.40 ± 0.52 and 1.42 ± 0.28 days, oviposition period 2.57 ± 0.18 and 2.77 ± 0.20 days, fecundity 157.30 ± 9.71 and 79.80 ± 29.51 eggs, incubation period 3.95 ± 0.54 and4.74 ± 0.39 days, total larval period 14.96 ± 0.52 and 17.03 ± 0.76 days and pre-pupal period 1.45 ± 0.09 and 1.63 ± 0.15 days, respectively. The freshly formed pupa was pinkish in colour which later turned dark brown, elongate oval in shape and had a pair of spiracles on each abdominal segment. The pupal period ranged from 7.08 to 8.08 days with an average of 7.47 ± 0.43 days during *kharif* 2016 and 9.16 to 10.87 days with an average of 9.96 ± 0.61 days during *rabi* 2016-17. The average longevity of male was 3.32 ± 0.22 and 4.03 ± 0.67 days while that of female was 4.58 ± 0.16 days and 5.41 ± 0.33 days, respectively during *kharif* and *rabi* seasons. The total life cycle of the shoot borer on potato (egg to adult emergence) occupied 29.72 to 32.92 days with a mean of 31.79 ± 1.16 days during *kharif* 2016 and 35.05 to 39.67 days with an average of 37.52 ± 1.44 days during *rabi* 2016-17.

Keywords: biology, potato and *Leucinodes orbonalis*

1. Introduction
Potato (*Solanum tuberosum* L.) is an annual vegetable crop which belongs to the family Solanaceaea and is widely grown in many countries for its starchy edible tubers. They are believed to be originated in the Peru-Bolivian region of South America. In 17th century, it was introduced to India by the Portuguese from Europe (Pal and Pushkarnath, 1951) [12]. In many parts of the world, potatoes are the staple food. Inspite of being a major source of carbohydrates, it also provides fiber, vitamins, minerals, and phytochemicals which are known to benefit human health. In India, potato is grown in an area of 20.85 lakh ha with production of 480.96 lakh metric tonnes and productivity of 23.07 t/ha (Anon., 2016a) [4]. The states *viz*., Uttar Pradesh, West Bengal, Punjab, Bihar and Gujarat holds a share of about 80 per cent of the total potato production in North India. In Karnataka, the potato crop is cultivated over an area of 38,126 hectares with an annual production of 2, 25,285 tonnes and a productivity of 6220 kg ha^{-1} during 2015-16. The major potato growing districts of Karnataka included Hassan (18,671 ha), Belagavi (4802 ha), Kolar (3648 ha), Dharwad (1160 ha) and Bengaluru- Rural (488 ha) (Anon., 2016) [3]. According to (Simpson, 1977) [16], the potato crop is attacked by over 100 pests of which, 80 have been reported from India (Anon., 1971; Saxena and Rizvi, 1974; Rataul and Misra, 1979; Saxena and Misra, 1983) [2, 15, 13, 14].
The lepidopteran pest *Leucinodes orbonalis* Guenee is basically a major pest of brinjal and is commonly known as brinjal fruit and shoot borer. However, it is also known to cause damage to potato shoots and such reports have been made in many places of India. In Karnataka, this pest incidence was reported as early as 1965 (Nair, 1967) [10]. (Hill, 1993) [6] reported that these lepidopteran pests feed on the foliage of potato in Africa and South Asia.
The larva of *L. orbonalis* attacks the shoots of potato causing withering and wilting of the stem ultimately resulting in retardation of the plant growth (Mishra and Chand, 1976) [9]. The shoot damage of 41.87 per cent with yield reduction of 2.25 t/ha was noticed in potato (Niranjanamurthy, 2001) [11]. So far no systematic studies has been done with respect to *L. orbonalis* biology on potato as it is important to know the life cycle of an insect so that control

mechanisms may be incorporated at the most susceptible stage of the life cycle. Therefore, a study was conducted under laboratory conditions and the findings of the present study would help in managing this pest.

