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RESEARCH PAPER

# Bio-Ecology of Leaf Roller / Capsule Borer *Antigastra catalaunalis* Duponchel

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**ABSTRACT**
*The bio-ecology of leaf roller / capsule borer Antigastra catalaunalis Duponchel was studied on Sesamum indicum (L.) variety TKG-22 under field and lab condition during 2004-06. The eggs were conical in shape, white in colour with length and width varying from 0.35-0.43 mm and 0.18-0.24 mm, respectively. The incubation period of the egg was 2-3 d and the neonate period was 17 min. There were five larval instars and length of the completely developed larva was 16 mm and larval period was 10-15 d. The larvae were observed maximum during last August to September. The pre-pupal and pupal periods were 2-8 and 4-12 d, respectively. The pupae were slender in shape. The mating was always at morning within 0.0148 min. The oviposition period was 3-4 d and fecundity 30-90. Life span of the adult was 4-12 d. Total life span was completed in 22-39 d. Mean adult emergence (per cent), sex ratio and growth index were 87 to 100%, 1:1 and 7.22 to 3.15, respectively. There are nearly 12-14 generations in a year. The leaves, flowers and capsules were infested to the extent of 23.4%, 7.94% and 3.12% by this insect. Maximum damage is caused during last of August and September.*
***KEY WORDS :*** *Bio-ecology, Antigastra catalaunalis Duponchel*

## INTRODUCTION

Sesame *Sesamum indicum* L., the ancient oilseed crop of India, is grown from time immemorial. This crop is attacked by 29 species of insect pests in different stages of its plant growth [1]. In India, sesame crop is attacked by 30 species of pests, of which shoot webber and capsule borer, *Antigastra catalaunalis* Dup. is an important pest causing 10-60% yield loss [2]. These pest caused 10 to 70% infestation of leaves, 34 to 62% of flower buds / flowers and 10 to 44% infestation of pods resulting 0 to even 72% yield losses.[3]. Leaf roller/capsule borer, *Antigastra catalaunalis* Dup. is a major and serious pest of sesame crop damaging the crop from seedling to flower and capsule stages at larval stages. At initial stage it webs the upper portion of plant and feed there upon, whereas at flowering stage it feeds on the flowers and at capsule stage it bores into the capsules. Thus, 20 to 50 per cent losses in yield are caused. One to three larvae are enough to denude a fully grown plant within 24 to 48 hours. The present work is a novel approach in Bundelkhand Zone of Madhya Pradesh, which has not been studied before or not explored elaborately. But, some work done on its bionomics has been reported [2, 3, 4, 5, 6, 7, 8, 9]. The present investigations conducted on different aspects of the bio-ecology of this insect are reported in this research paper.

## MATERIAL AND METHODS

Studies on the bionomics of leaf roller / capsule borer A*ntigastra catalaunalis D*uponchel were undertaken in the field in the ambient conditions during July to December of 2004, 2005 and 2006. For laboratory experiments, the cultivated sesame variety, TKG-22 and JT-7 were grown in glass jars. Full fed caterpillars were collected from the field of sesame crop and reared in glass jars and Petri dishes (7.5 cm diameter) on sesame leaves and fruiting bodies. The leaves/flowers were changed daily up to the second instar larval stage. Thereafter, buds, flowers, capsules and leaves were provided as food for the later larval stages. The matured larvae transform into pupae inside the bud and sometimes in deep dry soil available in fields and kept in glass jars/petri dishes in the lab. Moths emerging from pupae were released in lantern globes containing cotton swabs dipped in 20% glucose solution. Sexes

were examined by different morphological characters. The moths were kept under constant watch for studying mating, oviposition behaviour and egg laying.

Freshly laid eggs were counted and placed on fresh sesame leaves with the help of moist soft camel hairbrush. Observations were recorded on their colour, size, shape and incubation period. Duration of each larval instar, body segments and legs were recorded. Measurements of various stages were taken under the binocular with the help of ocular micrometer. However, advanced larval stages and pupae were measured with the help of Vernier calipers as described [10].

For adults, emerging from the above (the group being reared from freshly laid eggs), mating period, oviposition period, fecundity per female, pre-pupal, pupal period of larvae and longevity of male & females were recorded.

## RESULTS AND DISCUSSION

**The eggs**, laid singly on the undersurface of leaves, on capsules and branches (Fig. 1a), were minute and conical in shape. Freshly laid eggs were white in colour, which later changed to dark white before hatching. The freshly laid eggs varied from 0.35 to 0.37 mm (mean 0.36±0.01 mm) in length and matured eggs measured 0.39 to 0.43 mm (mean 0.41±0.023 mm). The width of freshly laid eggs varied from 0.18 to 0.19 mm (mean 0.18±0.003 mm) and matured eggs from 0.21 to 0.24 mm (mean 0.22±0.007 mm) (Table 5).

**Incubation period** of eggs was recorded to be 48.00 to 74.00 h (mean 59.36±4.65 h) (table 6). Incubation Period varied from 2.40±0.31 (First generation) to 2.76±0.19 d (Sixth generation) during July to November, 2004. During the same months in 2005 it varied from 2.56±0.33 (First generation) to 2.65±0.17 d (Sixth generation) and in 2006, 2.40±0.31 d (First generation) to 2.67±0.77 d (Sixth generation) (Table 7).

**Larva** is a cylindrical caterpillar, which is referred as the neonate larva just after hatching and passes through five larval instars before going in to pupation.

***Neonate larva.*** The newly hatched (neonate) larva is a tiny, cylindrical, semi translucent and cream coloured caterpillar (Fig. 1b) measuring 1.2 to 1.5 mm (mean 1.33±0.136 mm) in length and 0.10 to 0.15 mm (mean 0.13±0.021 mm) in width. Full fed nascent larva is 1.6 to 2.3 mm (mean 1.91±0.26 mm) in length and 0.16 to 0.35 mm (mean 0.23±0.038 mm) in width (Table 5). The colour of its head changes to black after 0.17±0.021 min. The period range of nascent larva has been found to be 0.15 to 0.22 min. (mean 0.17±0.021 min.) (Table 6). Nascent larvae feed on the leaf epidermis or tissue by scrapping.

