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Survey, biology and management of greater wax moth, *Galleria mellonella* L. in Southern Karnataka, India

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Abstract
The greater wax moth, *Galleria mellonella* L. (Lepidoptera: Pyralidae) is considered as a ubiquitous pest of honey bee colonies, causes highest loss to the beekeeping industry. The complete life cycle (egg to emergence) of *G. mellonella* occupied 35-45 days. Fecundity rate of wax moth was 300-600 eggs and were laid in batches. The eggs hatched within 5-8 days when temperatures ranged from 29 ^{o}C to 35 ^{o}C. The larvae tunnelled into the comb, lining their tunnels with silky web as they go inside. Freshly built combs were preferred by initial stages of larvae and latter stages were found feeding on the old comb. The colonies in the plain regions with high temperature were more susceptible to wax moth attack. In Chikkaballapur and Chitradurga regions 72 and 58 percent pest incidence were recorded. The incidence of *G. mellonella* in V- *Bt* treated combs was significantly lower than that observed in HD-1 treated ones, irrespective of the concentration of *Bt*. Out of the two *Bt* products, V-*Bt* (commercial product) and HD-1 (local *Bt* product), the highest larval mortality with less comb damage was recorded in case of the former. Placing yellow sticky trap fitted with *A. dorsata* comb on top cover of the *A. cerana* hive helped in better prevention of the wax moth infestation in *A. cerana* colonies.

Keywords: Greater wax moth, honey bee, beekeeping, pest, infestation

Introduction
Honey bees are well known and economically beneficial insects. Honey is the most valuable product obtained from honey bees. Apart from honey, bees wax, pollen and royal jelly have also gained economic importance. Honey bees are good pollinators as well. Rearing of honey bees in a scientific manner for such economic benefits is known as beekeeping. The beekeeping is a vibrant income generating activity of rural areas. The beekeeping industry is perpetually bedevilled by a number of enemies such as wax moth, wasps, ants, beetles, termites, mites, birds, lizards, mammals, etc. Among pests, the wax moth is considered as a notorious pest of honey bee colonies which is well distributed throughout the world. There are two species of wax moth, the greater wax moth (*Galleria mellonella* L.) and lesser wax moth (*Achoria grisella*).

Greater wax moth, *Galleria mellonella* L. (Lepidoptera: Pyralidae) causes heavy economic losses, sometimes reaching to up 60-70 percent of the beekeepers' income in the developing countries like India [1].

Greater wax moth undergoes complete metamorphosis with seven larval instars. Larvae are the damaging stage. Adult females enter the hive during night and lay egg on the cracks and crevices of the bottom board. After emergence the larvae starts feeding on the comb and tunnels inside and pupate inside the tunnel. Larvae even show cannibalistic nature. They destroy a large number of combs every year; attack the wax foundation, reduce stored combs and weaken young colonies to a pile of debris. Wax moth causes considerable damage in apiaries if the colony strength is poor. Susceptibility of the colony to attack against wax moth may be due to several causes such as malnutrition, disease, loss of queen or large scale mortality due to pesticide poisoning [2]. Wax moths may also be implicated in the spread of contagious diseases, especially the foulbrood [3].

Several control measures are being practised for the control of wax moth, though mechanical and physical methods are not giving best results. Chemical methods are not advisable because honey bee and its honey are involved, which will adversely affect human health.

In this context, greater emphasis is being laid on safer methods such as biological pest control, particularly, microbial pesticides and the use of botanicals. The microbial alternatives to chemical insecticides include a variety of entomopathogens such as bacteria, viruses and fungi. Of the various microbial agents that have been evaluated, the most successful so far, has been the *Bacillus thuringiensis* Berliner, more commonly referred to as *Bt.* It does not affect Hymenoptera and is considered non-pathogenic to human beings [4].

All India coordinated research project on Honey bee and Pollinators, GKVK, UAS, Bangalore, Karnataka, India has made an effort to manage this pest and further to minimise the loss for beekeepers and to encourage apiculture. Hence an information on incidence of Greater Wax moth in southern parts of Karnataka was collected. The life cycle of pest was studied to design the management aspects.

