Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2018; 6(3): 444-447

Received: 01-03-2018
Accepted: 02-04-2018

Gourav Kumar
Department of Entomology, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India

MS Khan
Department of Entomology, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India

Correspondence
Gourav Kumar
Department of Entomology, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India

Study of the life cycle of greater wax moth (*Galleria mellonella)* under storage conditions in relation to different weather conditions

Gourav Kumar and MS Khan

Abstract
Wax moths are serious pests of beeswax worldwide. The wax moth belongs to the subfamily Galleriinae of the family Pyralidae, order Lepidoptera. In the experiment that was carried out at G.B. Pant University of Agriculture and Technology, Pantnagar during 2013-2014, life cycle of the Greater wax moth was studied under different weather conditions. During the period of study fecundity, incubation period, Percent hatching, larval period, pupal period and adult longevity showed considerable variation under different weather conditions. The total developmental period from egg laying to adult emergence was longest at room temperature from December, 2012 to February, 2013 (2.5 ºC to 24 ºC temperature, 44% to 100% RH with food scarcity), while significantly short life cycle was observed inside the incubator (28±2 ^{0}C temperature and 65±5% RH). Lowest percentage of emerged adults was seen at room temperature and maximum adult emergence was seen inside the incubator.

Keywords: Wax moth, life cycle, pest of beeswax, weather parameters

Introduction
Greater Wax Moth causes the greatest damage in apiaries which lead to financial losses every year. Besides, it damages wax combs by larval feeding and destroy frames and wooden parts in the hive. Almost all colonies of Asian honeybees are prone to moth infestation [1-3].
Marston *et al.* [4] studied that wax moth population starts building from March, reaching its peak in August (99- 100%) and then show decline till February. The developmental cycle of *Galleria mellonella* varies from 4 weeks to 6 months. In the longer cycle, dormancy takes place in the pre-pupal stage.
The life cycle is completed in four stages *viz.*, egg, larva, pupa and adult stage. Adult moths emerging from active honey bee colonies leave the hive in order to mate [5]. Male and female wax moths mate and the female lay 300-600 eggs in a cluster on the comb within four to five days [6]. These eggs are laid in cracks between hive parts, in dark and hidden places [7]. The eggs generally hatch in 5 to 8 days or 8 to 10 days after being laid, but at low temperatures this period may be up to 30 days [4]. The newly hatched larvae tunnel into the combs, leaving a complex of silken galleries behind.
Laboratory studies showed that newly hatched larvae of *Galleria mellonella* can be found up to 50 m away from their hatching site [8]. Larva moults 4 to 6 times in its life. Larval period is between 22 to 60 days [9, 10], sometimes extending up to 100 days depending on abiotic factors [11]. Pupa is brownish white (young) to dark brown (old), 14 to 16 mm long in size. Pupal period is of 7 to 60 days [9, 10]. Adult moths are grayish to purplish brown, have dark markings and lead-colored tips on the forewings, pale brownish or yellowish hind wings and a wingspan of about 1 to 1.25 inch [12]. Adult moths are 10- 18 mm in length. Females are larger and heavier than males. In females, outer margin of fore wing is smooth while semi-lunar notch is found in males [13, 9, 14].
The population of wax moth fluctuates according to weather conditions [16]. A brief exposure of *Galleria mellonella* eggs to extreme temperatures (above 46 °C or below 0 °C) causes 100% mortality. Observations show that *Galleria mellonella* caterpillars are highly resistant to food shortage, but under deficient food conditions, their development (from egg to adult) may be extended up to 6 months. Adult insects from poorly nourished caterpillars are smaller with decreased vitality [4]. In the absence of adequate food supplies the larvae of *Galleria mellonella* become cannibalistic [16].

Materials and Methods

The experiments were carried out in Apiculture lab, Department of Entomology, Govind Ballabh Pant University of Agriculture & Technology, Pantnagar, Udham Singh Nagar- 263145 (Uttarakhand) to study the life cycle and management of Greater Wax Moth (*Galleria mellonella*) in *Apis mellifera* combs under storage conditions during the year 2012-2013. The experiment was laid in four treatments and three replications in completely randomized design. The experiment included 12 combs with dimensions 17x8 cm^2. The number of larvae was kept up to ten to avoid cannibalism among the insects.