***First instar larva,*** young larva emerged from the neonate stage is 3.00 to 4.00 mm (mean 3.41±0.14 mm) in length and 0.50 to 0.80 mm (mean 0.59±0.08 mm) in width (Table 5). It has 4 pairs of pro-legs on $6^{th}$, $7^{th}$, $8^{th}$ and $9^{th}$ abdominal segments in addition to three pairs of true thoracic legs on $1^{st}$, $2^{nd}$ and $3^{rd}$. The last (thirteenth) abdominal segment bears $5^{th}$ pair of pro-legs (Fig. 1c). First instar larvae feed for a little while on the leaf epidermis or within the leaf tissue by scrapping and soon after, bind together the tender leaves of the growing shoot with the help of silken threads while continuing feeding in the webbed mass (Fig. 1m & n). Therefore, the larva is also called "leaf webber'' and ''leaf roller". The larvae are very harmful to sesame crop because one plant is infested by 1 to 3 larvae which are enough to destroy it in 24 to 48 d. Full fed first instar larvae measure 4.10 to 5.70 mm (mean 4.85±0.13) in length and 0.90 to 1.00 mm (mean 0.93±0.03 mm) in width (Table 5). Period range of first instar larva is 96.00 to 132.00 hours (mean 110.16±7.87 h) (Table 6). The first instar larva lasts for 95.15 to 121.50 h including the first moulting period of 9.00 to 17.30 h and feeding period of 84.00 to 105.00 h during all the three seasons of study. Shorter period of this instar i.e. 95.15 to 100.15 h, was recorded during first, second, third and fourth generation (July to October), while it was longer i.e., 106.50 to 121.50 h during fifth and sixth generations (late October to end of December) because of increasing cold temperature (Table 8).

***The second instar larva*** (Fig. 1d) emerges in 4 d on an average. Young larvae have black dots on the abdomen and measure 5.20 to 8.00 mm (mean 6.58±0.52 mm) in length and 0.70 to 0.90 mm (mean 0.78±0.05 mm) in width. This instar also feeds on the leaf epidermis, soft part of branches and bores into pods by scrapping. Full fed second instar larvae measure 8.10 to 10.00 mm (mean 8.91±0.32 mm) in length and 0.90 to 1.20 mm (mean 1.05±0.07 mm) in width (Table 5). Period range of second instar

larvae was found to be 24.00 to 48.00 h (mean 34.80±6.19 h) during all the three seasons of study (Table 6). Feeding and moulting periods are shown in Table 8. Shorter period of this instar, 24.00 to 48.20 h, was recorded during first, second, third, fourth and fifth generation, while the duration was longer, 49.5 to 53.5 h during sixth generations (Table 8).

***Third instar larva*** (Fig. 1e) moults from the previous instar in a day, on an average. It has minute brown hair and black dots (setae & tubercles) on the abdomen. The larvae, when young, measure 10.10 to 10.80 mm (mean 10.49±0.32 mm) in length and 1.20 to 1.30 mm (mean 1.24±0.018 mm) in width. All legs and pro-legs change colour to white brown from white of the previous instar, while anal pro-legs become green. These larvae, after initial feeding on the epidermis of leaves and soft part of the branches, bore into flowers and capsules by scrapping (Fig. 1 o, p, q & r). Full fed larvae measure 11.20 to 13.10 mm (mean 12.54±0.34) in length and 1.40 to 1.70 (mean 1.49±0.11) in width (Table 5). Third instar larval duration was found to be 12.00 to 24.00 hours (mean 15.60±3.79 h) during all three seasons of study (Table 6). Shorter span of this instar, 11.00 to 16.50 hours was recorded during first, second, third and fourth generations, while it lasted for longer period 20.85 to 25.20 hours during fifth and sixth generations because of increasing cold. The feeding & moulting period is shown in Table 8.

***Fourth instar larva*** emerges within 24 h from the third and changes to green from earlier white/cream. It has minute green setae and two groups of three black tubercles / segment laterally present on both sides of the abdomen (Fig. 1f). Young larvae measure 13.20 to 13.80 mm (mean 13.53±0.13 mm) in width. All legs, pro-legs and anal legs are green in colour. Anal legs are hard and adhesive. This instar also feeds on the leaf epidermis, soft part of branches, bore into flowers and capsules by scrapping. Full fed larvae are measured to be 13.90 to 14.90 mm (mean 14.29±0.29 mm) in length and 1.70 to 2.00 mm (mean 1.82±0.008 mm) in width (table 8). This instar lasts for 19.00 to 25.40 h including the moulting period of 3.50 to 6.80 hours and feeding period of 14.30 to 18.20 h. During first, second, third and fourth generation, a shorter period of the instar is observed i.e. 19.00 to 20.50 h whereas during cold season (in $5^{th}$ & $6^{th}$ generation) it becomes longer i.e. 21.00 to 25.40 h (Table 8).

***Fifth instar larva*** is like the fourth instar but bigger in size and darker green in colour. One fine longitudinal line is present dorsally from thorax to the anal segment (Fig. 1g). This instar measures, 15.00 to 15.40 mm (mean 15.13±0.11 mm) in length and 1.50 to 1.80 mm (mean 1.69±0.012 mm) in width. Full fed larvae measure 15.70 to 17.00 mm (mean 16.21±0.27 mm) in length and 1.90 to 2.20 mm (mean 2.07±0.095 mm) in width (Table 5). This instar feeds mainly on flowers and capsules by scrapping. Feeding, moulting and total period were measured to be 48.00 to 60.00, 22.00 to 192.00 and 70.00 to 240.00 h respectively in first, second, third, fourth, fifth and sixth generations. Shorter larval duration was recorded viz. 70.00 to 90.00 h, during first, second, third and fourth generations, while it was longer viz. 98.00 to 240.00 h during fifth and sixth generations because of colder temperatures as mentioned earlier (Table 8).

**Cannibalism** is observed quite frequently in fourth and fifth instars (Fig. 1h). When more than one larva is reared in a dish, one attacks the other. Comparatively older larva attacks on its younger counter parts. After some resistance, the younger one is injured at dorsal region of meso or meta-thorax and the fluid oozing out of the injury is sucked by the winner and thereafter the injured is completely consumed leaving only head capsule along with pro-thorax. If this cannibal happens to get another one or two larvae, these are also consumed.

**Mean larval period** ($1^{st}$ instar to $5^{th}$ instar) varies from 9.59±0.75 to 15.14±0.17 d in field conditions. The mean larval period of first, second third, fourth, fifth and sixth generations were found to be 10.68±0.90, 10.86± 0.61, 9.59±0.75, 10.77±1.013, 11.33±0.13 and 13.89±1.48 d during 2004; 11.53±0.27, 11.42±0.45, 11.27±0.55, 11.30±0.69, 12.78±0.31 and 15.14±0.17 d during 2005, thereafter 10.66±0.29, 10.70±0.31, 10.98±0.48, 10.98±0.58, 12.49±0.42 and 14.99±0.35 d during 2006 (Table 7).