Materials and methods

Study Area: The biology & management of Greater wax moth were studied at AICRP on Honey bee and Pollinators, GKVK, UAS, Bangalore. In order to record the incidence of this pest, surveys were taken in potential beekeeping areas of Karnataka during 2014-2018.

Biology of Greater wax moth

The larvae of greater wax moth were collected from the bottom board of *Apis cerana* colonies in the apiaries and then reared in insect rearing boxes on artificial diet at room temperature. Artificial diet containing easily available ingredients was developed to rear *G. mellonella* larvae. The diet composed of corn meal, wheat flour, milk powder-yeast tablets, honey, glycerine and distilled water (Table.1).

Table1: Composition of the artificial diet used for rearing the larvae of *G. mellonella.*

Sl. No.	Ingredients	Quantity (g or ml per kg)	Quantity (%)
1	Corn meal	200	26.6
2	Wheat flour	100	13.3
3	Milk powder	100	13.3
4	10 Yeast tablets	50	6.66
5	Honey	150	20.0
6	Glycerine	150	20.0

Adult male and female moths were collected and transferred to another box with newspaper sheets fold in such a way that eggs are laid on each fold. Observations were recorded from the first day of egg laying up to the adult emergence.

Survey for wax moth infestation and identification of wax moth infestation

The survey and field visits were conducted to estimate the wax moth infestation in different regions of the Karnataka State. Apiaries in the plain and hilly regions of Karnataka were visited during every year and calculated the percent infestation in each year.

$$\text{Percent infestation} = \frac{\text{Number of colonies with wax moth}}{\text{Total number of colonies observed}} * 100$$

Honey bee colonies were inspected for wax moth larvae and silken galleries on the brood and honey comb. A white sheet spread on bottom board was examined to check the egg masses and crawling larvae on it. In addition, dark and disintegrated comb, cylindrical faeces on bottom board, large number of crawling bees or screen trays were indicative to wax moth infestation.

Efficacy of *Bt* isolates against *G. mellonella*

Isolated bacterial cultures (*Bt.*, local strain HD-1) grown at 30 ºC in 100 ml of Luria broth for 5-6 days were used for the study. Sporulated culture was centrifuged and the supernatant was discarded. The crystals obtained were diluted with water and mixed with 1-2.5g of the talc powder. Neutral pH was maintained by adding 15 g of calcium carbonate per kg of formulation. To the neutralised formulation, 6% glycerol and caboxymethyl cellulose (10g per kg product) were added and mixed thoroughly and later it was air dried [5] commercial *Bt* formulation *Bacillus thuringiensis* var. *kurstaki* (V-*Bt*) was obtained from Varsha Bio Science Pvt. Limited, Hyderabad. The commercial and local strains were prepared at 3, 6 and 9 gm or ml per 1 lit of water.

The prepared concentrations of *Bt* strains were sprayed on *Apis dorsata* comb by using a plastic hand sprayer and sprayed combs were aerated under a fan to remove water, later 10 larvae of wax moth 2nd, 3rd, 4th and 5th instar were released to treated combs and kept in a ventilated plastic box of size 2.1 x 8 cm for further observation.

After *Bt* spray, initial weight of the comb, number of cells per comb and seven days later final comb weight, number of cells damaged and number of larvae killed were recorded. Each treatment had three replications. The *Apis dorsata* combs were fitted to brood frames in Newton's hive. Each hive contains 6 frames, so that there were three replications maintained in GKVK apiary for treating combs with local and commercial *Bt* products at 3.00, 6.00 and 9.00 gm/L respectively.

Yellow sticky trap to manage *G. mellonella*

The old and unused brood combs of *Apis dorsata*, *A. cerana* and *A. florea* were fitted to sticky traps for attraction of greater wax moth. Yellow sticky trap with combs were placed in different apiaries and observations were taken to ascertain the preference of combs by wax moth and the efficiency of sticky trap in trapping the wax moth.

Statistical Analysis: The data obtained was subjected to statistical analysis by CRD and two factorials.

Results

Biology of Greater wax moth

The results on life cycle (egg to emergence) of *G. mellonella* revealed that 35-45 days was required for completion. The female moth laid eggs in groups and hatched in 5-8 days.

