



Seasonal Incidence of *Galleria mellonella* in Stored Wax Combs and its Correlation with Weather Parameters

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Abstract: The investigation was carried out at CCS Haryana Agricultural University, Hisar for two years i.e. 2016 and 2017 during June to October. During June, population of larvae of *Galleria mellonella* larvae started increasing till September in both years. However, during October, the number decreased. This pattern of seasonal incidence was same when eight, nine and ten combs were stored in a hive body (chamber). The number of larvae recorded per comb was highest when ten combs were stored in a hive body followed by 9, 8 and 7 combs. During both the years, pupal and adult population in stored combs also increased with from June to September while in October, the cumulative number of pupae and adults decreased. Correlation studies between number of wax moth population (larvae, pupae and adults) in stored combs related to different frame strength with the different weather parameters showed significant positive correlation with maximum RH and maximum temperature, whereas no significant correlation existed with min. temperature, min. RH and number of bright sunshine hours.

Keywords: Fumigation, Wax moth, *Galleria mellonella*

Galleria mellonella is a cosmopolitan, devastating and economically important pest causing serious economic damage to honey bee combs and stored bees wax during storage (Gillard 2009, Ellis and Hayes 2009). Wax moths are nocturnal pest flying at night and hide in dark places during the day time and stored combs are ideal places for breeding of moths. Larva is the most destructive stage of the pest. Besides damaging wax comb, larvae consume bees wax, destroying frames and wooden parts in the hive (Ellis et al 2013). The population of wax moth fluctuates according to weather conditions. Maximum infestation of wax moth was recorded during July to September, generally in the brood frames and occasionally in the super frames. In Sudan, Fathy et al (2017) reported that the high infestation of larvae of the GWM and LWM in storage in May, June and July but pupae and adult of GWM in storage during June to September. Stored combs without fumigation reported maximum infestation of wax moth (Kumari and Jha 2013). Therefore, the present work aimed to study incidence of the *Galleria* in the storage combs.

MATERIAL AND METHODS

All the combs were used for experimental purpose were initially fumigated with aluminium phosphide (Celphos) tablets. For this purpose, 9 combs were placed in each chamber and a stack of 4 chambers were made. The fumigated combs were used for experimental purpose after 7

days. For recording seasonal incidence of greater wax moth in stored combs 7, 8, 9 and 10 empty combs (without bees) were stored in hive bodies which were placed on bottom board and covered with inner cover. Each of the chambers with frames was made air tight by mud plastering to seal cracks and crevices. After making the chamber airtight, it was covered with top cover. Fortnightly observations were recorded on number of larvae, pupae and adults in experimental stored combs. Temperature and relative humidity (%) data were collected from observatory of Department of Agriculture Meteorology, CCS Haryana Agricultural University, Hisar. Each treatment was replicated five times from June to October.

RESULTS AND DISCUSSION

Seasonal incidence of greater wax moth (*G. mellonella*) larvae: During June, 2016 the number of larvae recorded per comb were 1.40 increased till September (29.60 on 30th September). However, during October, the number decreased to 13.60 on 30th October. This pattern of seasonal incidence was same when eight, nine and ten combs were stored in a hive body (chamber) during both years. On 30th October, the number of larvae recorded per comb was highest (13.60) when ten combs were stored in a hive body followed by nine combs in 2017. Mandal and Vishwakarma (2016) reported highest number of egg clusters and larvae of *G. mellonella* infesting *A. mellifera* combs during 37th and 38th

standard week during storage. Fathy et al (2017) reported the abundance of GWM in different months in 2014 highest population activity of the larvae/ colony were in June (36) followed by May (26).

Pupal population of greater wax moth (*G. mellonella*):

During June, 2016 the number of pupae recorded per comb were 0.20 increased till September (26.80 on 30th September). However, during October, the number decreased to 9.40 on 30th October. This pattern of seasonal incidence was same when eight, nine and ten combs were stored in hive body during both years. On 30th October, the number of larvae recorded per comb was highest (12.80) when ten combs were stored in a hive body followed by nine, eight comb and seven comb stored in 2017. Mandal and Vishwakarma (2016) indicated that the highest number of pupae (23.67) of *G. mellonella* infesting *A. mellifera* combs

was observed during 37th and 38th standard week in changing environmental conditions. The highest number of GWM pupae (89.67) was observed in September.