2. Materials and Methods

Potato plants were used as host throughout the study period. Studies on the biology of the insect was carried out under laboratory conditions at Department of Agricultural Entomology, College of Agriculture, University of Agricultural Sciences, Dharwad during *kharif* 2016 and *rabi* 2016-17 at 25±5ºC temperature and 75±5 per cent relative humidity as per the techniques adopted by Wankhede *et al*. (2009) [19] with slight modifications.

In order to study the biology of *L. orbonalis*, their larvae were collected in large numbers from Hangaraki village of Dharwad district which were brought to laboratory and reared in a plastic tub covered with muslin cloth. These larvae were fed with slices of fresh twigs of potato plant daily. Once the larval development was complete and the cocoons of fresh pupae were formed, they were transferred to petridishes for adult emergence. This was carried out daily as and when the new cocoons were formed. On emergence of adults, one pair of newly emerged male and female moths was released in a rearing apparatus. Within this apparatus, a fresh potato twig with 3 to 4 leaves was kept in a conical flask containing water for egg laying purpose. This was also replaced daily. The food source for adult moths were the two cotton swabs soaked in 10 per cent glucose solution placed in the rearing apparatus. On noticing egg laying on the twigs provided, these eggs were removed with a fine camel hair brush and transferred into clean petridishes with blotting paper as base material. Further, a binocular microscope was used to record the observations on the duration of different stages *viz*., egg, larvae, pupa and adult.

Ten moth pairs were selected to study each of the biology parameters and the average was worked out. Initially, the pre-oviposition and oviposition periods were recorded for these ten moth pairs and further were observed daily for the number of eggs laid in order to work out the fecundity. The total number of eggs laid by each female in its life time was recorded and average fecundity was calculated. Among the eggs laid by each female, ten each were transferred to ten different petriplates (10 x 2 cm) separately using a moist camel hair brush. These petriplates were observed for recording the emergence of larvae and the average incubation period was worked out. Further, the larval length and breadth was measured using a micrometer. The larvae hatched in each of the petriplate were transferred separately to ten different petriplates with a moist camel hair brush and were provided with fresh potato twigs daily. These were observed daily for the presence of exuviae of larvae, from which the duration of larval instar was noted in days. Subsequently, the length and breadth of each larval instar was measured with the help of a microscale. Five such instars were noted and the duration of each instar was recorded. The average duration of each instar and total larval period was worked out. The period from which larvae ceased feeding till it got fixed was considered as pre-pupal period. In this way, ten larvae were observed for recording the pre-pupal period which were further observed for pupal development in order to calculate the pupal period. Further, the length and breadth of pupae were also measured. Each pupa was observed until adult emergence and then, ten newly emerged adult pairs were used for recording adult longevity. The longevity of male and female adults in each pair was recorded along with length and breadth and average of such ten individuals. Finally, the total developmental period from egg laying to adult emergence was worked out by combining all the data obtained from incubation period to pupal period.

3. Results and Discussion

The pre-oviposition period, oviposition period and fecundity range on potato were found 1.00 to 2.00 days, 2.41 to 2.92 days and 140 to 170 eggs, respectively with an average of 1.40 ± 0.52 days, 2.57 ± 0.18 days and 157.30 ± 9.71 eggs, the length and breadth of eggs varied from 0.73 to 0.85 mm and 0.56 to 0.62 mm with an average of 0.80 ± 0.04 mm and 0.58 ± 0.02 mm, respectively during *kharif* 2016. Similarly during *rabi* 2016-17, the pre-oviposition period ranged from 1.00 to 1.83 days with a mean of 1.42 ± 0.28 days and the oviposition period ranged from 2.54 to 3.12 days with an average of 2.77 ± 0.20 days and the fecundity ranged from 72 to 100 with a mean of 79.80 ± 29.51 eggs, the length and breadth of eggs varied from 0.81 to 0.90 mm and 0.42 to 0.63 mm with an average of 0.85 ± 0.03 mm and 0.52 ± 0.07 mm, respectively (Table 1 and 2). Mannan *et al*., 2015 [8] reported that the pre-oviposition period, oviposition period and fecundity range on potato were found 1.08 to 1.21 days, 1.00 to 4.00 days and 100 to 281 eggs, respectively. These investigations are also in agreement with Yadav *et al*. (2015) [20] whose study on biology of *L. orbonalis* on brinjal revealed that, the average pre-oviposition period recorded was 1.293 ± 0.071 and 1.334 ± 0.060 days, oviposition period 2.223 ± 0.103 and 2.192 ± 0.099, fecundity 170.13 ± 0.945 and 170.90 ± 1.823 eggs/female during 2009 and 2010 at 35 ºC temperature and 90 per cent relative humidity. The present findings slightly differ with that of Boopal *et al*. 2013 [5] who reported that fecundity range of *L. orbonalis* reared on potato varied from 341 to 368 eggs. This might be due to change in the temperature and relative humidity during the course of study.