Table 2: Life cycle of *G. mellonella*

Sl. No.	Developmental Stages	Colour	Size	Duration (Days)
1	Egg	Creamy White	0.4-0.6mm	5-8
2	Larva	Creamy White to Grey	24-26mm	40-60
3	Pupa	Light Brown	14-18mm	14-16
4	Adult	Grey to Brown	Male:10-15mm Female: 15-18mm	10-15

The larva completed its different stages in 40-60 days with seven instars and entered pupal stage. The pupa was light brown in colour and pupal period lasted for 14-16 days at optimum temperature. The adult moth which emerged had a longevity of 10-15 days. Female moth soon after mating started egg laying and continued to oviposit up to five days (Table. 2) (Plate 1).

Eggs: Eggs were smooth pearl like creamy white in colour and were laid in masses. Fecundity of wax moth was 300-600 eggs and were laid in batches. The eggs hatched within 5-8 days, when temperatures ranged from 29 ºC to 35 ºC.

Larvae: Larvae were creamy white, later they turned grey on reaching their last stages of larval instars. There were seven larval instars and six moults were observed during its developmental cycle. After hatching, the larvae tunnelled into the comb, lining their tunnels with silky web as they entered inside. They moved from comb to comb through a mass of webbing. They moulted very quickly, if there was scarcity of food.

Pupae: After spinning the cocoon, the larvae started to pupate, which lasted about 14-16 days, when there was optimum temperature. Light brown coloured pupae turned darker in their final stages of pupation.

Adult: After emergence, the adult moths mated and the life cycle began again. Sexual dimorphism was very distinct in *G. mellonella.* Female moths were bigger than the males. Male moth had a semi-lunar notch on the outer margins of the fore wings. Labial palpi was rudimentary in case of males. Female moths had a smooth front wing without notch. The wing expansion of female was 25.20±1.22 mm, whereas in male, it was 24.60±0.53 mm. Longevity of adult male was 16.50±2.70 days that of and female was only 6.88±0.7 days. Adult moths were lighter in colour with uniformly coloured grey wings.

Infestation of Greater Wax Moth

Honey bee colonies were inspected for wax moth larvae and silken galleries on the brood and honey comb and it was found that weaker colonies were susceptible to wax moth attack. Highly populated colonies were more resistant to the pest attack. Larvae were major threat for the colonies and found eating away the combs in higher quantity resulting in the skeletonization of the comb. Wax moth larvae tunnelled into the comb and pupated inside the silken galleries spun by them. Freshly built combs were preferred by initial stages of larvae and latter stages feed on the old comb. The wax moth larvae often destroyed the unprotected combs and feed on honey, pollen and bee brood (Plate 2 &3).

The percentage of infestation of greater wax moth in different parts of Karnataka was surveyed and tabulated (Table.3). There was only 5 percent wax moth infestation recorded in Bengaluru (Rural) during the year 2014, but the percentage of attack increased suddenly to 45.00 in 2015 and showed a steady decline during 2016 (38.71%). Although wax moth infestation in Coorg region was increasing year wise 2014 (15.00%), 2015 (17.00%) and 2016 (26.53%). Lower wax moth infestation was noticed in 2015 (8.90%) and maximum was in 2016 (27.78%) in Dakshina Kannada district. Chitradurga region had a greater infestation percentage of 58.00 and 52.63 in 2015 and 2016, respectively. In Chikkaballapur 72 percent of the colonies were attacked by wax moth in 2015.

Table 3: Percentage of Greater wax moth infestation in different parts of Karnataka

Districts	Infestation of wax moth (%) over the years		
	2014	2015	2016
Bengaluru Rural	5.00	45.00	38.71
Chitradurga	-	58.00	52.63
Davanagere	-	40.00	45.45
Coorg	15.00	17.00	26.53
Shivamogga	-	21.00	42.8
Uttara Kannada	-	8.00	26.40
Dakshina Kannada	13.30	8.90	27.78
Chikkaballapur	-	72.00	70.00

Table 4: Effect of greater wax moth and other pests on the *A. cerana* colonies in different regions of Karnataka during 2018