Adult population of greater wax moth (*G. mellonella*):

During June, 2016 the number of adult recorded per comb were 0.00 increased till September (26.00 on 30th September). However, during October, the number decreased to 8.20 on 30th October. This pattern of seasonal incidence was same when eight, nine and ten combs were stored in hive body during both years. On 30th October, the number of adults per comb was highest (11.00) when ten combs were stored in a hive body followed by nine, eight comb and seven comb stored in 2017. Mandal and Vishwakarma (2016) indicated that the highest number of adult (8.00) of *G. mellonella* infesting *A. mellifera* combs was during 37th and 38th standard week during storage. The

Table 1. Seasonal incidence of Greater wax moth (*G. mellonella*) larvae during June to October in stored combs during 2016 and 2017

| Number of combs in hive body | Cumulative number of larvae/comb during different months of 2016 | | | | | | | | | | Mean |
|------------------------------|--|----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| | June | | July | | August | | September | | October | | |
| | 15.6.16 | 30.6.16 | 15.7.16 | 30.7.16 | 15.8.16 | 30.8.16 | 15.9.16 | 30.9.16 | 15.10.16 | 30.10.16 | |
| Seven | 1.40 (1.54) | 3.00 (1.98) | 5.60 (2.54) | 12.20 (3.61) | 19.40 (4.51) | 24.00 (4.98) | 27.20 (5.29) | 29.60 (5.50) | 20.00 (4.58) | 13.60 (3.81) | 15.60 (3.83) |
| Eight | 1.80 (1.65) | 3.80 (2.17) | 6.20 (2.66) | 15.00 (3.99) | 20.40 (4.60) | 25.20 (5.11) | 28.40 (5.41) | 31.00 (5.6) | 24.40 (5.03) | 13.80 (3.84) | 17.00 (4.01) |
| Nine | 2.40 (1.82) | 4.00 (2.23) | 7.60 (2.89) | 16.60 (4.19) | 23.00 (4.88) | 26.60 (5.23) | 33.20 (5.83) | 35.40 (6.03) | 24.80 (5.06) | 16.60 (4.16) | 19.02 (4.23) |
| Ten | 2.80 (1.92) | 4.60 (2.36) | 9.80 (3.24) | 18.20 (4.37) | 25.80 (5.17) | 29.00 (5.47) | 32.80 (5.80) | 36.40 (6.11) | 25.60 (5.15) | 16.80 (4.21) | 20.18 (4.38) |
| Mean | 2.10 (1.73) | 3.85 (2.19) | 7.30 (2.83) | 15.50 (4.04) | 22.15 (4.79) | 26.20 (5.20) | 30.40 (5.58) | 33.10 (5.82) | 23.70 (4.95) | 15.20 (4.01) | - |
| Factors | | | | C.D. | | | SE(d) | | | SE(m) | |
| Month | | | | 0.11 | | | 0.05 | | | 0.04 | |
| Combs | | | | 0.18 | | | 0.09 | | | 0.06 | |
| Month × Combs | | | | 0.36 | | | 0.18 | | | 0.12 | |
| | Cumulative number of larvae/comb during different months of 2017 | | | | | | | | | | Mean |
| | June | | July | | August | | September | | October | | |
| | 15.6.17 | 30.6.17 | 15.7.17 | 30.7.17 | 15.8.17 | 30.8.17 | 15.9.17 | 30.9.17 | 15.10.17 | 30.10.17 | |
| Seven | 1.80 (1.66) | 3.20 (2.04) | 6.00 (2.61) | 12.60 (3.66) | 19.80 (4.55) | 25.00 (5.08) | 28.20 (5.38) | 30.20 (5.55) | 22.60 (4.48) | 14.40 (3.91) | 16.38 (3.93) |
| Eight | 2.00 (1.72) | 4.00 (2.32) | 6.40 (2.70) | 15.80 (4.09) | 21.80 (4.75) | 26.80 (5.26) | 28.80 (5.44) | 31.20 (5.66) | 25.40 (5.13) | 15.00 (3.99) | 17.72 (4.10) |
| Nine | 2.80 (1.92) | 4.20 (2.27) | 7.80 (2.93) | 17.00 (4.23) | 23.80 (4.97) | 27.60 (5.33) | 31.60 (5.69) | 34.80 (5.98) | 26.40 (5.22) | 16.80 (4.21) | 19.28 (4.28) |
| Ten | 3.00 (1.96) | 4.80 (2.40) | 10.20 (3.30) | 20.20 (4.59) | 26.80 (5.26) | 30.20 (5.58) | 32.20 (5.75) | 35.60 (6.04) | 27.60 (5.33) | 17.20 (4.26) | 20.78 (4.45) |
| Mean | 2.40 (1.82) | 4.05 (2.37) | 7.60 (2.89) | 16.40 (4.14) | 23.05 (4.88) | 27.40 (5.31) | 30.20 (5.57) | 32.95 (5.81) | 25.50 (5.13) | 15.85 (4.09) | - |
| Factors | | | | C.D. | | | SE(d) | | | SE(m) | |
| Month | | | | 0.11 | | | 0.05 | | | 0.04 | |
| Combs | | | | 0.18 | | | 0.09 | | | 0.06 | |
| Month × Combs | | | | 0.36 | | | 0.18 | | | 0.12 | |