**Pre-pupa** Full-grown last instar larvae stop feeding and descend to dry leaves and crevices of the ground for pupation. At first, the larvae shorten in length, then become semilunar in shape and change to pre-pupa, (Fig. 1i). Mean length and width of pre-pupa is 13.00 to 15.20 mm (mean 13.67±0.39 mm) and 1.50 to 2.20 mm (mean 1.89 ± 0.12 mm) (Table 6). Shorter **pre-pupation period** after $5^{th}$ larval instar was recorded to be 22.00 to 30.00 h during first, second, third and fourth generations,

while it was longer i.e. 48.00 to 192.00 h during fifth and sixth generations during all three seasons of study (Table 8).

Pupation takes place in a transparent pale white silken cocoon on a dry leaf or in the surface litter on the ground. Abdominal pro-legs and then thoracic legs are lost. Ultimately head capsule is casted out and **pupa** is formed (Fig. 1j).

The **Pupa** is slender, long necked and greenish-reddish-brown in colour. A pair of eyes is present on anterior end. The body is light reddish brown, greenish white at first. It changes gradually to pale reddish white, dark reddish, reddish brown and pale whitish later on. Abdomen is distinctly marked into 10 segments. Shape of the head, thorax, abdomen and tail is pointed broader and cylindrical respectively. Mean length and width of pupa varies from 7.00 to 8.00 mm (mean 7.37±0.25 mm) and 1.00 to 1.80 (mean 1.42±0.17) respectively (Table 6).

**Pupal period** is shown in Table 6 & 7. The average pupal period has been found to be 3.78±0.14 to 11.50±0.25 d during the studies. The length of pupae in the first, second, third, fourth, fifth and sixth generations were 4.96±0.46, 4.86±0.47, 4.74±0.63, 4.75±0.55, 6.95±1.12 and 11.46±0.57 d during 2004; thereafter 4.08±0.08, 3.78±0.14, 4.08±0.01, 4.07±0.16, 5.42±0.89 and 11.28±0.12 d during 2005 and, 3.88±0.13, 3.86±0.09, 3.90±0.07, 3.92±0.15, 5.56±0.51 and 11.50±0.25 d during 2006 respectively. It was longer in fifth and sixth generation during all three seasons because of coldest temperatures (Table 7).

**Larval and pupal** developmental periods (A) is recorded to be 12.76-33.42 d (mean 20.83±9.47 d) (Table 6).

**Adults** are stout and have medium size with a wing span of 23.00 to 26.77 mm. The colours vary from light reddish brown to dark reddish brown. Forewings are dark reddish brown having dark reddish veins on the upper sides and a series of black dots towards the margins (Fig. 1k & l). White dots are present on ventral side of wings just beneath the black dots. Hind wings are transparent. Males are 8.00 to 8.50 mm (mean 8.19 ± 0.12 mm) in length and 22.00 to 24.00 mm (mean 23.00 ± 0.83 mm) in width with expanded wings. Females are longer, being 11.00 to 12.00 mm (mean 11.52 ± 0.30 mm) in length and 25.50 to 28.00 mm (mean 26.77 ± 0.37 mm) in width with expanded wings (Table 6). The sexes are identified by the presence of a large and double-segmented tuft on the thorax of female moths.

**Adult emergence (B)**: The percentage of adult emergence on an average has been found to be 87-100 ± 2.30. Moths emerge from pupae during 12.00 to 6.00 am in night. Female and male sex ratio is normally (F: M) 1:1.

**Mating** Male and female moths, after emergence rest for a while on branches and soil then undertake short flights in search of food. Next night, the male moths fly, first in search of food for 3-4 h and then they are engaged in characteristic high speed directed flights in search of pheromone plumes. During this time females are inactive, releasing pheromones. The mating is completed within 0.01 to 0.02 min (mean 0.0148 ± 0.0035 min). Thus, pre-mating period is recorded to be 24 to 26 h (mean 24.9 ± 0.96 h) (table 6). Mating takes place only in nights.

**Oviposition** Females oviposit after 10.00 to 12.00 h (mean 11.15 ± 0.89 h) of mating (Pre-oviposition period). Ovipositon period (egg laying time) is found to be 3.00 to 4.00 d (mean 3.34 ± 0.37 d) and post-oviposition period 24.00 to 26.00 h (mean 24.27 ± 0.47 h) (Table 6). Eggs are minute and laid singly on the undersurface of leaves, outside of capsules and branches of sesame plants in the field. Fecundity per female is 30.00 to 90.00 (mean 59.16 ± 9.05) as recorded during all the three seasons of study. Eggs are laid only in early morning, around 4.00 to 7.00 am.

**Longevity** As shown in Table 7, the average life span of an adult of first, second, third, fourth, fifth and sixth generations have been found to be 5.26 ± 0.83, 5.36 ± 0.64, 5.42 ± 0.32, 5.33 ± 0.71, 6.38 ± 0.86 and 8.03 ± 1.37 d during 2004; thereafter, 5.51 ± 0.25, 5.54 ± 0.17, 5.59 ± 0.22, 5.53 ± 0.39, 7.23 ± 0.42 and 8.36 ± 0.41 d during 2005 and, 5.24 ± 0.42, 5.29 ± 0.15, 5.69 ± 0.17, 5.44 ± 0.18, 6.73 ± 0.39 and 9.76 ± 0.33 d during 2006. It is always found to be longer in fifth and sixth generations as mentioned earlier. Longevity of males and females vary from 4.00 to 9.00 d (mean 6.60 ± 1.94 d) and 6.00 to 12.00 d (means 8.75 ± 2.05 d) respectively as averaged from the studies during all the three yr (Table 6).

**Growth index (B/A)** has been found to vary from 6.92 to 3.12, 7.75 to 3.22 and 7.50 to 3.12 (mean range 7.22 to 3.15 ± 0.62).

**Total Life Span**, as shown in Table 7, from egg laying to adult stage, is completed in 22.17 to 36.08, 23.17 to 37.34 and 22.14 to 38.76 d during 2004, 2005 and 2006 respectively. Mean life cycle period of first, second, third, fourth, fifth and sixth generation were 23.27 ± 0.05, 23.55 ± 0.01, 22.17 ± 0.03, 23.49 ± 0.01, 27.22 ± 0.03 and 36.08 ± 0.006 d during 2004; thereafter, 23.58 ± 0.12, 23.17 ± 0.03, 23.25 ± 0.05, 23.47 ± 0.08, 28.13 ± 0.02 and 37.34 ± 0.07 d during 2005 and, 22.14 ± 0.02, 22.19 ± 0.04, 23.12 ± 0.01, 22.71 ± 0.15, 27.26 ± 0.05 and 38.76 ± 0.16 d during 2006 respectively. It is longer in fifth and sixth generation.

**Nature and extent of damage** : Maximum per cent damage to leaves and flowers caused by larvae of *Antigastra* was 23.4% and 7.94% during last of August (34$^{th}$ SMW) and September (37$^{th}$ SMW) and minimum 15.92% and 4.36% during starting of August (32$^{nd}$ S.M.W.) and September (35$^{th}$ SMW) respectively. But, capsule damage was 3.12% at last September (38$^{th}$ SMW) Fig. 2).