Places with GPS co-ordinates	No. of Bee colonies observed	No. of bee colonies which absconded due to pest and diseases& lack of flora	% Absconding	Major reason for absconding	
				Wax Moth	Others
Bengaluru					
GKVK 13.076 & 77.577	40	12	30	Wax Moth	Lack of Flora
JP Nagar, Karnataka Apiaries 12.896 & 77.572	55	5	9.1		Lack of Flora
Lalbagh 12.950 &77.584	12	2	16.7	Wax moth	TSBV
Chandralayout 12.954 &77.522	4	2	50		Poor management
Bengaluru Rural					
Hesarghatta 13.140 & 77.481	20	4	20	Wax Moth	Lack of Flora
KVK, Hadonahalli 13.375 & 77.545	5	1	20		Poor management
Vaderahalli 13.095 & 77.451	28	5	17.9	Wax Moth	
Ramanagar					
Kolagondanahalli 12.460 & 77.608	10	1	10		Poor management
Mandya					
Nidaghatta, Madhur 12.607 &77.083	15	2	13.3	Wax moth	Ants
Gejjalgere Madhur 12.584 &76.994	15	2	13.3	Wax moth	
Horticulture Dept 12.524 & 76.883	10	1	10	Wax moth	Lack of flora
Subhash Nagar 12.522 & 76.886	5	1	20		Poor management
Mysuru					
Ballahalli 12.263 & 76.557	20	1	5		Wasp,
Thibbaiyanahundi 12.256 & 76.558	18	2	11.1		Ants, wasp
KVK, Naganahalli 12.375 & 76.660	10	1	10	Wax moth	
Chamarajanagar					
Ganeshpura, Nanjangudu 11.938 & 76.500	180	10	5.6	Waxmoth,	Ants
Yelanduru 12.038 & 77.021	15	2	13.3	Waxmoth	
Coorg					
Madikeri 12.433 & 75.723	20	3	15		Ants, Birds, TSBV
Polibetta, Gonikoppa 12.238 & 75.909	10	2	20		Ants, Birds, TSBV
Ponnampet 12.609 & 76.952	85	12	14.1		Ants, Birds, TSBV
Shivamogga					
Navile, UAHS 13.971 & 75.578	25	8	32	Wax moth,	lack of flora
Yalavatti 13.920 & 75.631	20	3	15	Wax moth	
Sagara 14.075 &74.51032	30	23	76.7		TSBV
Chikkaballapur					
Chintamani 13.402 &78.055	10	2	20	wax moth	TSBV

*TSBV: Thaisac Brood Viral Disease

During 2018, the incidence of wax moth and other pests were recorded in 24 apiaries in eight districts (Table 4). The results revealed that greater wax moth, Thai sac brood viral disease, lack of bee flora, ants and birds were the major factors for absconding behaviour of bee colonies in apiaries. The beekeepers of dry regions expressed that wax moth incidence was severe, especially during dearth period. The maximum of 76.7 per cent of colonies absconded due to Thai sac brood disease at Sagara and 32 per cent of the colonies absconded due to wax moth attack in UAHS, Shivamogga. The minimum percentage of absconded colonies were recorded in case of wasp attack *i.e*., 5per cent. The least percentage (5.6%) of the colonies absconded due to wax moth and ant attack in Ganeshpura, Nanjangud.

Bioassay of *Bacillus thuringiensis against G. mellonella*

The experiment was carried out to establish the toxicity of the six *Bt* isolates from the soil samples and the HD-1 (standard) against the third instar larva of greater wax moth. The toxicological characterization of the toxin was performed by using spore crystal complex. The mortality data was recorded in the test insects, when fed with artificial diet contaminated with the *Bt* isolates as shown in Table 5. Considering the most active cultures, a statistical analysis of these results by single factor ANOVA, with the 6 isolates and HD-1 (Standard) treatments was carried out. Comparison of the *Bt* isolates revealed an overall significant difference between the Bt isolates with respect to larval mortality against each of them. However, A3 and N12; and F2, and A7, were on par with each other in their effectiveness against the larvae (F=23.73; $p<0.05$; Table 4).

Table 5: Mortality of III instar larva of *G. mellonella* due to different isolates of Bt.

Sl. No.	Isolate No.	*Corrected mortality (%)
1	C7	57.6
2	A3	51.4
3	N12	51.0
4	F2	47.0
5	A7	46.3
6	M2	46.0
7	HD1	43.0
F value	23.73*	
SEm	0.52	
CD@5%	0.99	

Table 6: Mean incidence of *G. mellonella* in combs of *Apis dorsata* treated with one, two and three sprays of *Bt* products at different concentrations.