Figures in parentheses are $\sqrt{(n+1)}$ transformed value

highest number (30.67) of GWM adults were observed in September/. The peak month population was in September 22.01% of total population of the adults. Fathy et al (2017) observed number of wax moths changed greatly in different months.

Correlation between weather parameters and Greater wax moth (*G. mellonella*) incidence in stored comb:

During both years, the greater wax moth's larvae starts infesting combs from first fortnight of June and progressively to acquire peak in September in 7, 8, 9 and 10 combs/hive. During September, average of weather parameters of both years were recorded as maximum temperature (35.07°C), minimum temperature (23.63°C), maximum RH (86.72%), minimum RH (51.85%) and number of bright sunshine hour (7.84 hour). During this period, the weather condition for the development of the greater wax moth was very congenial. In June, the average of different weather parameters recorded

as maximum temperature (40.2°C), minimum temperature (26.2°C), maximum RH (66.45%), minimum RH (35.3%) and number of bright sunshine hour (8.15 hour). Correlation between number of larvae and weather parameters were positive and significant for minimum temperature and maximum R), positive and highly significant for minimum R). Correlation did not exist between number of larvae and maximum temperature and bright sunshine hours.

The correlation between number of pupae and minimum RH was positive and highly significant. Correlation did not exist between pupal population and weather parameters such as maximum temperature, minimum temperature, maximum RH and bright sunshine hours. The correlation between number of adults and weather parameters were positive and significant for minimum temperature and positive and highly significant for maximum RH, whereas no correlation existed between number of adults and weather

Table 2. Pupal population of Greater wax moth (*G. mellonella*) during June to October in stored combs during 2016 and 2017