The per cent damage of flower and capsule is positively correlated with the maximum temperature (significantly) except to leaves damage but negatively correlated with the minimum temperature, relative humidity and rainfall except to leaves damage (Table 1).

**Table-1: Correlation coefficient between per cent damage of leaf, flower and capsule caused by *Antigastra* larvae and weather parameters.**

| Weather Parameters | Per cent leaf damage | Per cent flower damage | Per cent capsule damage |
|---|---|---|---|
| Maximum Temperature ($^0$C) | -0.9139 | +0.9742* | +0.4991 |
| Minimum Temperature ($^0$C) | +0.3040 | -0.2159 | -0.6810 |
| Relative Humidity (%) | +0.9141* | -0.9547 | -0.1846 |
| Rainfall (mm) | +0.4260 | -0.54241 | -0.1688 |

*Significant@ 0.05 probability

**Correlation with weather parameters :** Out of 5 weather parameters tested 3 parameters viz. maximum temperature, mean temperatures and rainfall during 30-34 SMW were found to be effective in determining the level of infestation. The analysis inferred that prevalence of maximum temperature (31-36$^0$C), mean temperature around 27$^0$C and lower rainfall (below 55mm) recorded in maximum increase of number of larval population. Predictive equation explained more than 80% variability of pest population. The observed peak larval population and predicted peak larval population are quite closure. Thus, if at early stage of crop growth (30-34 SMW) mean maximum temperature prevails 31-36$^0$C, minimum around 25$^0$C and dry weather conditions (rainfall around 50mm per week), there will be higher incidence of leaf roller / capsule borer during flowering and pod formation stages (Table 2, 3 & 4).

The results of present studies differ from the studies conducted by some earlier workers under varying agro-climatic conditions. The egg incubation, larval, pupal, adult period, total life span (all in days), number of generations and fecundity (number of eggs / female) were recorded, as 2, 10-33, 4-19, 6-8, 18-64, 14 and 14-95 respectively by [4] at Pusa (Bihar); 2-9, 8-19, 3-9, 5-16, 18-40, 6 and upto 223 by [5]at Kanpur (U.P.); 4-5, 10-15, 4-5, 6-10, nil, nil and 71 by [6] at Junagarh (Gujrat); 2-6.5, 9-32, 4-20, 5-6, 18-61, 12 and 13-116 by [11] at Ludhiana (Punjab); 2-5.87, 9.58-30.53,4.08-14.90, 5-11, 18-51, 12 and 18-91 and sex ratio was 1.5:1.0 (lab) & 1.22:1.0 (field) reported by (12) 2-6, 15-18, 4-9 and 5-6, 26-39, nil and about 20 by [13]; 2-9, 8-33, 3-20, 4-16, 17-78, 6-14 and nil by [7] at Ludhiana (Punjab); 2-3, 9-13, 4-5, 5-7, 20-28, nil and nil by [14] at Annamalai (T.N.); 2-7, 10-15, 4-19, 5-26, 23-67, 14 and 86-232 by [3] at Tikamgarh (M.P.); 2-4, 8-11, 6-8, 6-10, 22-23, nil and 20-30, and adult emergence & growth index was 65-95% & 4.64-5.00 by (2) at Hyderabad (A.P.); 2-7, 10-33, 4-20, 4-5, 20-65, 14 and 150-300 by [15]; 2-7, 10-33, 4-20, 4-5, 23-67, 14 and 140 by [9] and 2-3, 9-11, 4-

6, 5-7, 20-27, 12-14 and 55-80 and adult emergence & growth was calculated as 90-100 & 6.93-5.88, respectively by [8] at Tikamgarh (M.P.).

**Table-2: Correlation between mean weekly larval population (30-40SMW) and corresponding weekly weather parameters.**

| Weather parameters | Maximum Temperature | Minimum Temperature | Mean Temperature | Relative humidity | Rainfall |
|---|---|---|---|---|---|
| Correlation coefficients | + 0.39 | + 0.06 | + 0.45 | -0.05 | -0.35 |

**Table-3: Correlation between peak pest population periods (35-39th SMW) with corresponding week (35-39thSMW) weather parameters.**

| Weather parameters | Maximum Temperature | Mean Temperature | Rainfall | Temperature differences |
|---|---|---|---|---|
| Correlation coefficients | + 0.39 | + 0.35 | -0.66 | +0.36 |

**Table-4: Correlation between peak larval population and previous week weather parameters (30-34th SMW).**

| Weather parameters | Maximum Temperature | Mean Temperature | Rainfall | Temperature differences |
|---|---|---|---|---|
| Correlation coefficients | + 0.59 | + 0.63 | -0.53 | +0.44 |

Equation for the prediction module

$Y = - 0.750 + 0.084X1 – 0.058 X2 + 0.002 X3$

$R2 = 0.88^*$, Standard Error =0.028, *Significant at 5 % level

Y = Leaf roller larval population / plant

X1 = Weekly maximum temperature of preceding weeks (30-34th SMW)

X2 = weekly mean temperature of preceding weeks (30-34thSMW)

X3 = weekly total rainfall during peak period (35-39th SMW)

**Table-5: Mean*(±SEM) size of egg and larval stages of *Antigastra catalaunalis* Duponchel studied during 2004-06**

| Stage | | Length (mm) | | Width (mm) | |
|---|---|---|---|---|---|
| | | Range | Mean*±SEM | Range | Mean*±SEM |
| Egg : | Fresh | 0.35-0.37 | 0.36±0.01 | 0.18-0.19 | 0.18±0.003 |
| | Matured | 0.39-0.43 | 0.41±0.023 | 0.21-0.24 | 0.22±0.007 |
| Nascent larva : | Young | 1.20-1.50 | 1.33±0.136 | 0.10-0.15 | 0.13±0.021 |
| | Full fed | 1.60-2.30 | 1.91±0.26 | 0.16-0.35 | 0.23±0.038 |
| 1st instar larva : | Young | 3.00-4.00 | 3.41±0.14 | 0.50-0.80 | 0.59±0.08 |
| | Full fed | 4.10-5.70 | 4.85±0.13 | 0.90-1.00 | 0.93±0.03 |
| 2nd instar larva : | Young | 5.20-8.00 | 6.58±0.52 | 0.70-0.90 | 0.78±0.05 |
| | Full fed | 8.10-10.00 | 8.91±0.32 | 0.90-1.20 | 1.05±0.07 |
| 3rd instar larva : | Young | 10.10-10.80 | 10.49±0.32 | 1.20-1.30 | 1.24±0.018 |
| | Full fed | 11.20-13.10 | 12.54±0.34 | 1.40-1.70 | 1.49±0.11 |
| 4th instar larva : | Young | 13.20-13.80 | 13.53±0.13 | 1.30-1.50 | 1.45±0.04 |
| | Full fed | 13.90-14.90 | 14.29±0.29 | 1.70-2.00 | 1.82±0.08 |
| 5th instar larva : | Young | 15.00-15.40 | 15.13±0.11 | 1.50-1.80 | 1.69±0.012 |
| | Full fed | 15.70-17.00 | 16.21±0.27 | 1.90-2.20 | 2.07±0.095 |