***Bt* concentration (g/l)**	**Mean number of larvae found in treated *A. dorsata* combs**								
	First spray			**Second spray**			**Third spray**		
	Commercial Bt (V-Bt)	**Local Bt (HD-1)**	**Mean**	**Commercial Bt (V-Bt)**	**Local Bt (HD-1)**	**Mean**	**Commercial Bt (V-Bt)**	**Local Bt (HD-1)**	**Mean**
3.00	16.49	15.05	15.77	10.54	15.05	12.79	5.24	13.00	9.12
6.00	23.35	19.01	21.18	11.88	17.71	14.79	3.45	15.12	9.29
9.00	17.04	23.59	20.32	13.33	15.07	14.20	2.29	18.54	10.42
Control	38.34	38.34	38.34	38.34	38.34	38.34	38.24	38.34	38.34
Mean	23.81	23.99	23.91	18.53	21.55	20.04	12.33	21.25	16.79
	SEm±	CD @ p=0.05		SEm±	CD @ p=0.05		SEm±	CD @ p=0.05	
Concentration	0.34	0.99		0.22	0.65		0.37	1.06	
Bt products	0.24	NS		0.16	0.46		0.26	0.77	
Con. X Products	0.48	1.42		0.31	0.92		0.52	1.54	

First, second and third spray applications were made at an interval of 0, 30 and 60 days

Bt HD-1 (local strain) and V-*Bt* (Commercial strain) were sprayed on combs of *A. dorsata* and fixed to frames of *A. cerana* hive at concentrations of 9, 6, & 3 g/l and observed for natural incidence of greater wax moth. The results revealed that the treated combs have incidence of *G. mellonella* larvae as 15.77, 21.18, 20.32 and 38.34 larvae per hive corresponding 3, 6, 9 g/l of *Bt* and control treatments at first spray on the day zero. The *Bt.* products didn't show any significant difference between themselves with respect to their effect against wax moth infestation. The control hive had significantly higher infestation than in the *Bt* treatments (Table 6).

The treated combs have incidence of *G. mellonella* larvae as 12.79, 14.79, 14.20 and 38.34 larvae per hive after second spray on the 30th day with 9.12, 9.29, 10.42 and 38.34 larvae of *G. mellonella* per hive corresponding to 3, 6, 9 g/l of *Bt* and control treatments at third spray on the 60th day.

The incidence of *G. mellonella* in V- *Bt* treated combs was significantly lower than that observed in HD-1 treated ones, irrespective of the concentration of *Bt*. The incidence of *G. mellonella* in control (38.34 larvae per hive) was significantly higher than the incidence observed on the *Bt* treated combs which ranged from 2.29 – 5.24 and 13.00 – 18.54 larvae per hive, respectively in V-*Bt* and HD- 1 treated combs.

Efficacy of yellow sticky trap to manage *G. mellonella.*

The old brood combs of *Apis dorsata* were found to be very attractive to wax moths than *A. cerana* and *A. florea*. The results revealed that the delta trap fitted with old brood combs of *Apis dorsata* attracted the females of greater wax moth. Yellow sticky trap was installed in five apiaries for the study and noticed that female moths were trapped. The results (Table 7) showed that Apiary 1 (Rajanukunte, Bengaluru rural) had eight female moths in each month whereas; Apiary-2 (GKVK, Bengaluru) and Apiary- 3 (GKVK, Bengaluru) had maximum numbers *viz.*, 15 and 11, respectively. Apiary – 4 (Puttur, Dakshina Kannada) and Apiary-5 (Baghaluru, Yelahanka, Bengaluru) had 07 and 10 moths trapped. Yellow Sticky Trap at GKVK was found to be very effective in managing the wax moth infestation. Placingyellow sticky trap fitted with *A. dorsata* comb on top cover of the *A. cerana* hive helped prevention of the wax moth infestation in *A. cerana* colonies (Plate 4).

Table 7: Adult moth catches of *G. mellonella* in yellow sticky trap during September and October, 2016 at different locations.