| Number of combs in hive body | Cumulative number of pupae/comb during different months of 2016 | | | | | | | | | | Mean |
|------------------------------|---|----------------|----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| | June | | July | | August | | September | | October | | |
| | 15.6.16 | 30.6.16 | 15.7.16 | 30.7.16 | 15.8.16 | 30.8.16 | 15.9.16 | 30.9.16 | 15.10.16 | 30.10.16 | |
| Seven | 0.20 (1.08) | 1.40 (1.54) | 2.80 (1.93) | 8.20 (3.02) | 12.80 (3.70) | 21.40 (4.68) | 25.80 (5.15) | 26.80 (5.25) | 19.60 (4.52) | 9.40 (3.21) | 12.86 (3.41) |
| Eight | 0.40 (1.14) | 2.20 (1.76) | 3.00 (1.99) | 12.00 (3.59) | 19.20 (4.46) | 23.40 (4.92) | 26.60 (5.25) | 27.40 (5.32) | 20.00 (4.57) | 10.40 (3.36) | 14.44 (3.63) |
| Nine | 1.00 (1.34) | 3.80 (2.18) | 4.60 (2.36) | 14.60 (3.94) | 20.80 (4.66) | 24.40 (5.03) | 30.60 (5.60) | 33.00 (5.82) | 22.80 (4.87) | 10.80 (3.42) | 16.64 (3.92) |
| Ten | 1.40 (1.54) | 4.80 (2.39) | 6.00 (2.64) | 15.20 (4.01) | 23.00 (4.89) | 27.40 (5.32) | 32.20 (5.75) | 34.80 (5.98) | 23.80 (4.97) | 12.80 (3.71) | 18.14 (4.12) |
| Mean | 0.75 (1.27) | 3.05 (1.97) | 4.10 (2.23) | 12.50 (3.64) | 18.95 (4.43) | 24.15 (4.99) | 28.20 (5.44) | 30.50 (5.59) | 21.55 (4.73) | 10.85 (3.43) | - |
| Factors | | | | C.D. | | | SE(d) | | | SE(m) | |
| Month | | | | 0.12 | | | 0.06 | | | 0.04 | |
| Combs | | | | 0.20 | | | 0.10 | | | 0.07 | |
| Month × Combs | | | | 0.40 | | | 0.20 | | | 0.14 | |
| | Cumulative number of pupae/comb during different months of 2017 | | | | | | | | | | Mean |
| | June | | July | | August | | September | | October | | |
| | 15.6.17 | 30.6.17 | 15.7.17 | 30.7.17 | 15.8.17 | 30.8.17 | 15.9.17 | 30.9.17 | 15.10.17 | 30.10.17 | |
| Seven | 0.60 (1.22) | 1.80 (1.65) | 3.00 (1.97) | 8.80 (3.11) | 13.60 (3.80) | 21.00 (5.64) | 26.20 (5.20) | 27.60 (5.32) | 20.00 (4.56) | 10.40 (3.36) | 13.30 (3.48) |
| Eight | 1.00 (1.41) | 2.00 (1.70) | 3.40 (2.08) | 12.80 (3.70) | 19.80 (4.52) | 24.80 (5.06) | 27.00 (5.28) | 28.40 (5.41) | 21.20 (4.71) | 11.20 (3.49) | 15.16 (3.74) |
| Nine | 1.20 (1.39) | 4.00 (2.23) | 4.80 (2.40) | 15.00 (3.99) | 21.60 (4.75) | 25.60 (5.15) | 30.20 (5.57) | 33.20 (5.84) | 23.80 (4.97) | 12.40 (3.65) | 17.18 (3.99) |
| Ten | 1.40 (1.47) | 5.00 (2.44) | 6.40 (2.71) | 17.20 (4.25) | 25.00 (5.09) | 27.20 (5.30) | 32.60 (5.79) | 34.40 (5.94) | 24.40 (5.03) | 13.60 (3.81) | 18.72 (4.18) |
| Mean | 1.05 (1.37) | 3.20 (2.01) | 4.40 (2.29) | 13.45 (3.76) | 20.00 (4.54) | 24.65 (5.04) | 29.00 (5.46) | 30.90 (5.63) | 22.35 (4.82) | 11.90 (3.58) | - |
| Factors | | | | C.D. | | | SE(d) | | | SE(m) | |
| Month | | | | 0.13 | | | 0.06 | | | 0.04 | |
| Combs | | | | 0.20 | | | 0.10 | | | 0.07 | |
| Month × Combs | | | | 0.41 | | | 0.20 | | | 0.14 | |

Figures in parentheses are $\sqrt{(n+1)}$ transformed value

parameters as maximum temperature, minimum RH and bright sunshine hour. In 8 combs stored per hive, the correlation between number of larvae and weather parameters were positive and highly significant for minimum temperature, maximum RH, minimum RH and negative and significant for bright sunshine hours. Correlation did not exist between larvae and maximum temperature. The correlation between number of pupae and weather parameters were positive and highly significant for minimum temperature, maximum R), minimum RH and negative and significant for bright sunshine hour. Correlation did not exist between number of pupae and maximum temperature. The correlation between number of adults and weather parameters were positive and highly significant for minimum temperature, minimum RH, positive and significant for maximum RH, whereas negative and significant for bright sunshine hour. No

