



RESEARCH ARTICLE

Wax Moth Infestation and its Management in Indian Honey bee, *Apis cerana* F. Colonies in Tamil Nadu

Mathialagan, M¹, Johnson Thangaraj Edward, Y.S.² and David, P.M.M³

¹Department of Agricultural Entomology, Sethu Bhaskara Agricultural College and Research Foundation (SBAC&RF), Sivagangai-6

²Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore-641 003

³Mother Teresa College of Agriculture, Pudukkottai-2

ABSTRACT

Wax moths, *Galleria mellonella* L. and *Achroia grisella* F. (Lepidoptera: Galleriidae) are one of the causes of absconding in honey bees. We in 2016 – 2017 conducted a survey of wax moth infestation in Indian honey bees, *Apis cerana indica* Fabricius (Hymenoptera: Apidae) in Tamil Nadu, in addition to a management study in Coimbatore and Trichy. The results indicated that all colonies in the surveyed districts had a wax moth infestation, more in the non-swarming season. Keeping over the wooden bottom board a screened bottom board sealed with a laminated white sheet in between the two boards was found to be significantly more effective in reducing wax moth infestation in *A. cerana* colonies. The need for wax moth monitoring and management in *A. cerana* colonies is discussed.

Received : 5th February, 2019

Revised : 13th June, 2019

Accepted : 13th June, 2019

Keywords: Wax moths, *Apis cerana*, screened bottom board, Tamil Nadu.

INTRODUCTION

Honey bees play a key role in the pollination of crops, besides providing honey, beeswax, bee pollen, royal jelly, propolis, etc. However, honey bees are subject to stress from different factors. Even though not as serious as other stressors, the wax moth attack by *Galleria mellonella* Linnaeus (greater wax moth) and *Achroia grisella* Fabricius (lesser wax moth) (Lepidoptera: Pyralidae) often causes concern because of poor management practices, leading to absconding (Ebadi *et al.*, 1980) and economic loss to the beekeeping industry all over the world (Caron, 1999). Both greater and lesser wax moths are attracted not only to weak colonies but also to strong colonies, reducing the comb to a mass of web and debris, with severe infestation leading to suspension in brood rearing and foraging, ultimately absconding (Gulati and Kaushik, 2004), a very common behaviour in *A. cerana*, including natural swarming (Pokhrel *et al.*, 2006). Often beekeepers neglect wax moth infestation which follows unidentified stress in bees, according to them.

Thus there is a need to control wax moths by providing a structural improvement to the hives as the floorboard debris first invites the wax moths when the colony gets weaker and the combs are not renewed. With no information available on the physical method of wax moth management by trapping them in beehives, this study was undertaken to trap them in the hives as a management method

after assessing the extent of wax moth infestation in *A. cerana* colonies in Tamil Nadu.

MATERIAL AND METHODS

Roving survey

A roving survey was conducted in two spells, first during September in 2016 and second during May-June in 2017 in 12 districts of Tamil Nadu (Figure 1), namely, Dharmapuri, Salem, Krishnagiri, Karur, Erode, Coimbatore, Trichy, Madurai, Tirunelveli, Tuticorin, Kanyakumari and Namakkal. With 3.96 per cent geographical area of India, Tamil Nadu lies between 8° 05' N-13° 35' N latitude and 76° 15' -80° 20' E longitude. The average temperature in the state ranges from 29°C - 37°C. The average annual rainfall ranges from 228 - 902 mm (Table 1). At all the places 3-4 beekeeper-maintained colonies were selected at random and examined for the occurrence of wax moth infestation using a transparent 1.0 cm² grid to count the number of wax moth larvae present in 25 cm² area on the bottom board at four places when the laminated white sheet was not used or on the latter when it was used (Figure 2).

Field experiment

A 6-month long experiment was also conducted at two locations, one at Tamil Nadu Agricultural University (TNAU) campus, Coimbatore and the other at Anbil Dharmalingam Agricultural College & Research Institute, Trichy during 2016-2017 to evaluate the effect of keeping a screened bottom

*Corresponding author's e-mail: mathialagan08637@gmail.com

board on trapping wax moth larvae. The following treatments were included in a paired *t*-test:

- Hives with a metal screened bottom board (27.0 x 22.0 x 1.5 cm, 120 mesh/ square inch) and a white laminated sheet seal kept on the regular wooden bottom board (Figure 3).
- Hives without a screened bottom board but with a white laminated sheet kept on the regular wooden bottom board as control.