Locations	**Moth catches/Trap/month**
Apiary-1 (Rajanukunte, Bengaluru rural)	08
Apiary- 2 (GKVK, Bengaluru)	15
Apiary- 3 (GKVK, Bengaluru)	11
Apiary – 4 (Puttur, Dakshina Kannada)	07
Apiary-5 (Baghaluru, Yelahanka, Bengaluru)	10

Discussion

The greater wax moth is a major problem in beekeeping industry and results in heavy loss to the beekeepers. In order to manage the wax moth, the urgent need to study in detail about the biology and the nature of damage was felt necessary, besides their eco-friendly management hence use of biological agent was found feasible. Adult moth of *G. mellonella* enters into the bee colonies during night and lays egg on the bottom board. Yellow sticky trap attracts wax moth adult female moths and kills the adult moth, hence egg laying is curtailed.

Egg hatches at 29 ^{0}C to 35 ^{0}C and it shows that wax moth needs high temperature for their survival. Hence the plain regions with high temperature were more susceptible to wax moth attack. Chikkaballapur and Chitradurga regions registered 72 and 58 per cent wax moth infestation which was due to high temperature during the experimental period. Incidence of greater wax moth was less in colder regions because eggs will not survive at lower temperature. Greater wax moth eggs develop quickly at warm temperatures (29 °C-35 °C) and more slowly by about 30 days at lower temperatures (18 °C) [6]. Eggs will not survive in extreme cold (at or below 0 °C for 4.5 hours) or extreme heat (at or above 46 °C for 70 minutes). As the larva grows in size its colour changes to dirty grey. The growth rate of the larvae depends upon the temperature and the nature of food. The growth is quick on old or darker combs containing brood and pollen, but very slow and hindered on white or fresh combs [7]. Adult moths were lighter in colour which was due to the artificial diet fed during their life cycle. This investigation complies the observations made by [7] who reported that the colour and size of the moth vary according to the food ingested during the larval period whereas, on dark brown combs they develop into darker and bigger adults and the larvae which feed on fresh combs, become moths of lighter colour and smaller size. Adult longevity of 21-30 days for males and 8-15 days for females [8]. Life span of adult male was 16.50±2.70 days and female were only 6.88±0.7 days in the present study. This variation might be change in geographical factors and also the quality of food consumed in their larval stage. However, [9] who reported that adult longevity was 16.4 days for males and 6.90 days for females. The present findings are in agreement with the findings of [9].

Two *Bt* products, commercial V-*Bt* and local strain (HD-1) were compared for their efficacy against different instars of greater wax moth at 3 concentrations, *viz*., 3, 6, 9 g per lit applied on the comb. The early instar larvae of greater wax moth were found to be highly susceptible to commercial V-*Bt* when compared to the local *Bt* strain HD-1. V-*Bt* caused higher mortality of first instar at its highest concentration of 9 g per lit (96.67%) resulting in lower comb damage and loss in comb weight at 4.26 and 5.49 per cent, respectively. Ability to protect combs against second instar was poor since only 23.34 per cent mortality was registered. In case of HD-1 treated combs, no larval mortality was observed for II instar and onwards but the damage potential of larvae on treated combs was less in early instars but not by later stages of larvae. Further, the *Bt* product failed to protect the bee combs from the attack of later instars.

The present results were similar to the findings of [10] who reported that *Bt* @ 2 g per lit. caused the larval mortality of 68per cent after spray. Combs of honey bees sprayed with *Bacillus thuringiensis* var. *Kurstaki* resulted in 85 per cent mortality of III instar larvae at 5 g per 100 ml of water [11]. The effect of *Bt* formulations was highly detrimental to I instar larvae of greater wax moth causing 100 per cent mortality [12]. Further, he reported that with the increase in instars there was significant reduction in the effect of *Bt* formulation against the larvae.

The local and commercial *Bt* formulations were tested at 3, 6 and 9 g per lit. by spraying them on *Apis dorsata* combs spread over a period of two months. The results revealed that spraying V-Bt at 9 g per lit, thrice at 0, 30 and 60 days' interval protected the combs from infestation by greater wax moth, while single spray was ineffective and two sprays were less effective, while three sprays were superior in protecting the combs. This was evident by 2.39 larvae per hive, with 3 sprays of 9 g, as against 17.04 and 13.33 larvae per hive in the former two treatments, respectively.