Freshly laid eggs of *L. orbonalis* were elongated and oval in shape and creamy white in colour. As incubation period advanced, the eggs turned to deep orange with a prominent black spot at the tip of the egg which was the developing head of the larva. The incubation period varied from 3.29 to 5.08 days with an average of 3.95 ± 0.54 and 4.16 to 5.20 days with an average of 4.74 ± 0.39 days during *kharif* 2016 and *rabi* 2016-17, respectively. Srinivasan and Sundarbabu (1998) [18] recorded 3.47 days incubation period. The findings are also in conformity with the observations of Allam *et al*., 1982 [1] and Yadav *et al*. (2015) [20].

The larvae developed through five instars. The first, second, third, fourth and fifth instars lasted from 2.16 to 2.83 days with a mean of 2.48 ± 0.20 days and 2.54 to 3.00 days with an average of 2.74 ± 0.17 days, 2.50 to 3.12 days (2.70 ± 0.16 days) and 2.83 to 3.41 days (3.12 ± 0.24 days), 2.75 to 3.54 days (3.13 ± 0.28 days) and 2.92 to 3.79 days (3.39 ± 0.30 days), 3.33 to 3.83 days (3.60 ± 0.17 days) and 3.54 to 4.00 days (3.81 ± 0.14 days) and 2.92 to 3.42 days (3.06 ± 0.23 days) and 3.20 to 4.42 days (3.98 ± 0.43 days) respectively, during *kharif* 2016 and *rabi* 2016-17. The full grown larva was cylindrical in shape and pinkish brown in colour with length and width varying from 18.56 to 20.78 mm and 3.12 to 3.65 mm with an average of 19.47 ± 0.84 mm and 3.38 ± 0.19 mm, respectively during *kharif* 2016. During *rabi* 2016-17, the length and width of fifth instar larvae varied from16.42 to

19 mm and 3.42 to 4.00 mm with an average of 17.55 ± 0.82 mm and 3.72 ± 0.20 mm. respectively.

Table 1: Biological study of shoot borer, *Leucinodes orbonalis* on potato during *kharif* 2016 and *rabi* 2016-17