Six hives of identical colony strength and queen age were maintained for each treatment on both locations wherein no supplementary feeding was given during the experimental period. Observations were made at the weekly interval on the number of wax moth larvae found on the laminated white sheet

in 25 cm² area on the bottom board at four places using the transparent cm-grid (Figure 2, 6). The data collected during the roving survey of mean and percentages were calculated using Microsoft Excel. The data on wax moth larvae from the experiments were subjected to *t*-test analysis after square root transformation.

RESULTS AND DISCUSSION

Roving survey

The roving survey indicated the presence of wax moth attack in all the 12 districts of Tamil Nadu (Figure 1), irrespective of the hive type (Marthandam, BSI, Janata, Newton), with 80.6 and 72.2 per cent colonies showing infestation in the

Table 1. The geographical positions and climatic conditions in the surveyed districts of Tamil Nadu

District (village)	Latitude	Longitude	Altitude (M)	Maximum Temperature/day (°C)	Rainfall (mm / year)	Relative Humidity
Dharmapuri (Theerthamazhai)	12 10'19"N	78 59'05"E	392.0	35.0	446.5	61.0
Salem (Sandhiyur)	11 56'82"N	78 13'79"E	261.0	34.0	511.1	62.0
Krishnagiri (Chaparam)	12 42'15"N	78 21'74"E	454.0	36.0	587.2	62.0
Karur (Vellaikovil)	8 60'85"N	78 05'46"E	231.0	32.0	455.9	74.0
Erode (Maanikampalayam)	11 14'10"N	77 05'86"E	240.0	33.0	307.7	82.0
Coimbatore (TNAU)	9 53'80"N	77 28'40"E	467.0	34.0	816.9	76.0
Trichy (NavalurKuttapattu)	10 65'74"N	78 74'64"E	147.0	36.0	675.9	62.0
Madurai (Agrl. college)	9 92'94"N	78 11'58"E	121.0	35.0	650.1	76.0
Tirunelveli (Vasudevanallur)	9 23'96"N	77 41'14"E	182.0	37.0	385.7	57.0
Tuticorin (Killikulam)	8 70'34"N	77 85'96"E	40.0	36.0	227.8	72.0
Kanyakumari (Devicode)	8 21'41"N	77 21'94"E	37.0	29.0	902.2	87.0
Namakkal (Senthamangalam)	11°74'44"N	79°38'10"E	107.0	33.0	381.2	64.0

first and second survey, respectively, averaging 76.4 per cent (Table 2). Most infested colonies were weak to moderate in colony strength (43.8 - 49.3 %) while

only 5.5 per cent of the colonies were strong (Figure 4). In both the surveys all the examined colonies (100 %) had wax moth attack in Karur, Erode,

Table 2. Infestation level of *A. cerana* colonies by wax moth in Tamil Nadu

District (village)	1 st survey				2 nd survey				Pooled mean		
	Sampling date	No. of colonies inspected	No. of infested colonies	Infestation %	Sampling date	No. of colonies inspected	No. of infested colonies	Infestation %	No. of colonies inspected	No. of infested colonies	Infestation %
Dharmapuri (Theerthamazhai)	19.09.2016	3.0	2.0	66.7	28.05.2017	3.0	1.0	33.3	6.0	3.0	50.0
Salem (Sandhiyur)	21.09.2016	3.0	2.0	66.7	29.05.2017	3.0	1.0	33.3	6.0	3.0	50.0
Krishnagiri (Chaparam)	20.09.2016	3.0	2.0	66.7	27.05.2017	3.0	1.0	33.3	6.0	3.0	50.0
Karur (Vellaikovil)	22.09.2016	3.0	2.0	66.7	30.05.2017	3.0	3.0	100.0	6.0	5.0	83.3
Erode (Maanikampalayam)	11.09.2016	3.0	3.0	100.0	31.05.2017	3.0	3.0	100.0	6.0	6.0	100.0
Coimbatore (TNAU)	23.09.2016	3.0	3.0	100.0	07.06.2017	3.0	3.0	100.0	6.0	6.0	100.0
Trichy (NavalurKuttapattu)	07.09.2016	3.0	2.0	66.7	02.06.2017	3.0	1.0	33.3	6.0	3.0	50.0
Madurai (Agrl. college)	06.09.2016	4.0	4.0	100.0	03.06.2017	3.0	3.0	100.0	7.0	7.0	100.0
Tirunelveli (Vasudevanallur)	03.09.2016	3.0	2.0	66.7	04.06.2017	3.0	2.0	66.7	6.0	4.0	66.7
Tuticorin (Killikulam)	04.09.2016	3.0	2.0	66.7	05.06.2017	3.0	2.0	66.7	6.0	4.0	66.7
Kanyakumari (Devicode)	05.09.2016	3.0	3.0	100.0	06.06.2017	3.0	3.0	100.0	6.0	6.0	100.0
Namakkal (Senthamangalam)	18.09.2016	3.0	3.0	100.0	01.06.2017	3.0	3.0	100.0	6.0	6.0	100.0
Mean	-	3.1	2.5	80.6	-	3.0	2.2	72.2	6.1	4.7	76.4