***Mean of 10 individuals***

**Table-6: Life span (mean*± SEM) of *Antigastra catalaunalis* Duponchel and size (mean*± SEM) of different development stages derived from observations during 2004-06**

| Parameters | Period Range | | Size Range (mm) | | | |
|---|---|---|---|---|---|---|
| | Range | Mean*±SEM | Length | Mean*±SEM | Width | Mean*±SEM |
| Egg (Incubation) | 48.00-74.00 | 59.36±4.65 (H) | 0.35-0.43 | 0.38±0.012 | 0.18-0.24 | 0.20±0.007 |
| Larval stage | | | | | | |
| Neonate larvae | 0.15-0.22 | 0.17±0.021 (M) | 1.20-2.30 | 1.67±0.25 | 0.10-0.35 | 0.19±0.04 |
| I instar | 96.00-132.00 | 110.16±7.87 (H) | 3.00-5.70 | 4.30±0.58 | 0.50-1.00 | 0.71±0.81 |
| II instar | 24.00-48.00 | 34.80±6.19 (H) | 5.20-10.00 | 7.57±0.75 | 0.70-1.20 | 0.84±0.17 |
| III instar | 12.00-24.00 | 15.60±3.79 (H) | 10.10-13.10 | 11.19±0.69 | 1.20-1.70 | 1.46±0.10 |
| IV instar | 20.00-22.00 | 21.05±0.70 (H) | 13.20-14.90 | 14.03±0.53 | 1.30-2.00 | 1.56±0.20 |
| V instar | 48.00-72.00 | 56.40±4.73 (H) | 15.00-17.00 | 16.20±0.33 | 1.50-2.20 | 1.80±0.13 |
| Pre-pupa | 22.00-192.00 | 90.80±9.26 (H) | 13.00-15.20 | 13.67±0.39 | 1.50-2.20 | 1.89±0.12 |
| Pupa | 3.50-13.00 | 7.12±0.63 (D) | 7.00-8.00 | 7.37±0.25 | 1.00-1.80 | 1.42±0.17 |
| Developmental period (Larva & Pupa)-A | 12.76-33.42 | 20.83±9.47 (D) | - | - | - | - |
| Adults | | | | | | |
| Male | 4.00-9.00 | 6.60±1.94 (D) | 8.00-8.50 | 8.19±0.12 | 22.00-24.00 | 23.00±0.83** |
| Female | 6.00-12.00 | 8.75±2.05 (D) | 11.00-12.00 | 11.52±0.30 | 25.50-28.00 | 26.77±0.37** |
| Pre-mating | 24.00-26.00 | 24.90±0.96 (H) | - | - | - | - |
| Mating | 0.01-0.02 | 0.0148±0.0035 (M) | - | - | - | - |
| Pre-oviposition | 10.00-12.00 | 11.15±0.89 (H) | - | - | - | - |
| Oviposition | 3.00-4.00 | 3.34±0.37 (D) | - | - | - | - |
| Post-oviposition | 24.00-26.00 | 24.27±0.47 (H) | - | - | - | - |
| Total life span | 22.00-39.00 | 27.93±3.50 (D) | - | - | - | - |

***Mean of 10 individuals; ** : Width of wing span; D : Days; H : Hours; M : Minutes***

**Table-7: Mean duration (days)*±SEM of developmental stages and the total life span of *Antigastra catalaunalis* Duponchel (First to sixth generations only) during 2004-06**

| Period of Study (From 2004 | To) '04 | Incubation Period | Larva | Pupa | Adult | Total Life Span |
|---|---|---|---|---|---|---|
| 20/7 | 12/8 | 2.40±0.31 | 10.68±0.90 | 4.96±0.46 | 5.26±0.83 | 23.27±0.05 |
| 13/8 | 05/09 | 2.50±0.26 | 10.86±0.61 | 4.86±0.47 | 5.36±0.64 | 23.55±0.01 |
| 06/09 | 28/09 | 2.45±0.25 | 9.59±0.75 | 4.74±0.63 | 5.42±0.32 | 22.17±0.03 |
| 29/09 | 21/10 | 2.66±0.15 | 10.77±1.013 | 4.75±0.55 | 5.33±0.71 | 23.49±0.01 |
| 22/10 | 19/11 | 2.59±0.25 | 11.33±0.13 | 6.95±1.12 | 6.38±0.86 | 27.22±0.03 |
| 20/11 | 24/12 | 2.76±0.19 | 13.89±1.48 | 11.46±0.57 | 8.03±1.37 | 36.08±0.006 |
| '05 | '05 | | | | | |
| 17/07 | 09/08 | 2.56±0.33 | 11.53±0.27 | 4.08±0.08 | 5.51±0.25 | 23.58±0.12 |
| 10/08 | 02/09 | 2.49±0.24 | 11.42±0.45 | 3.78±0.14 | 5.54±0.17 | 23.17±0.03 |
| 03/09 | 26/09 | 2.36±0.23 | 11.27±0.55 | 4.08±0.01 | 5.59±0.22 | 23.25±0.05 |
| 27/09 | 20/10 | 2.63±0.18 | 11.30±0.69 | 4.07±0.16 | 5.53±0.39 | 23.47±0.08 |
| 21/10 | 18/11 | 2.76±0.18 | 12.78±0.31 | 5.42±0.89 | 7.23±0.42 | 28.13±0.02 |
| 19/11 | 25/12 | 2.65±0.17 | 15.14±0.17 | 11.28±0.12 | 8.36±0.41 | 37.34±0.07 |
| '06 | '06 | | | | | |
| 24/07 | 15/08 | 2.40±0.31 | 10.66±0.29 | 3.88±0.13 | 5.24±0.42 | 22.14±0.02 |
| 16/08 | 07/09 | 2.39±0.38 | 10.70±0.31 | 3.86±0.09 | 5.29±0.15 | 22.19±0.04 |
| 08/09 | 30/09 | 2.60±0.45 | 10.98±0.48 | 3.90±0.07 | 5.69±0.17 | 23.12±0.01 |
| 01/10 | 23/10 | 2.52±0.18 | 10.98±0.58 | 3.92±0.15 | 5.44±0.18 | 22.71±0.15 |
| 24/10 | 20/11 | 2.57±0.26 | 12.49±0.42 | 5.56±0.51 | 6.73±0.39 | 27.26±0.05 |
| 21/11 | 28/12 | 2.67±0.77 | 14.99±0.35 | 11.50±0.25 | 9.76±0.33 | 38.76±0.16 |

