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BIOMETRIAL MEASURMENTS OF LIFE STAGES OF *SENOMETOPIA ILLOTA* CURRAN (DIPTERA: TACHINIDAE) A LARVAL PUPAL PARASITOID ON *HELICOVERPA ARMIGRA* HUBNER.

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Abstract: A biometrial measurements of life stages of *Senometopia illota* Curran, a larval pupal parasitoid on *Helicoverpa armigera* Hubner was studied. Size of egg, larvae, puparia and adults was measured. The length and width of cephalic skeleton, posterior spiracles of all three instars were measured. Duration of different life stages recorded. Size of macrotype eggs 0.65 mm 1x0.22 mm w. The newly hatched microscopic first instar larva was 0.517 mm in length and 0.11 mm width. The third instar larvae emerged from host body measured 9.413 mm in length and 2.788 mm in width. Body size, cephalic skeleton and posterior spiracles increased in length and width as larva grown. Total larval and pupal duration each recorded was about 11-12 days at 25±1°C. The body size of male and female recorded was 9.7 x 3.8 mm and 9.25 x 3.25 mm, respectively. The longevity in adults 2 to 30 days with an average of 12 days was recorded. Premating period, duration of mating, preoviposition period, oviposition period, total times for adult emergence were also recorded.

Keywords: Biology, Biometry, *Senometopia illota, Helicoverpa armigera*, Life Stages.

INTRODUCTION

Recently natural enemies are being utilized as bio control agents to reduce pest populations. For this purpose, it is the basic need to understand the biology of the parasitoids. Knowledge of biology provides the key to success of pest management programmes. The information on biology and biometry is essential to understand morphological peculiarities of immature forms; it provides information for establishing the mass rearing of the natural enemies. It also contributes basic data for workers on taxonomy. Tachinid flies as well as chalcid and ichneumon wasps are the living tools for bio control. Some have already been cultured artificially to control the number of insect pests.

Carcelia illota = *Senometopia* (as *Eucarcelia* and *Zenillia*) *illota* (Curran) (=*Carcelia noctuae* (Curran)) Curran (Diptera: Tachinidae) is a larval pupal parasitoid of *H. armigera* on pigeonpea and chickpea [8]. *C. illota* on percent parasitisation record on *H. armigera* revealed 4-52% control of pest in fields on pigeonpea and chickpeas [3, 4]. Achan et al. (1968) investigated breeding method, mating period, preoviposition period, egg laying, time for hatching, larval and pupal period in *C. illota.* The data on biology and rearing technology was inadequate. The present work was undertaken on the biology and biometry of immature stages such as egg, larval instars and puparia. The biometry includes length and width of larval body cephalic skeleton and posterior spiracles, which helps to distinguish larval instars. It provides more precise information on morphology, anatomy and the duration of developmental stages of the species.

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MATERIALS AND METHODS

The continuous rearing of host larvae *H. armigera* (fig.1) and its parasitoid, *S. illota* (fig.2) were maintained in the laboratory conditions with natural photo period and temperature. Sufficient collection of larvae of *H. armigera* were made available for investigation, parasitisation of host larvae with exact time was recorded. The parasitized host larvae were dissected time to time to obtain various stages of the parasitoids. larval instars I were placed in 10% or 5% aqueous solution of KOH for 12 hours whereas II and III larval instars were boiled for few minutes in 10% KOH solution, washed with distilled water, dehydrated, cleared in xylene and then were mounted in DPX.

Fig.1: Larva of *H. armigera* feeding on pigeon pea pod

Fig. 2: Female *S. illota*

Fig. 3: Mating in *S. illota*

The egg size, the larval body length and widths, cephalic skeleton lengths and widths, posterior spiracle lengths and widths were then measured. The cephalic skeleton and posterior spiracles were observed under compound microscope. The egg size, lengths and widths of cephalic skeleton and posterior spiracles were measured by using ocular grid. Only one microscope and magnification (15x 10 xs) was used throughout the study. A significance of the biometrial measurements of length and width of larval body and cephalic skeleton and posterior spiracles was tested with regression analysis. 'P' values were calculated by applying student's't' test.