Coimbatore, Madurai, Kanyakumari and Namakkal districts, while only 33.3 - 66.7 per cent colonies

had an infestation in other districts (Table 2). The pooled data also indicated wax moth infestation

in all the examined colonies in Erode, Coimbatore, Madurai, Kanyakumari and Namakkal districts, 50.0 per cent in Dharmapuri, Salem, Krishnagiri and Trichy districts, and 66.7- 83.3 per cent in other

districts. Individual colony-wise, the wax moth larval population density in 300-400 cm² (3-4 x 100 cm²) was highest in Madurai (17.0 / colony), followed by Coimbatore (9.0 / colony) and Kanyakumari (7.0 / colony).

Table 3. Population density of wax moth larvae in the surveyed districts

District (village)	No. of wax moth larvae / 300-400 cm ² bottom board area		
	1 st Survey	2 nd Survey	Pooled
Dharmapuri (Theerthamazhai)	2.0	1.0	3.0
Salem (Sandhiyur)	2.0	3.0	5.0
Krishnagiri (Chaparam)	3.0	2.0	5.0
Karur (Vellaikovil)	4.0	2.0	6.0
Erode (Maanikampalayam)	5.0	3.0	8.0
Coimbatore (TNAU)	9.0	15.0	24.0
Trichy (NavalurKuttapattu)	4.0	2.0	6.0
Madurai (Agrl. college)	17.0	15.0	32.0
Tirunelveli (Vasudevanallur)	2.0	3.0	5.0
Tuticorin (Killikulam)	2.0	2.0	4.0
Kanyakumari (Devicod)	7.0	13.0	20.0
Namakkal (Senthamangalam)	2.0	16.0	18.0
Mean	5.0	6.0	11.0

The total number of wax moth larvae recovered from the bottom board (sum of 12 observations)

They were fewer in Dharmapuri, Salem, Tirunelveli, Tuticorin and Namakkal (2.0 / colony), followed by Krishnagiri (3.0 / colony) (Table 3). On average, there were 5.0 wax moth larvae per colony in the first

survey. In the second survey, the overall wax moth population density was highest in Namakkal (16.0 / colony), followed by Coimbatore and Madurai (15.0 / colony) and Kanyakumari (13.0 / colony). They

Table 4. Wax moth larvae on the bottom board of *A. cerana* in the surveyed districts of Tamil Nadu.

District (village)	No. of wax moth larvae / 25 cm ² bottom board area					
	1 st Survey		2 nd Survey		Pooled mean	
Dharmapuri (Theerthamazhai)	0.2	0.1	0.1	0.1	0.1	0.1
Salem (Sandhiyur)	0.2	0.1	0.3	0.1	0.2	0.1
Krishnagiri (Chaparam)	0.3	0.1	0.2	0.1	0.2	0.1
Karur (Vellaikovil)	0.3	0.2	0.2	0.1	0.3	0.1
Erode (Maanikampalayam)	0.4	0.2	0.3	0.1	0.3	0.1
Coimbatore (TNAU)	0.8	0.2	1.3	0.4	1.0	0.2
Trichy (NavalurKuttapattu)	0.3	0.2	0.2	0.1	0.3	0.1
Madurai (Agrl. college)	1.4	0.2	1.3	0.3	1.3	0.2
Tirunelveli (Vasudevanallur)	0.2	0.1	0.3	0.1	0.2	0.1
Tuticorin (Killikulam)	0.2	0.1	0.2	0.1	0.2	0.1
Kanyakumari (Devicod)	0.6	0.2	1.1	0.3	0.8	0.2
Namakkal (Senthamangalam)	0.2	0.1	1.3	0.2	0.8	0.2

(Mean of 12 observations; SE, Standard error) were fewer in Dharmapuri (1.0 / colony),

followed by Krishnagiri, Karur, Trichy and Tuticorin (2.0 / colony). On average, there were 6.0 wax moth larvae per colony in the second survey. Cumulatively, the data from both surveys indicated highest population density in Madurai (32.0 / colony), followed by Coimbatore (24.0 / colony), Kanyakumari (20.0 / colony) and Namakkal (18.0 / colony), and lowest in Dharmapuri (3.0 / colony), followed by Tuticorin (4.0 / colony), the average being 11.0 larvae per colony.