correlation existed between adult and maximum temperature. In 9 combs stored per hive. The correlation between number of larvae and weather parameters were found positive and highly significant for maximum temperature, minimum RH and positive and significant for maximum RH. The correlation between number of pupae and weather parameters were positive and highly significant for minimum RH and positive and significant for minimum temperature. No correlation existed between number of pupae and weather parameters for maximum temperature, maximum RH and bright sunshine hours. In 10 frame stored in hive body, the correlation between number of larvae and weather parameters was found positive and highly significant for minimum RH ($r= 0.311$) but no correlation existed between larval and weather parameters. The correlation between number of pupae and weather parameters were

Table 3. Seasonal incidence of Greater wax moth (*G. mellonella*) adult during June to October in stored combs during 2016 and 2017

| Number of combs in hive body | Cumulative number of adults/comb during different months of 2016 | | | | | | | | | | Mean |
|------------------------------|--|----------------|----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| | June | | July | | August | | September | | October | | |
| | 15.6.16 | 30.6.16 | 15.7.16 | 30.7.16 | 15.8.16 | 30.8.16 | 15.9.16 | 30.9.16 | 15.10.16 | 30.10.16 | |
| Seven | 0.00 (1.00) | 1.00 (1.37) | 1.40 (1.53) | 6.00 (2.63) | 11.60 (3.53) | 17.60 (4.29) | 23.40 (4.93) | 26.00 (5.18) | 15.20 (4.01) | 8.20 (3.02) | 11.04 (3.15) |
| Eight | 0.40 (1.16) | 1.40 (1.54) | 2.80 (1.94) | 9.40 (3.21) | 16.80 (4.21) | 20.40 (4.62) | 24.00 (4.99) | 27.00 (5.27) | 16.60 (4.18) | 8.80 (3.12) | 12.76 (3.42) |
| Nine | 0.80 (1.29) | 3.00 (1.98) | 4.00 (2.23) | 11.80 (3.56) | 18.80 (4.44) | 22.80 (4.87) | 25.20 (5.11) | 30.20 (5.56) | 19.40 (4.50) | 9.80 (3.28) | 14.58 (4.68) |
| Ten | 1.20 (1.47) | 3.20 (2.03) | 4.40 (2.31) | 14.60 (3.94) | 19.80 (4.55) | 23.20 (4.91) | 27.80 (5.36) | 32.40 (5.77) | 19.60 (4.51) | 10.40 (3.37) | 15.66 (3.82) |
| Mean | 0.60 (1.23) | 2.15 (1.73) | 3.15 (2.00) | 10.45 (3.34) | 16.75 (4.18) | 21.00 (4.67) | 25.10 (5.09) | 28.90 (5.45) | 17.70 (4.30) | 9.30 (3.20) | - |
| Factors | | | | C.D. | | | SE(d) | | | SE(m) | |
| Month | | | | 0.11 | | | 0.06 | | | 0.04 | |
| Combs | | | | 0.18 | | | 0.09 | | | 0.06 | |
| Month × Combs | | | | 0.36 | | | 0.18 | | | 0.13 | |
| | Cumulative number of adults/comb during different months of 2017 | | | | | | | | | | Mean |
| | June | | July | | August | | September | | October | | |
| | 15.6.17 | 30.6.17 | 15.7.17 | 30.7.17 | 15.8.17 | 30.8.17 | 15.9.17 | 30.9.17 | 15.10.17 | 30.10.17 | |
| Seven | 0.00 (1.00) | 1.60 (1.61) | 2.00 (1.71) | 6.40 (2.71) | 12.60 (3.68) | 18.80 (4.42) | 25.00 (5.09) | 27.00 (5.27) | 16.80 (4.19) | 9.00 (3.14) | 11.92 (3.28) |
| Eight | 0.60 (1.24) | 1.80 (1.65) | 2.60 (1.89) | 9.60 (3.24) | 17.80 (4.31) | 20.80 (4.66) | 25.40 (5.13) | 27.80 (5.35) | 17.40 (4.27) | 9.20 (3.19) | 13.30 (3.49) |
| Nine | 1.00 (1.34) | 3.40 (2.09) | 4.20 (2.27) | 12.20 (3.62) | 20.40 (4.62) | 23.80 (4.97) | 26.00 (5.18) | 31.60 (5.70) | 20.80 (4.65) | 10.80 (3.42) | 15.42 (3.79) |
| Ten | 1.00 (1.39) | 4.20 (2.26) | 4.80 (2.40) | 15.80 (4.08) | 21.40 (4.73) | 24.00 (4.99) | 28.40 (5.41) | 32.40 (5.77) | 20.80 (4.64) | 11.00 (3.45) | 16.38 (3.91) |
| Mean | 0.65 (1.24) | 2.75 (1.90) | 3.40 (2.07) | 11.00 (3.41) | 18.05 (4.33) | 21.85 (3.76) | 26.20 (5.20) | 29.70 (5.52) | 18.95 (4.44) | 10.00 (3.30) | - |
| Factors | | | | C.D. | | | SE(d) | | | SE(m) | |
| Month | | | | 0.12 | | | 0.06 | | | 0.04 | |
| Combs | | | | 0.19 | | | 0.10 | | | 0.07 | |
| Month × Combs | | | | 0.39 | | | 0.20 | | | 0.14 | |