RESULTS

Egg laying (Fig.4):

Mated (fig.3) females after completion of preoviposition period deposit eggs all over the body of the host (fig. 4 & 5) mostly on inter segmental regions, lateral body segments, posterior end, near the head, etc. 1-3 eggs were laid per host. Description of life stages:

Fig.4: Female *S. illota* after mating depositing eggs on body of host larva *H. armigera.*

Eggs (Fig.4):

Freshly laid macrotype eggs are broadly oval in outline, creamy white and translucent, with thick tough dorsal and lateral chorion and a flat membranous ventral surface by which it was glued externally to the integument of the host. The mean length and width of twenty-five eggs were 0.65mm (range 0.449-0.733mm) and 0.22mm (range 0.166-0.249mm), respectively. The micropylar opening is placed dorsally; time for hatching was 15minutes to 24hrs depending on temperature, lengthening of the preoviposition period and availability of host in the laboratory.

Table.1: Biometrial measurements of three larval instars of *S. illota*

Larval instars	Age in days	Larval Body Structure (mm)					
		Body		Cephalic Skeleton (CSK)		Posterior Spiracle (PSP)	
		Length	Width	Length	Width	Length	Width
I	1	0.5172	0.11	0.0891	0.00951	-	-
	3	1.78	0.529	0.26	0.0374	0.0416	0.0166
II	5	2.95	1.13	0.374	0.0384	0.0478	0.0249
	7	4.5	1.75	0.53	0.1166	0.1587	0.104
III	9	7.16	2.416	0.682	0.196	0.303	0.228
	10	11.66	3.16	0.945	0.274	0.408	0.308

Body For length- X=6;Y=4.761;a=-1.5307;b=1.0486**; r=0.9596
Body For width- X=6;Y=1.5158;a=-0.3298;b=0.3076**; r=0.9967
For length of C.SK. - X=6;Y=0.480;a=-0.0087;b=0.08145**; r=0.9921
For width of C.SK. - X=6;Y=0.11198;a=-0.0488;b=0.0268**; r=0.9583
For length of P.SP. - X=7;Y=0.1918;a=-0.154;b=0.0494**; r=0.9715
For width of P.SP. - X=7;Y=0.1363;a=-0.13876;b=0.03929**; r=0.9709

Fig.5: *S. illota* eggs deposited on body of host larva *H. armigera.*

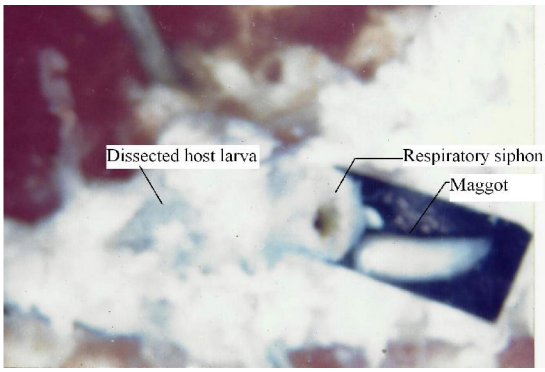

Fig.6. Maggot of *S. illota* in the dissected larva of *H. armigera.*

Larvae:

First Instar (Table.1 & 2): During hatching the first instar larvae bores directly through the base of egg. It is microscopic, segmented, and fusiform in shape, transparent white, pointed anteriorly and somewhat rounded posteriorly. Head capsule absent, its pointed anterior end contains a pair of mouth hooks (cephalic skeleton). In newly hatched larva at blunt posterior end spiracles not visible. It measured 0.517 mm L x 0.11 mm W (mean of 12 larvae) in size. The first instar newly hatched larvae enter the host body by boring through the integument. The site of entry can be seen as a black scar on host body. The parasitoid larvae enter the host's fat bodies and create a hole for respiration in one of the tracheae. A respiratory funnel was observed around the parasitoid. It was 1.78 mm L x 0.529 mm W in size (Five larvae). The first instar lasts for about 3 days.

Table.2: Biometrial measurements of life stages of *S. illota.* (All measurements in mm)