In the present study the local Bt strain HD-1 was completely ineffective against *G. mellonella* in lab, store and field conditions. The present findings are in agreement with those of [13], who reported highest mortality (98.72%) of wax moth in honey bee colonies sprayed with a suspension of Dipel (10% *Bt.* var. *kurstaki*) and protected the combs for period of 5.5 months from wax moth infestation. Wax combs sprayed with Certan, a *Bt.* var. *Kurstaki* product, recorded less damage by greater wax moth upto 3 months in storage [14]. The application of 3 g per lit spore crystal complex of *B. thuringiensis* by spray inside the bee hive gave protection against the wax moth for a minimum period of 52 days [15]. The spores of *B. thuringiensis* Berliner dusted on wax combs at 5 mg/dm^2 caused mortality of greater wax moth larvae ranging from 80-100 per cent [16]. The formulation of *B. thuringiensis* sub sp. *aizawai* spores (B-401 containing 10^6 viable spores/mg when sprayed on combs or wax foundation gave protection from *G. mellonella* infestation for up to 12 months [17]. Depending on the strain, the level of protection against greater wax moth also varied.

The incidence of greater wax moth was more in the month of September and hence more number of female moths was trapped during September using yellow sticky traps [18]. The present investigation showed that the more number of females of greater wax moth were trapped in apiaries of Bengaluru.

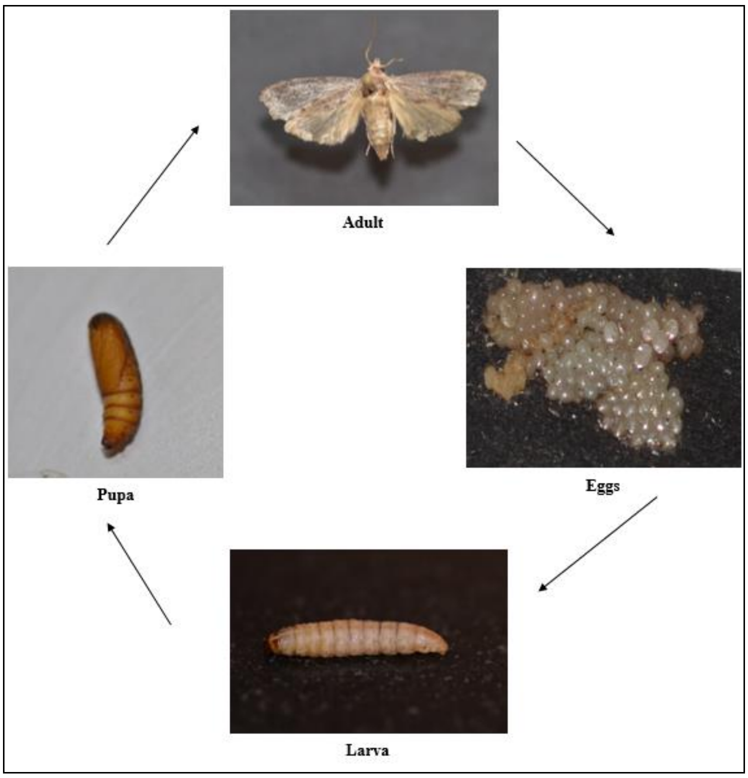

Plate 1: Life cycle of *Galleria mellonella*

Plate 2: Infestation of *Galleria mellonella*

Plate 3: Damage caused by *Galleria mellonella*

Plate 4: Yellow Sticky Trap installed at Apiary to trap *Galleria mellonella*

Conclusion

- Greater wax moth is an omnipresent pest of honey bees hence it's the most destructive among honey bee pests.
- Fecundity rate of wax moth was 300-600 eggs and are laid in batches. The eggs hatch within 5-8 days when temperature ranges from 29 ºC to 35 ºC.
- The bee colonies maintained in plain regions with high temperature were more susceptible to wax moth attack. Incidence of greater wax moth was less in cold regions.
- The incidence of *G. mellonella* in V- *Bt* treated combs was significantly lower than that observed in HD-1 treated ones, irrespective of concentration of *Bt*.
- The yellow sticky trap fitted with old brood combs of *Apis dorsata* attracted more number of female moths of greater wax moth.

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