Pantnagar is located in the sub-tropical zone at 29' North latitude79.30' East longitude and at an altitude of 243.84 m above mean sea level in the "*Tarai"* region of Uttarakhand in Northern India. The climate is humid, subtropical with maximum temperature ranging from 32 ºC to 45 ºC during summer and minimum temperature ranging from 0º to 9 ºC during winter season. The maximum and minimum temperatures, relative humidity at I hr (07: 12 AM) and at II hr (02:12 PM); rainfall and the number of bright sunshine hours during the period of experimentation from July to August 2012, December 2012 to January 2013 at the University meteorological observatory are presented in Appendix I.

Naturally-infested wax combs of *Apis mellifera* with Greater Wax Moth were obtained from the hives of apiary of G.B Pant University and were taken to a rearing chamber in the same Faculty. To ascertain pure culture, infested wax combs (feeding medium) were cut and transferred to clean 5 kg-glass jars covered with muslin cloth. These jars were supplemented with the wax from old combs as food for developing larvae. They were reared under laboratory conditions for adult emergence to be used for species identification. Emerged moths were then transferred to new jars fortified with uninfected waxes and to copulate and lay eggs. Cuttings of a hard white paper folded at several angles were transferred to the jars to provide the female the site of egg laying. Rearing and treatments were conducted at room conditions (28±5 °C temperature and 65±5% RH).

Since wax moth infestation is at its peak during monsoon season, to study the life cycle and effect of weather conditions on the developmental stages, the period of observation was kept from July to August during the summer season and December to January during the winter season. During this period following observations were recorded:

The morphological (shape, size and colour) analysis was done and number of eggs laid by a single female in one batch was recorded. Number of eggs per unit area was counted in case of larger layings in a single batch. Again the number of eggs laid and eggs morphology was recorded during winter season. One batch of eggs laid by wax moth female was kept inside the incubator. The temperature was kept at 28±2 °C and a relative humidity of 65±5% was maintained. To maintain the relative humidity, a dish with absorbent cotton dipped in water was kept inside the incubator. The other batch of eggs was kept on room temperature. The time taken and uniformity in hatching was recorded separately for both the conditions. During winter season incubation period was recorded at room temperature.

Ten larvae of the same age (2^{nd} instar) were selected randomly and kept in separate jars in three replicates. During summer season, they were provided with necessary food, and the larval period was recorded at room conditions. During winter season, two types of observation were taken; the larval period was recorded for those larvae which were provided with adequate food all through their development and those with scarcity of food in later instars. The total time taken from pupation to adult emergence was observed and recorded. Number of adults emerged from these pupae were recorded along with the life of adults in two different weather conditions.

Results and discussion

Life cycle of the greater wax moth was studied under storage conditions during the year 2012 and 2013 under different weather conditions. The egg laying capacity (fecundity), time (days) taken in hatching (incubation period), Percent hatching, larval period, pupal period and life span of adults (adult longevity) were the parameters for which observations were recorded. Four different weather conditions *viz.*, T1: at room temperature in July-August, 2012 (24.8 ºC to 34.5 ºC temperature, 61% to 91% RH), T2: inside the incubator (28±2 ^{0}C temperature and 65±5% RH), T3: at room temperature from December, 2012 to February, 2013 (2.5 ºC to 24 ºC temperature, 44% to 100% RH with availability of proper food) and T4: at room temperature from December, 2012 to February, 2013 (2.5 ºC to 24 ºC temperature, 44% to 100% RH with food scarcity) were taken as different treatments.

Fecundity

The freshly laid eggs were shiny white in colour and later became brownish and dull. Fecundity (eggs/female) varied under different weather conditions. Highest average number of eggs (208.33 eggs/female) was recorded under T2 incubated conditions (28±2 ^{0}C temperature and 65±5% RH) (Table 1). Lowest fecundity (145.66 eggs/female) was observed in T4, during December (5.7 ºC to 24 ºC temperature, RH 44% to 97%, food shortage). The mean fecundity of the all four treatments was calculated as 175.58eggs/female. During, July 2012 (25.2 ºC to 34.5 ºC temperature, 61% to 90% RH), the average fecundity of wax moth (194 eggs/ female) was recorded significantly reduced as compared to (208.33 eggs/female) in T2 (incubator with 28±2 ^{0}C temperature and 65±5% RH). The reduced fecundity of female wax moth during the month of December is due to the unfavourable weather conditions (5.7 ºC to 24 ºC temperature, RH 44% to 97%) (Table 1).