Life stages	Characters		Range		Mean
			Minimum	Maximum	
Egg	Size	Length	0.499	0.733	0.65
		Width	0.166	0.249	0.22
Larvae	Body	Length	0.375	2.00	1.486
		Width	0.095	0.55	0.319
Ist instar	Cephalic skeleton	Length	0.066	0.33	0.17455
		Width	0.0075	0.0499	0.02345
	Posterior spiracle	Length	0.033	0.05	0.0416
		Width	0.012	0.0167	0.0166
	Body	Length	2.5	5.2	3.725
		Width	0.9	2.0	1.44
IInd instar	Cephalic skeleton	Length	0.199	0.699	0.452
		Width	0.0166	0.15	0.0775
	Posterior spiracle	Length	0.029	0.0333	0.1032
		Width	0.166	0.216	0.0644
	Body	Length	5.5	13.0	9.413
		Width	2.0	3.5	2.788
IIIrd instar	Cephalic skeleton	Length	0.602	1.06	0.814
		Width	0.158	0.383	0.235
	Posterior spiracle	Length	0.116	0.532	0.355
		Width	0.0666	0.449	0.268
Puparia	Size	Length	7.72	8.41	7.93
		Width	1.66	2.49	2.2
Adults					
Male	Body size	Length	9.0	10.0	9.7
		Width	3.5	4.00	3.8
	Head capsule	Length	3.16	3.35	3.27
		Width	1.745	1.95	1.84
	Distance bet. com.eyes		0.838	0.916	0.877
	Wing expansion		10.0	12.5	10.8
Female	Body size	Length	8.5	9.5	9.25
		Width	3.0	3.5	3.25
	Head capsule	Length	3.14	3.26	3.173
		Width	1.59	1.876	1.715
	Distance bet. com.eyes		1.032	1.082	1.059
	Wing expansion		10.0	11.00	10.25

Second instar (Fig.6, Table.1 & 2): It was yellowish-greenish or white in color, depending on the feeding material inside the host body; fusiform in shape, distinct body segmentation. Cephalic skeleton paired, mouth hooks sharp (fig. 8, 9 &10). It was about 2.95mm in length and 1.13 mm in width (mean of five larvae) on fifth day. As the age advances the developing larvae increased in size. It feeds on internal body parts of host larvae. It remains inside the respiratory siphon. It lasts for about 4 days. On 7th day size 4.5 mm L x 1.75 mm W (five larvae) was recorded.

Fig.7. Newly formed pupa (1) & 2nd maggot of *S. illota* emerging (2), from host pupa.

Fig.8. Mouth parts of 3rd day larva of *S. illota* (10x)

Third instar (Fig.7, Table 1 & 2): Its body was distinctly segmented, white in color, fusiform in shape, anterior end bluntly pointed, posterior end round with a pair of well sclerotised posterior spiracle. Cephalic skeleton (fig. 8, 9 &10), paired, each divided into three regions, anterior non-serrated mouth hooks, middle irregular narrow region, large posterior hooks projecting anterio ventrally. Spiracles surrounded by a peritreme and bear three straight radiating slits (fig. 11 & 12). On 9th day it attains length 7.16 mm and 2.416mm width (mean of five).

Fig.9. Mouth parts of 5th day larva of *S. illota* (10x).

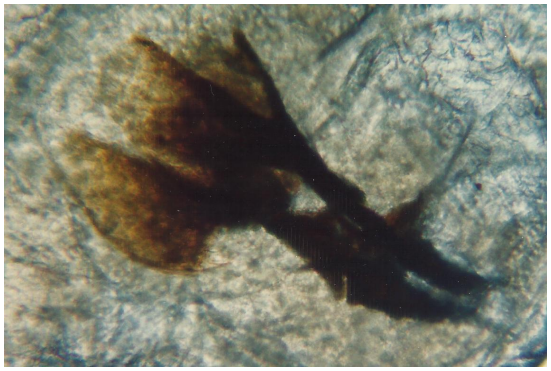

Fig.10. Mouth parts of II instar larva of *S. illota* (10x).

Fig.11. Posterior spiracles of II instar

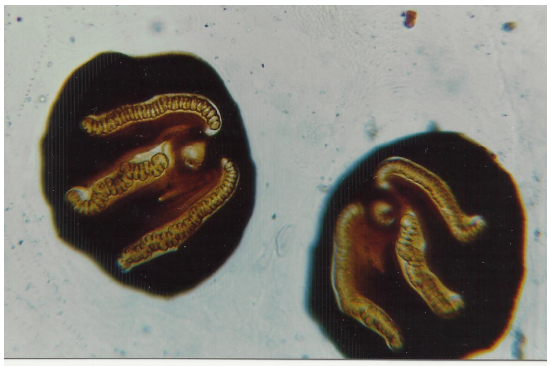

Fig.12. Posterior spiracles of III instar larva of *S. illota*.