Sl. No	Life Stages	Duration (days)			
		Kharif 2016		*Rabi* 2016-17	
		Range	Mean ± SD	Range	Mean ± SD
1	Pre-oviposition period in days	1.00 - 2.00	1.40 ± 0.52	1.00 - 1.83	1.42 ± 0.28
2	Oviposition period in days	2.41 - 2.92	2.57 ± 0.18	2.54 - 3.12	2.77 ± 0.20
3	Fecundity in numbers	140 – 170	157.30 ± 9.71	72 – 100	79.80 ± 29.51
4	Incubation period in days	3.29 - 5.08	3.95 ± 0.54	4.16 - 5.20	4.74 ± 0.39
5	Larval period				
	First instar	2.16 - 2.83	2.48 ± 0.20	2.54 - 3.00	2.74 ± 0.17
	Second instar	2.50 - 3.12	2.70 ± 0.16	2.83 - 3.41	3.12 ± 0.24
	Third instar	2.75 - 3.54	3.13 ± 0.28	2.92 - 3.79	3.39 ± 0.30
	Fourth instar	3.33 - 3.83	3.60 ± 0.17	3.54 - 4.00	3.81 ± 0.14
	Fifth instar	2.92 - 3.42	3.06 ± 0.23	3.20 - 4.42	3.98 ± 0.43
	Total larval period	14.40 - 15.81	14.96 ± 0.52	15.49 - 17.97	17.03 ± 0.76
6	Pre-pupation period in days	1.33 - 1.58	1.45 ± 0.09	1.42 - 1.83	1.63 ± 0.15
7	Pupation period in days	7.08 - 8.08	7.47 ± 0.43	9.16 - 10.87	9.93 ± 0.61
8	Adult longevity in days				
	Male	3.00 - 3.66	3.32 ± 0.22	3.00 - 4.83	4.03 ± 0.67
	Female	4.37 - 4.83	4.58 ± 0.16	4.91 - 5.79	5.41 ± 0.33
9	Total life cycle (egg to adult)	29.72 - 32.92	31.79 ± 1.16	35.05 - 39.67	37.52 ± 1.44

Data based on 10 pairs

Table 2: Morphometric parameters of different stages of *Leucinodes orbonalis* on potato during *kharif* 2016 and *rabi* 2016-17.

Sl. No	Stage	Measurement	*Kharif* 2016		*Rabi* 2016-17	
			Range (mm)	Mean ± SD	Range (mm)	Mean ± SD
1.	Egg	Length	0.73 - 0.85	0.80 ± 0.04	0.81 - 0.90	0.85 ± 0.03
		Width	0.56 - 0.62	0.58 ± 0.02	0.42 - 0.63	0.52 ± 0.07
2.	Larva					
	First instar	Length	1.63 - 2.45	1.89 ± 0.27	1.38 - 1.45	1.41 ± 0.02
		Width	0.24 - 0.36	0.29 ± 0.05	0.32 - 0.38	0.34 ± 0.02
	Second instar	Length	4.12 - 4.91	4.50 ± 0.29	5.21 - 6.01	5.61 ± 0.31
		Width	0.62 - 0.80	0.69 ± 0.06	0.65 - 0.92	0.78 ± 0.09
	Third instar	Length	7.21 - 8.98	7.92 ± 0.57	8.16 - 9.15	8.65 ± 0.35
		Width	1.30 - 1.69	1.50 ± 0.13	1.24 - 1.73	1.52 ± 0.16
	Fourth instar	Length	9.81 - 12.24	10.81 ± 0.93	11.56 - 11.84	11.70 ± 0.09
		Width	1.94 - 2.18	2.01 ± 0.09	1.82 - 1.98	1.89 ± 0.06
	Fifth instar	Length	18.56 - 20.78	19.47 ± 0.84	16.42 - 19.00	17.55 ± 0.82
		Width	3.12 - 3.65	3.38 ± 0.19	3.42 - 4.00	3.72 ± 0.20
3.	Pupa	Length	10.28 - 12.36	11.22 ± 0.72	9.18 - 10.98	9.74 ± 0.55
		Width	2.53 - 3.27	2.92 ± 0.32	3.42 - 3.92	3.69 ± 0.20
4.	Adult					
	Male	Length	8.24 - 10.89	9.26 ± 0.86	9.32 - 9.50	9.36 ± 0.79
		Width	18.45 - 22.66	20.27 ± 1.21	19.48 - 21.36	20.19 ± 0.69
	Female	Length	10.42 - 11.87	10.95 ± 0.57	11.31 - 13.52	12.60 ± 0.74
		Width	19.21 - 23.50	21.47 ± 1.34	20.01 - 22.32	21.00 ± 0.83