The observations about the fecundity are nearly the same as reported by Opoosun and Odebiyi [17] who reported that the females had an average oviposition period of 5.8 days and fecundity of 220.4 eggs/ female, more than 50% of which were laid within the first 2 days. However, present findings that a female lays average 208.33 eggs under ideal conditions, are in contrast to those of observed by El-Sawaf [18] who observed that the eggs were laid in masses and fertilized females deposited 500-1800 each. Knoxfield [6] reported that male and female of greater wax moths mate and the female lay 300-600 eggs in a cluster on the comb within four to five days, while present findings suggest that the average number of eggs laid vary from 145.66 in December (5.7 ºC to 24 ºC temperature, RH 44% to 97%) to 208.33 in incubator (28±2 ^{0}C temperature and 65±5% RH).

Incubation period and Percent hatching

The results on incubation period of *Galleria mellonella* (L.) showed difference between all the weather conditions during 2012 and 2013. The average incubation period varied from minimum (4.66 days) in T2: Incubator (28±2 ^{0}C temperature and 65±5% RH) to maximum (14.33 days) in T3 (December

with 5.7 ºC to 24 ºC temperature, RH 44% to 97%, food available). The mean incubation period of all treatments was 9.99 days. The treatments T3 and T4 were at par as they showed no significant difference with each other. However, T3 and T4 showed a significantly longer incubation period when compared with 6.33 days in T1: July (25.2 ºC to 34.5 ºC temperature, 61% to 90% RH) and 4.66 days in T2. The treatments T1 (6.33) and T2 (4.66) were statistically equal to each other. The variation in incubation period under different treatments may be due to lower temperature during December (5.7 ºC to 24 ºC temperature, RH 44% to 97%), which delayed the hatching of eggs (Table 1).

These results are supported by Opoosun and Odebiyi [17], who reported that the egg of wax moth lasts for 9.5 days. Present findings showed a slight difference from those of El-Sawaf [18], who reported that the egg-stage lasted 9-10 days in summer and autumn, and 17 days in spring.

Number of eggs from which larvae emerged, out of the total number of eggs were counted and Percent hatching under different conditions was calculated. The highest percentage of hatching (96.06%) was seen in case of T2: Incubator conditions (28±2 ^{0}C temperature, 65±5% RH) and the minimum Percent hatching (78.42%) was seen in T3: during December (5.7 ºC to 24 ºC temperature, RH 44% to 97%, food available). The mean percent hatching was observed as 86.64%. This difference in Percent hatching among these different weather conditions was due to variation in temperature (5.7 ^{0}C to 34.5 ^{0}C). Inside the incubator, the temperature was kept constant at 28±2 ^{0}C as it is considered to be the most favourable for the development of the greater wax moth, *Galleria mellonella* (L.). The lower temperature during December (5.7 ºC to 24 ºC) resulted into least Percent hatching as it was unfavourable for the greater wax moth development (Table 1).

Larval period

The average larval period (days) of *Galleria mellonella* (L.) varied from minimum (17.7 days) in T3: December-February (5.7 ºC to 24 ºC temperature, 44% to 100% RH, with food availability) to maximum (29.69 days) in T4: December-February (2.5 ºC to 24 ºC temperature, 44% to 100% RH, with food scarcity). The mean larval period was 21.28 days. The treatments T1, T2 and T3 were at par and showed statistically equal larval period (19.46, 18 and 17.7 days, respectively). But T4 (29.96) showed a significantly longer larval period when compared to T1, T2 and T3. From December, 2012 to February, 2013 the larvae which were supplied with proper food underwent pupation within 17-18 days because of unfavourable weather conditions, while those with food scarcity (after second instar) ceased their further development and continued to hibernate in the larval stage itself. These larvae covered their bodies with silken material and faecal matter to protect their bodies from direct exposure to cold, hence proved an escape mechanism to avoid death in immature stages. Their bodies turned black and only few of them undergone pupation but the adults emerged from these pupae were either smaller in size or their bodies were distorted. During summer season (July-August) mean larval period of *Galleria mellonella* (L.) was recorded as 19.46 days at room conditions (24.8 ºC to 34.5 ºC temperature, 61% to 91% RH), and 18 days in Incubator (28±2 ^{0}C temperature, 65±5% RH). The variation in temperature (28 ^{0}C to 34.5 ^{0}C) between the two conditions resulted in variation of larval period from their mean larval period (18.73) (Table 1).