The larvae rapidly feed on most of the internal tissues of the host, moves inside the host body. At this stage host if changes from larvae to pupa dies. The dead host pupae indicate presence of parasitoid third instar larvae. The host pupa dies in about 4-5 days of its transformation as larvae to pupa. The fully grown parasitoid larvae (maggot) after completely feeding on host internal body organization emerged from the host pupa (fig.7) after about 11-12 days. It cut the integument of the host with the pharyngeal hooks. Generally, it emerged in the morning from the anterior part of the host pupa by making a slit like opening. The emerged full grown five larvae measured in their mean length and width as 11.66mm and 3.16mm, respectively. The duration of third instar larvae was found to be 5 days. After emergence the maggot crawls for a proper place, in search of concealed place, it pupates in surface of soil but do not found to penetrate deep inside the soil in the laboratory. After about an hour, white maggot changed into pale or creamy white colored early puparia (fig.7). Total larval period was found to be 11 to 12 days.

Table.3: Statistics of linear regression relationship between larval age and length & width of larvae of *S. illota*.

Age in days X	X2	length of P.SP.Y	Y2	XY	Expected values Y	width of P.SP.Y1	$Y1^2$	XY1	Expected values Y1
3	9	0.0416	0.001730	0.1248	-0.0058	0.0166	0.000275	0.0498	-0.02089
5	25	0.0478	0.002284	0.2391	0.093	0.0249	0.00062	0.1245	0.05769
7	49	0.1587	0.02518	1.1109	0.1918	0.104	0.0108	0.728	0.13627
9	81	0.303	0.918	2.727	0.2906	0.228	0.0519	2.052	0.21485
11	121	0.408	0.1664	4.488	0.3894	0.308	0.0948	3.388	0.29343
36	286	0.9591	0.28739	8.6897	-	0.6815	0.15839	6.3423	-

Body For length- X=6; Y=4.761; a=-1.5307; b=1.0486**; r=0.9596
Body For width- X=6; Y=1.5158; a=-0.3298; b=0.3076**; r=0.9967

From the simple linear relationship between length, width and age of the larvae of *S. illota*, for body length and width b = 1.0486** and r^2=0.9208, b = 0.3076**, r^2 =0.9932, respectively. Linear relationship between length and width and age of the larvae has revealed that as the age increases, body length and width also increases accordingly at the rate of 1.0486 mm and 0.3076 mm per day, respectively. The significance of this rate i.e. 'b' indicates that there was a feasible and actual increase in the body length and width of larvae of *S. illota.* It was also justified with r^2 =0.9208 (for length) and r^2 = 0.9932 (for width). It indicated that age was the contributing factor for length and width, which was 92% and 99%, respectively (Table.3). Similarly for length and width of cephalic skeleton of larva b=0.08145** and r^2 =0.9842, b = 0.0268** and r^2 =0.9184, respectively (Table 4). For length and width of posterior spiracle of larvae b=0.0494**, r^2 = 0.9429, b = 0.03929 and r^2 = 0.9426, respectively (Table. 5).

Table.4: Statistics of linear regression relationship between larval age and length & width of cephalic skeleton (C.SK.) Of larvae of *S. illota.*

Age in daysX	X2	length of C.SK.Y	Y2	XY	Expected values Y	width of C.SK.Y1	$Y1^2$	XY1	Expected values Y1
1	1	0.08908	0.007935	0.08908	0.7275	0.00951	0.0009044	0.00951	-0.022
3	9	0.26	0.0576	0.78	0.23565	0.0374	0.00139	0.1122	0.0316
5	25	0.374	0.1398	1.87	0.39855	0.0384	0.001474	0.192	0.0852
7	49	0.53	0.2809	3.71	0.56145	0.1166	0.01359	0.8162	0.1388
9	81	0.682	0.4651	6.138	0.72435	0.196	0.0384	1.764	0.1924
11	121	0.945	0.8930	10.395	0.88725	0.274	0.07507	3.014	0.246
36	286	2.88008	1.8543	22.982	-	0.6719	0.13001	5.9079	-

For length of C.SK. - X=6;Y=0.480;a=-0.0087;b=0.08145**; r=0.9921
For width of C.SK. - X=6;Y=0.11198;a=-0.0488;b=0.0268**; r=0.9583

Linear relationship between length, width of cephalic skeleton and posterior spiracle and the age of the larvae *S. illota* has revealed that as the age increases length and width increases accordingly at the rate 'b' per day. The significance of which indicated that there was a feasible and actual increase in these larval body structures. It was also justified with r^2= 0.9842, 0.9184 for length and width of cephalic skeleton, respectively and r^2=0.9429 for length and r^2 =09426 for width of posterior spiracle, the contributing factor for length 98%, width 91% of cephalic skeleton, for length and width 94% of posterior spiracle (Tables.3, 4 & 5). Width of posterior spiracle, the contributing factors for length (98%), width (91%) of cephalic

skeleton, for length and width (94%) of posterior spiracle.