***Mean of 10 individuals***

**Table-8: Mean duration (hours)*±SEM of feeding (F) and moulting (M) in larval instars of *Antigastra catalaunalis* Duponchel (First to sixth generations only) during 2004-06**

| Year of Study / Generation | First instar | | | Second instar | | | Third instar | | | Fourth instar | | | Fifth instar | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | F | M | T | F | M | T | F | M | T | F | M | T | F | PP | T |
| 2004 | 84.00 | 12.00 | 96.00 | 16.00 | 8.00 | 24.00 | 9.00 | 3.00 | 12.00 | 16.00 | 4.00 | 20.00 | 48.00 | 22.00 | 70.00 |
| | ±1.21 | ±0.46 | ±2.07 | ±0.35 | ±0.21 | ±0.56 | ±0.27 | ±0.09 | ±0.36 | ±0.48 | ±0.02 | ±0.50 | ±1.12 | ±0.48 | ±2.00 |
| | 84.00 | 12.00 | 96.00 | 16.00 | 8.00 | 24.00 | 9.00 | 3.00 | 12.00 | 16.00 | 4.00 | 20.00 | 48.00 | 22.00 | 70.00 |
| | ±1.17 | ±0.32 | ±1.49 | ±0.17 | ±0.39 | ±0.56 | ±0.29 | ±0.10 | ±0.39 | ±0.39 | ±0.15 | ±0.53 | ±1.41 | ±0.50 | ±2.31 |
| | 84.00 | 11.15 | 95.15 | 26.00 | 10.00 | 36.00 | 9.00 | 3.00 | 12.00 | 16.50 | 4.00 | 20.50 | 48.00 | 24.00 | 72.00 |
| | ±2.39 | ±0.21 | ±3.00 | ±1.02 | ±0.42 | ±1.44 | ±0.29 | ±0.17 | ±0.46 | ±0.44 | ±0.22 | ±1.06 | ±1.27 | ±0.22 | ±1.49 |
| | 86.80 | 14.00 | 100.00 | 26.00 | 10.15 | 36.15 | 9.00 | 3.00 | 12.00 | 16.50 | 4.00 | 20.50 | 60.00 | 30.00 | 90.00 |
| | ±1.20 | ±1.12 | ±2.32 | ±0.47 | ±0.47 | ±1.34 | ±0.33 | ±0.11 | ±0.44 | ±0.29 | ±0.42 | ±1.11 | ±2.07 | ±1.24 | ±3.31 |
| | 99.80 | 15.20 | 115.00 | 36.20 | 12.00 | 48.20 | 15.00 | 7.00 | 22.00 | 18.00 | 5.00 | 23.00 | 48.00 | 50.00 | 98.00 |
| | ±2.10 | ±1.11 | ±3.21 | ±1.15 | ±0.34 | ±1.49 | ±0.49 | ±0.27 | ±1.16 | ±1.12 | ±0.39 | ±1.51 | ±1.44 | ±2.22 | ±4.06 |
| | 104.00 | 16.00 | 120.00 | 36.00 | 14.00 | 50.20 | 15.50 | 8.50 | 24.00 | 18.00 | 5.00 | 23.00 | 60.00 | 168.00 | 228.00 |
| | ±2.40 | ±2.11 | ±4.51 | ±1.40 | ±1.02 | ±2.42 | ±1.07 | ±0.29 | ±1.36 | ±1.12 | ±0.22 | ±1.34 | ±2.24 | ±4.41 | ±7.05 |
| 2005 | 85.50 | 10.00 | 95.50 | 17.00 | 9.00 | 26.00 | 9.00 | 3.00 | 12.00 | 15.00 | 4.00 | 19.00 | 48.00 | 23.00 | 71.00 |
| | ±1.41 | ±0.24 | ±2.05 | ±0.48 | ±0.34 | ±1.22 | ±0.25 | ±0.11 | ±0.36 | ±0.27 | ±0.17 | ±0.44 | ±0.59 | ±0.44 | ±1.03 |
| | 85.50 | 10.00 | 95.50 | 17.00 | 9.00 | 26.00 | 10.00 | 2.00 | 12.00 | 15.00 | 4.00 | 19.00 | 48.00 | 23.00 | 71.00 |
| | ±1.22 | ±0.41 | ±2.03 | ±0.48 | ±0.34 | ±1.22 | ±0.49 | ±0.09 | ±0.58 | ±0.32 | ±0.42 | ±1.14 | ±1.22 | ±0.41 | ±2.03 |
| | 86.00 | 11.00 | 97.00 | 17.50 | 10.00 | 27.50 | 10.00 | 2.00 | 12.00 | 16.00 | 3.50 | 19.50 | 60.00 | 24.00 | 84.00 |
| | ±2.41 | ±1.00 | ±3.41 | ±1.17 | ±0.48 | ±2.05 | ±0.49 | ±0.09 | ±0.58 | ±0.42 | ±0.22 | ±1.04 | ±2.02 | ±1.04 | ±3.06 |
| | 85.00 | 12.00 | 97.00 | 28.00 | 10.00 | 38.00 | 9.00 | 3.00 | 12.00 | 15.50 | 3.50 | 19.40 | 48.00 | 24.00 | 72.00 |
| | ±2.32 | ±1.23 | ±3.55 | ±1.24 | ±1.05 | ±2.29 | ±0.24 | ±0.21 | ±0.45 | ±0.27 | ±0.41 | ±1.08 | ±1.55 | ±0.44 | ±2.39 |
| | 92.50 | 14.00 | 106.50 | 34.00 | 11.50 | 45.50 | 16.00 | 6.00 | 22.00 | 16.00 | 5.00 | 21.00 | 60.00 | 48.00 | 108.00 |
| | ±3.17 | ±1.18 | ±4.35 | ±1.18 | ±0.33 | ±1.51 | ±0.48 | ±0.37 | ±1.25 | ±0.34 | ±0.21 | ±0.55 | ±2.21 | ±1.23 | ±3.44 |
| | 100.00 | 17.30 | 117.30 | 34.00 | 15.50 | 49.50 | 16.00 | 8.00 | 24.00 | 16.50 | 6.50 | 23.40 | 48.00 | 192.00 | 240.00 |
| | ±2.22 | ±0.41 | ±3.03 | ±2.10 | ±0.42 | ±2.52 | ±1.41 | ±0.27 | ±2.08 | ±0.25 | ±0.46 | ±1.11 | ±2.17 | ±4.45 | ±7.02 |
| 2006 | 90.00 | 9.00 | 99.00 | 17.00 | 9.20 | 26.20 | 8.00 | 3.00 | 11.00 | 14.50 | 4.50 | 19.40 | 48.00 | 24.00 | 72.00 |
| | ±1.32 | ±0.17 | ±1.49 | ±0.33 | ±0.24 | ±0.57 | ±0.31 | ±0.11 | ±0.42 | ±0.24 | ±0.17 | ±0.41 | ±1.04 | ±1.12 | ±2.16 |
| | 90.00 | 9.00 | 99.00 | 18.00 | 9.20 | 27.20 | 8.00 | 3.50 | 11.50 | 14.30 | 4.50 | 19.20 | 48.00 | 23.00 | 71.00 |
| | ±1.32 | ±0.17 | ±1.49 | ±0.42 | ±0.19 | ±1.01 | ±0.18 | ±0.22 | ±0.40 | ±1.12 | ±0.22 | ±1.34 | ±2.00 | ±1.12 | ±3.12 |
| | 90.00 | 10.15 | 100.15 | 18.00 | 10.20 | 28.20 | 9.00 | 3.50 | 12.50 | 14.30 | 4.70 | 19.40 | 48.00 | 24.00 | 72.00 |
| | ±1.20 | ±0.32 | ±1.52 | ±0.39 | ±0.44 | ±1.23 | ±0.41 | ±0.27 | ±1.08 | ±1.15 | ±0.29 | ±1.44 | ±1.57 | ±1.04 | ±3.01 |
| | 85.00 | 11.20 | 96.20 | 35.00 | 10.50 | 45.50 | 12.00 | 4.50 | 16.50 | 15.40 | 5.00 | 20.40 | 48.00 | 27.00 | 75.00 |
| | ±1.57 | ±0.71 | ±2.28 | ±1.23 | ±1.12 | ±2.35 | ±0.51 | ±0.29 | ±1.20 | ±0.44 | ±0.31 | ±1.15 | ±0.59 | ±1.27 | ±2.26 |
| | 96.20 | 13.15 | 109.35 | 30.00 | 12.50 | 42.50 | 14.15 | 6.70 | 20.85 | 17.00 | 5.50 | 22.50 | 60.00 | 52.00 | 112.00 |
| | ±2.18 | ±0.44 | ±3.02 | ±1.11 | ±0.44 | ±1.55 | ±0.44 | ±1.03 | ±1.47 | ±0.37 | ±0.14 | ±0.51 | ±2.24 | ±1.45 | ±4.09 |
| | 105.00 | 16.50 | 121.50 | 38.00 | 15.50 | 53.50 | 16.20 | 9.00 | 25.20 | 18.20 | 6.80 | 25.40 | 60.00 | 144.00 | 204.00 |
| | ±2.44 | ±1.11 | ±3.55 | ±0.49 | ±0.37 | ±1.26 | ±0.57 | ±0.22 | ±1.19 | ±1.04 | ±0.22 | ±1.24 | ±2.31 | ±4.24 | ±6.55 |