The total larval duration varied from 14.40 to 15.81 during *kharif* 2016 and 15.49 to 17.97 days during *rabi* 2016-17 with an average of 14.96 ± 0.52 days and 17.03 ± 0.76 days, respectively (Table 1 and 2). These results are in agreement with the description reported by Mannan *et al*., 2015 [8], who reported that, total larval period varied from 11 to 25 days with an average of 14.50 ± 0.18 days in *rabi* season. Kavita *et al.*, 2008 [7], Wankhede *et al*. (2009) [19] and Yadav *et al*. (2015) [20] reported the similar trend with respect to larval development on brinjal. However, the present findings slightly differ with that of Allam *et al*., 1982 [1] who recorded six larval instars on brinjal. The possible reason for variation in duration could be the difference in temperature, relative humidity and photo period regimes.

The pre-pupal period varied from 1.33 to 1.58 days and 1.42 to 1.83 days during *kharif* 2016 and *rabi* 2016-17, respectively, with an average mean pre-pupation period 1.45 ± 0.09 and 1.63 ± 0.15 days. The pupal period ranged from 7.08 to 8.08 days with an average of 7.47 ± 0.43 days during *kharif* 2016 and 9.16 to 10.87 days with an average of 9.96 ± 0.61 days during *rabi* 2016-17. The length of pupae varied from 10.28 to 12.36 mm and 9.18 to 10.98 mm with an average of 11.22 ± 0.72 and 9.74 ± 0.55 mm, respectively and width varied from 2.53 to 3.27 and 3.42 to 3.92 mm with an average of 2.92 ± 0.32 and 3.69 ± 0.20 mm, respectively during *kharif* 2016 and *rabi* 2016-17 (Table 1 and 2). The present findings are in close agreement with the reports of Mannan *et al*., 2015 [8], wherein, pupal period varied from 9 to 13 days with a range of 10.65 ± 0.06 days in *rabi* season. Kavita *et al.*, 2008 [7] reported that pupal period was 8.01 days on brinjal while, it was 6.73 ± 0.305 and 6.40 ± 0.400 days during 2009 and 2010 at 35 ºC temperature and 90 per cent relative humidity, respectively Yadav *et al*. (2015) [20].

The longevity of male varied from 3.00 to 3.66 days and 3.00

to 4.83 days with a mean of 3.32 ± 0.22 and 4.03 ± 0.67 days, respectively during *kharif* 2016 and *rabi* 2016-17. The longevity of female ranged from 1.83 to 4.37 days and 4.91 to 5.79 days with an average of 4.58 ± 0.16 days and 5.41 ± 0.33 days, respectively during *kharif* and *rabi* seasons (Table 1 and 2). These observations are in accordance with the findings of Mannan *et al*., 2015 [8] who reported the longevity of male was 2 to 5 days with an average of 3.50 ± 0.05 days whereas it was 5 to 8 days with an average of 6.20 ± 0.05days, for females.

The total life cycle of the shoot borer on potato (egg to adult emergence) occupied 29.72 to 32.92 days with a mean of 31.79 ± 1.16 days during *kharif* 2016 and 35.05 to 39.67 days with an average of 37.52 ± 1.44 days during *rabi* 2016-17 (Table 1). The present findings are in close agreement with the reports of Mannan *et al*., 2015 [8], who reported life cycle of potato shoot borer as 23 to 44 days with an average of 31.95 ± 0.21 days. Singh and Singh (2009) [17], Wankhede *et al*. (2009) [19] and Yadav *et al*. (2015) [20] also observed similar results on biology of *L. orbonalis* reared on brinjal under laboratory conditions.

4. Conclusion

On the basis of the results on biological parameters of different stages of *L. orbonalis* on potato over two seasons, it can be concluded that the duration of total life cycle of shoot borer on potato was comparatively more in *rabi* than *kharif* season, which may be due to variation in temperature, relative humidity and photo period regimes. Potato being a close relative of brinjal in solanaceae family, needs to be studied widely as it acts as a supplementary diet source for *L. orbonalis*.

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