These results are in agreement with Abrol and Kakroo [19], who reported that the larval stage may only take 20 days when food and temperature are ideal. The results shown by Opoosun and Odebiyi [18], described the larval stage of the greater wax moth lasted for about 22.7 days (1st instar, 4.3 days; 2nd instar, 3.9 days; 3rd instar, 2.9 days; 4th instar, 2.7 days; 5th instar, 2.8 days; 6th instar, 3.4 days; 7th instar, 2.7 days), also supported our findings.

Pupal period, Percent adult emergence and adult longevity

When the larvae reached to maturity they started to pupate in a coarser silk with which they make a cocoon that is papery in texture and was very strong. The colour of the cocoon is normally white. The pupal period of *G. mellonella* varied from minimum (9.09 days) in T2: Incubator (28±2 ^{0}C temperature, 65±5% RH) to maximum (49.52 days) in T4: winter (2.5 ºC to 24 ºC temperature, 44% to 100% RH, with food scarcity). The mean pupal period was recorded as 26.01 days. Observations showed longest pupal period (49.52 days) in T4 which was significantly higher when compared to T1 and T2. This may be the result of incomplete development of larvae since the temperature was unfavourable and the food was short. The temperature from December, 2012 to February, 2013 went on decreasing and the pupae ceased the development to escape this unfavourable and lethal weather (Table 1).

These results are similar to those put forth by El-Sawaf [18], who reported that the pupal stage lasted 8-11 days in the May-June generations and 12-49 days in the overwintering generations. Opoosun and Odebiyi [17] reported that the pupal period lasted for 25.4 days.

Number of adults emerged during the experiment was counted and Percent adult emergence was calculated. The highest Percent adult emergence (89.62) was recorded in T2: Incubator (28±2 ^{0}C temperature, 65±5% RH), while the lowest Percent adult emergence (58.33) was recorded in T4: winter (2.5 ºC to 24 ºC temperature, 44% to 100% RH, with food scarcity). Mean adult emergence was recorded as 76.02. The treatments T1, T2 and T3 were at par. Life span of adult moths showed a little difference under different weather conditions and it was recorded minimum (10.48 days) in T3: during winter season (2.5 ºC to 24 ºC temperature, 44% to 100% RH, with food), followed by 10.91 days in T4: December February (with food shortage) and 13.2 days in T2: Incubator conditions (28±2 ^{0}C temperature, 65±5% RH). The maximum adult longevity (13.63 days) was observed in T1: during July-August (24.8 ºC to 34.5 ºC temperature, 61% to 91% RH). The adult longevity during different conditions did not differ significantly (Table 1).

These results are in accordance to El-Sawaf [18], who told that the males of *Galleria mellonella* L., survived in the laboratory without food for 21-30 days and females for 8-15 days. Opoosun and Odebiyi [17], who reported that the longevity of adult was 10.6 days for mated females and 11.1 days for mated males of *Galleria mellonella* L., also support our findings during present studies.

Table 1: Life Cycle of The Greater Wax Moth, *Galleria mellonella* L. under different weather conditions.

Treatments	Fecundity (n=3)	Incubation period (days)	Percent Hatching	Larval period (days)	Pupal period (days)	Total development period (days) from egg to adult emergence	Percent adult emergence	Longevity of Adults (days)
T1 (At Room conditions in July-August)	194[b]	6.33[a]	93.1[b]	19.46[a]	11.45[a]	37.24	82.5[b]	13.63[a]
T2 (Incubator at 28±2 ^{0}C temperature, 65±5% RH)	208.33[c]	4.66[a]	96.06[b]	18[a]	9.09[a]	31.75	89.62[b]	13.32[a]
T3 (December-February, with food availability)	154.33[a]	14.33[c]	78.42[a]	17.7[a]	34.01[b]	66.04	73.66[a]	10.48[a]
T4 (December-February, food scarcity)	145.66[a]	13.12[c]	78.98[a]	29.96[b]	49.52[b]	92.6	58.33[ab]	10.91[a]
Mean	175.58	9.99	86.64	21.28	26.01	56.90	76.02	12.08
SEM	4.22	1.004	1.17	1.20	1.65	-	5.46	1.09
CD at 5%	14.61	3.47	4.06	4.16	5.7	-	18.88	3.78