Puparia (Fig.7):

The body of the larvae shrivels and the anterior segments were withdrawn so that it became cylindrically ovoid. Newly formed puparia were soft, somewhat pointed anteriorly and rounded posteriorly, cream white colour changes to light brown or scarlet reddish, gradually changed to dark reddish-brown. The last larval skin becomes dark brown with in few hours; it forms a protective covering, the pupal case or puparium. The size of the puparium depends very much upon the food material available to the larva during its development. The puparia those were formed from host larval emergence were small in size in comparison with puparia Those were formed from host pupal emergence. The puparium measured 7.93-mm l x 2.2-mm w in size (mean of fifteen) (Table 2). The pupal duration was for 11 to 12 days at 25°C±1°C.

The transformation of pupal colour from dark-brown to blackish-brown (fig. 13) indicates imminent emergence of adult. It has been observed that excessive handling, transportation of puparia results in failure of emergence of adults. On an average, 90% of the laboratory reared puparia developed into adults.

Imago (Fig.14):

The fully developed pharate adult breaks open the puparium with frontal sac or ptilinum. Adult generally emerges from the puparium in the morning (in between 7.30a.m. to 9.00a.m.) hours. The newly emerged adults have soft and crumpled colorless integument and perfectly formed (though not fully pigmented) pubescence and bristles. The newly emerged adult swallows air to expand its body. The ptilinum an inflatable membranous sac in the head was slowly withdrawn permanently in the cavity of the head. It takes about 45-60 minutes. The wings of the newly emerged adult's lies folded, which then becomes straight or normal. The average time required for spreading the wings was 12.5 minutes (ten flies), range 10-15 minutes. The genital part seen outside gets retracted inside at the time of emergence. When the wings were normal, the mean body length and width of the five males measured were 9.7 mm and 3.8 mm, respectively (Table.2).

Fig.13. Old Cocoon (Pupa) of *S. illota*

Fig.14. *S. illota* Imago.

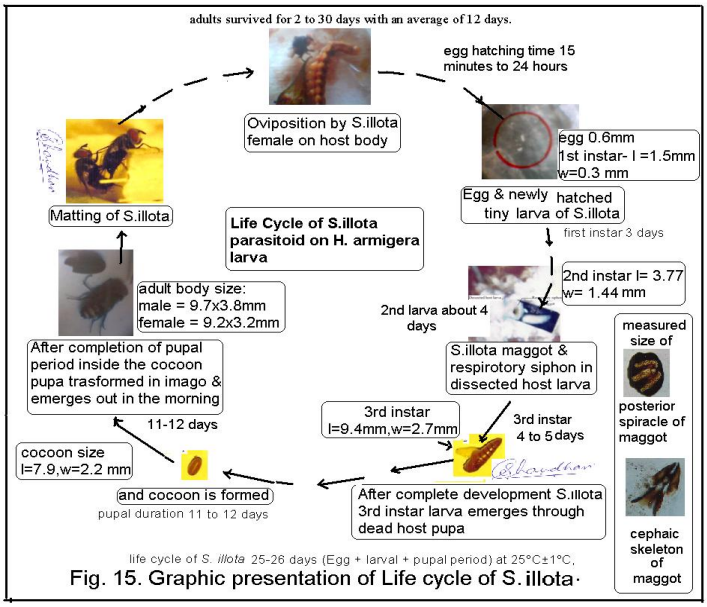

Fig. 15. Graphic presentation of Life cycle of S. illota·

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The adult's blackish gray in color. They were sexed on the basis of the following characteristics:

I. Male larger in size than females.
II. Males have more bristles on abdomen. In female, bristles are present only.
III. In male the tip of the abdomen is pointed and black, in female abdominal tip is round, last abdominal segment more white.
IV. In male ventral side of the abdomen is a shiny black, segmental line on ventral side not so

distinct; in female segmental lines on ventral side are distinct. The compound eyes in male at the top are closer than in female.