***Mean of 10 individuals; F : Feeding duration; M : Moulting duration; PP : Pre-pupal period T : Total hours of instar***

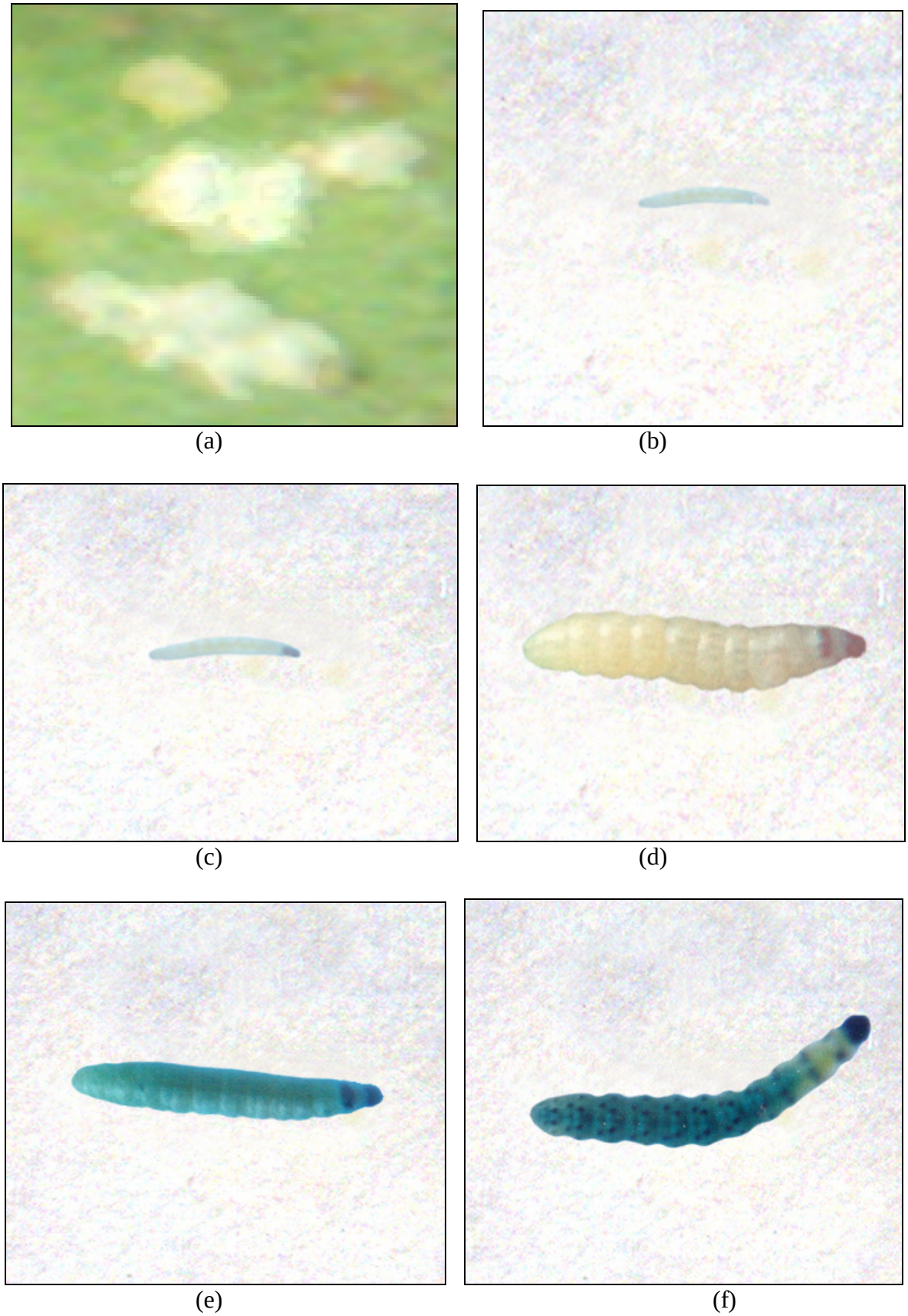
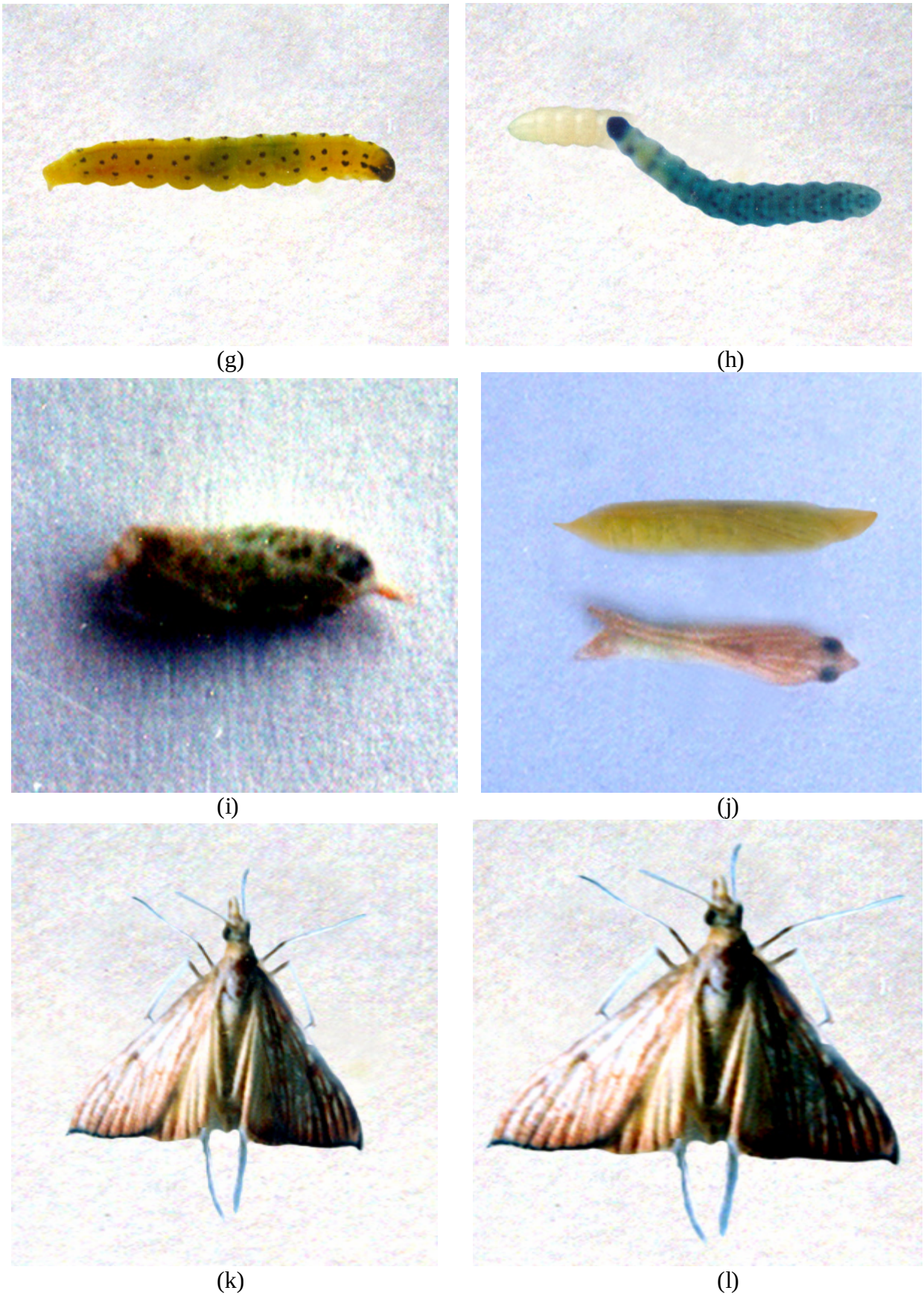


**Fig. 1:** (a) Eggs of *Antigastra catalaunalis* Dup. (b) Neonate larva (c) First instar larva (d) Second instar larva (e) Third instar larva (f) Fourth instar larva



(g) (h)

(i) (j)

(k) (l)