Conclusion

The results on developmental period from egg to adult and adult longevity are depicted in the Table 1. The total developmental period (days) from egg laying to adult emergence varied from minimum 31.75 in T2: Incubator (28±2 ^{0}C temperature, 65±5% RH) to maximum 92.6 in T4: winter (2.5 ^{o}C to 24 ^{o}C temperature, 44% to 100% RH, with food scarcity). Overall results on incubation period, larval period, pupal period and adult longevity showed that at each stage significantly longer period was observed during December-February (without food), followed by December-February (with food), July-August and inside the Incubator. This trend of results may be due to lower temperature prevailing in December- February as compare to July-August (Table 1). Therefore, the lower temperature during December-February significantly reduced the average fecundity and Percent hatching while it enhanced the mean incubation period, period of larval development and pupal period in comparison to July-August and Incubator as they showed comparatively higher temperature and hence short life cycle.

References

1. Adlakha RL, Sharma OP. *Apis mellifera* vs. *Apis indica*. Gleanings in Bee Culture. 1975; 103(5):160.
2. Brar HS, Gatoria GS, Jhajj HS, Chahal BS. Seasonal infestation of *Galleria mellonella* and population of *Vespa orientalis* in *Apis mellifera* apiaries in Punjab. Indian Journal of Ecology. 1985; 12(1):109-112.
3. Viraktamath, S. Incidence of greater wax moth *Galleria mellonella* L. in three species of honey bees. Indian Bee Journal. 1989; 51(4):139-140.
4. Marston N, Campbell B, Boldt PE. Mass producing eggs of the greater wax moth, *Galleria mellonella* L., U.S. Department of Agriculture, Technical Bulletin 1510, 1975.
5. Nielsen RA, Brister D. The greater wax moth: adult behavior. Annals of Entomological Society of America, Shi. 1977; 70(1):101-103.
6. Knoxfield RG. Agriculture notes, Wax Moth-A Pest of Combs and Honey Bee Products. State of Victoria, Department of Primary Industries, 2006.
7. Morse, RA. Honey bee pests, predators and diseases. Cornell University Press, 1978.
8. Nielsen RA, Brister CD. Greater wax moth: Behaviour of larvae. Annals of the Entomological Society of America. 1979; 7(2):1-81.
9. Jyothi JVA, Reddy CC. Rate of larval mobility and orientation of greater wax moth, *Galleria mellonella* L. GBOSBU. 1992; 19:168-170.
10. Khanbash MS, Oshan HS. Biological study on greater wax moth *Galleria mellonella* L. in Lahj region, Yemen. Arab Journal of Plant Protection. 1997; 15(2):80-83.
11. Allegret P. Elements for Experimental Analysis of Morphogenesis of Male Genital System in *Galleria-mellonella* L. Lepidoptera-Pyralidae. Comptes Rendus des Seances de la Societe de Biologie et de Ses Filiales. 1975; 169(2):403.
12. Chang CP, Hsieh FK. Morphology and bionomics of *Galleria mellonella* L. Chinian Journal of Entomology. 1992; 12(2):121-129.
13. Kapil RP, Sihag RC. Wax moth and its control. Indian Bee Journal. 1983; 45(2-3):47-49.
14. Brar HS, Brar BS, Gatoria GS, Jhajj HS. Biology of greater wax moth, *Galleria mellonella* L. infesting *Apis mellifera* L. colonies in Punjab. Journal of Insect Science. 1996; 9(1):12-14.
15. Gupta M. Wax moth in *Apis mellifera* L. in Haryana, India. Indian Bee Journal. 1987; 49:26-27.
16. Ben, HB. Bee disease diagnosis. Zaragoza: International Centre for Advanced Mediterranean Agronomic Studies, 1999, 147-165.
17. Opoosun OO, Odebiyi JA. Life Cycle Stages of Greater Wax Moth, *Galleria mellonella* (L.) (Lepidoptera: Pyralidae), Ibadan, Oyo State, Nigeria. Nigerian Journal of Entomology, 2009, 26.
18. El-Sawaf SK. The life-history of the greater wax moth (*Galleria mellonella* L.) in Egypt, with special reference to the morphology of the mature larvae. Bulletin of Society Found ler Entomb. 1950; 34:247-297.
19. Abrol DP, Kakroo SK. Studies on seasonal activity and control of wax moths (*Galleria mellonella* and *Achroia grisella* F.) attacking combs of four honeybee species. Mysore Journal of Agricultural Sciences. 1996; 30(4):365-373.