Figures in parentheses are $\sqrt{(n+1)}$ transformed value

Table 4. Correlation between weather parameters and greater wax moth, *Galleria mellonella* in stored comb (without bees) with different strength during both years

| Weather parameters | Number of empty combs group/ hive body/ chamber during both years | | | | | | | | | | | |
|----------------------|---|---------|--------|---------|---------|---------|---------|---------|---------|----------|---------|---------|
| | 7 frame | | | 8 frame | | | 9 frame | | | 10 frame | | |
| | Larvae | Pupae | Adults | Larvae | Pupae | Adults | Larvae | Pupae | Adults | Larvae | Pupae | Adults |
| Max. temp (°C) | 0.138* | 0.122 | 0.119 | 0.170 | 0.162 | 0.194 | 0.214 | 0.186 | 0.146 | 0.192 | 0.143* | 0.214 |
| Min. temp. (°C) | 0.252 | 0.237 | 0.217 | 0.327** | 0.289** | 0.377** | 0.380** | 0.378** | 0.332** | 0.353* | 0.251* | 0.389* |
| Max. RH (%) | 0.356** | 0.373** | 0.265* | 0.438** | 0.343** | 0.455** | 0.462** | 0.469* | 0.386** | 0.468** | 0.350** | 0.451** |
| Min. RH (%) | 0.223 | 0.207 | 0.121* | 0.301** | 0.200 | 0.257* | 0.264** | 0.270* | 0.224 | 0.311* | 0.196 | 0.194 |
| Bright sunshine (hr) | -0.083 | -0.09 | -0.076 | -0.138 | -0.164 | -0.189* | -0.164* | -0.248 | -0.236 | -0.149 | -0.046 | -0.112 |

found positive and highly significant for minimum RH. No correlation existed between number of pupae and maximum temperature, minimum temperature, maximum RH and bright sunshine hour. The correlation between number of adults and weather parameters were positive and significant for minimum R). Correlation also did not exist between adult and weather parameters such as maximum temperature, minimum temperature, RH and number of bright sunshine hour. Mandal and Vishwakarma (2016) reported positive and significant in maximum temperature, minimum temperature and minimum relative humidity with the larval population of GWM per hive, whereas the negative non-significant correlation with the maximum relative humidity and positive non-significant correlation with rainfall. Therefore, it is concluded that the GWM population were positively correlated with temperature and minimum relative humidity.

CONCLUSIONS

During both the years, larval, pupal and adult population in stored combs increased with the passage of time from June to September. However, in October, the cumulative number of larvae, pupae and adults decreased. Larval, pupal and adult population was highest when ten combs were stored followed by 9, 8 and 7 combs. Correlation studies between

number of greater wax moth population in stored combs related to different frame strength with the different weather parameters and showed significant positive correlation with maximum RH and maximum temperature, whereas no significant correlation existed with minimum temperature, minimum RH and sunshine hours during both the years.

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