Fig. 1: (g) Fifth instar larva (h) Cannibalism (i) Pre-pupa in silken cocoon (j) Mature pupae (k) Male adult (l) Female adult

(m)

(n)

(o)

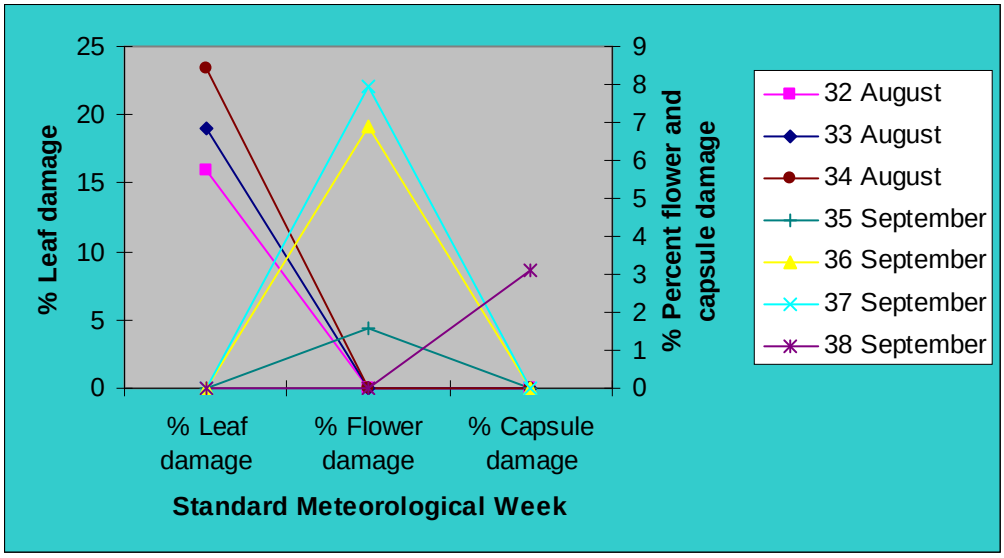
(p)

(q)

(r)

Fig. 1 : (o & p) Damaged plant in the field, by *Antigastra catalaunalis* (Dup.), showing rolled and webbed leaves
(q & r) Damaged flowers by larvae of *Antigastra catalaunalis*

**Fig. 2:** Mean per cent damage of flowers caused by *Antigastra catalaunalis*.

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