V. The adults survived for 2 to 30 days with an average of 12 days.

DISCUSSION

The eggs laid by this species are macrotype, creamy white in color, and oblong in outline. The egg swells slightly before hatching, the mean length and width 0.65 mm and 0.22mm, respectively. Achan et al. (1968) had reported microtype egg of *C. illota* but they have not given the size of egg. Van Emden (1954) divided the Tachinidae and Askew (1971) has given the modifications, into six groups as (1) in some larvae or eggs are laid apart from the host on leaves or the surface of soil. The eggs must be minute. One female may lay upto 6000 eggs. (2) Larviparous or ovoviviparous place their progeny to the host's body. (3) Oviparous, eggs laid on foliage. The eggs are very small (microtype), usually less than 0.2 mm long. (4) Oviparous, lay large eggs (macrotype) on the host. The egg approaches one millimeter in length and may be soft shelled and attached to the host hair by stalk (*Carcelia*) (100 to 200 eggs). (5) Oviparous species that insert their thin-shelled eggs into the host by means of a piercing substitute ovipositor. (6) Larviparous or oviparous, introduce their progeny inside the body of host by a piercing apparatus.

Senometopia illota belongs to the 4th group of species, female depositing macrotype egg on the host body, eggs present in uterus, counted upto 225 in number. Datta and Mukherjee (1978) studied the macrotype egg of *Tricholyga bombycis*, a parasite of *Bombyx mori*, and its length 0.51 mm and width egg type of *T. bombycis*. Patel and Singh (1972) reported microtype eggs of *Gomiophthalmus halli*, which are 0.186 mm in length and 0.103 mm in breadth, tiny and oval and were deposited on cotyledons of pigeonpea. Jackson et al. (1976) studied development of Palaxorista laxa, in this species eggs hatch immediately. In *Drino munda*, the eggs also hatch immediately (0 to 15 seconds) [5]. In the present study, *S. illota* eggs hatch in 15 minutes to 24 hrs. depending on temperature and preoviposition period i.e. at low temperature, the hatching was prolonged, similarly if preoviposition period lengthened or if the host larvae were not supplied the hatching time decreased. Achan et al. (1968) reported in *P. laxa, Exorista fallax, Goniophthalmus halli* and *C. illota* larval period as 4-7 days, 7 to 11 days, 17 days and 9 to 14 days, respectively. In the present findings larval period for *S. illota* at 25°C±1°C was 11 to 12 days.

In *S. illota*, in the present study puparia were formed outside the dead body of host animal, when soil was provided they were formed on the surface and did not pass deep in soil for pupation. Only one parasite larva successfully developed and emerged from each host larva in laboratory as well as in the field collection. Rarely two parasite larvae were found to emerge in which the larvae that emerge early, form the big pupa and other which emerges later on forms comparatively smaller pupa. No super- parasitism or multi-parasitism was observed. Multi-parasitism refers to that condition in which individuals of two or more species of parasitoids occur in or on the same host at the same time. The present findings are in agreement with Achan et al. (1968). They also reported single parasite larva per hot. Ziser et al. (1977) in biology of *Eucelatoria* sp. found that larvae are more tolerant to crowding than other tachinids. In *G. halli* single puparium develops inside the pupa of *H. armigera* [1, 9]. Datta and Mukherjee (1978) reported single pupa in T. bombycis outside the host in dark places. Chauthani and Hamm (1967) in *Drino munda* reported 5 to 6 normal parasites from full-grown corn earthworm, *H. zea* larva. Achan et al. (1968) recovered 4 to 8 parasite larvae of *Palexorista imbersis* from a single host. They reported total developmental period from egg to adult in four different tachinid flies viz., *P. imberbis, C. illota, E. fallax* and *G. halli* as 12-17, 18-29, 19-31 and 51 days, respectively at varying temperatures, 74°F-82°F.

T. bombyecis complete its life cycle in 18.47 to 22 days [6]. *D. munda* in fall armyworm and corn earworm requires 25.5 and 21.5 days, respectively to complete its life cycle [5]. In *Paradrino halli* total developmental period recorded was 23-36 days [10]. In the present investigation, life cycle of *S. illota* (Fig.15) was completed in 25-26 days (Egg + larval + pupal period) at 25°C±1°C which is in agreement with Achan et al. (1968) and Chauthani and Hamm (1967).

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