When the mean of the 3-4 inspected colonies per 25 cm² was taken into consideration in each

district, the larvae were found to be less numerous in Dharmapuri, Salem, Tirunelveli, Tuticorin and Namakkal in the first survey (0.2 larva / 25 cm²), and in Dharmapuri in the second survey (0.1 larva / 25 cm²) (Table 4). It was most numerous in Madurai (1.4 / 25 cm²) in the first survey, and in Coimbatore, Namakkal and Madurai (1.3 / 25 cm²) in the second survey (Table 4). The overall 2-survey mean was lowest in Dharmapuri, Salem, Krishnagiri, Karur, Trichy, Tirunelveli and Tuticorin districts (0.1-0.3 larva / 25 cm²), moderate in Coimbatore district (1.0 larva / 25 cm²), and highest in Madurai (1.3 larvae/ 25 cm²) district.

Table 5. Effect on wax moth larvae of keeping a screened bottom board sealed with a laminated white sheet over the wooden bottom board

Treatments	No. of wax moth larvae / 100 cm ²				Pooled mean		%
	Trichy		Coimbatore				
Hives with a screened bottom board and white a laminated white sheet as seal	0.7	0.1	1.1	0.2	0.9	0.1	52.6
	(1.0	0.0)	(1.3	0.1)	(1.2	0.1)	
Control hives without a screened bottom board but with a laminated white sheet	1.7	0.2	2.2	0.2	1.9	1.5	-
	(1.5	0.1)	(1.6	0.0)	(1.5	0.0)	
	4.0		3.6		4.9		-
<i>t</i> – value	(P < 0.002)		(P < 0.003)		(P < 0.00005)		

(Mean \pm SE of 36 observations; SE, standard error; Figures in parenthesis are $\sqrt{x+0.5}$ transformed values)

Experiment (Effect of using the screened bottom board on wax moth incidence)

The experimental results indicated that wax moth larvae (mixed species) in hives on the bottom board provided with a metal screen and sealed with a laminated white sheet were significantly fewer (0.7 - 1.1 / 25 cm²) than in control hives without a screened bottom and laminated seal (1.7 - 2.2 / 25 cm²) (P < 0.002-0.003) on both locations (Table 5). The pooled analysis also confirmed this result, with significantly more larvae on the seal under the screen (0.9 / 25 cm²) than without a screen (1.9 / 25 cm²) (P < 0.00005).

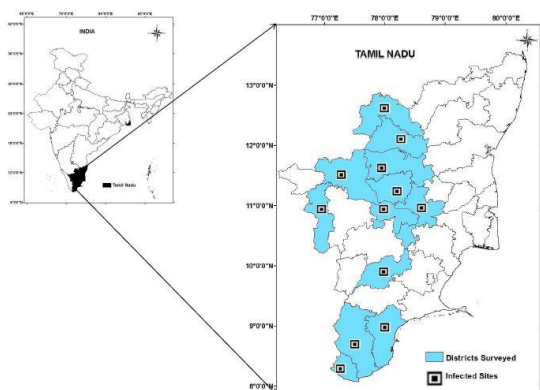


Figure 1. Map showing the districts surveyed for wax moths in Tamil Nadu. Wax moth infestation was found in all the surveyed districts

All over the world honey bees have been under stress from both abiotic and biotic factors in the recent past. Climate change and habitat loss, deforestation and hunting, scarcity of flora and poisoning from pesticides, especially neonicotinoids, are cited as major abiotic factors (Naug, 2009; Oldroyd and Nanork, 2009; Hamdi *et al.*, 2011; Huang and Giray, 2012; Mitchell *et al.*, 2017), while parasites and pathogens, especially *Varroa*, *Nosema* and viral diseases, are considered as major biotic stressors (Hamdi *et al.*, 2011). A specific syndrome caused by these stressors, often termed as colony collapse disorder (CCD), act in combination or synergistically, leading to enormous colony losses,



Figure 2. The transparent 1.0 cm grid sheet used to count the wax moth larvae on the bottom board or the laminated white sheet

especially in Italian bees, *Apis mellifera* (Neumann and Carreck, 2010). Although all honey bee colonies are subject to one or more of the above stressors in India (Mathialagan, 2018), absconding due to wax moths continue to be a problem in *A. cerana*, especially when they are weak (Singh, 1982;



Figure 3. A screened bottom board (27.0 x 22.3 x 1.5 cm) sealed with a laminated white sheet underneath it

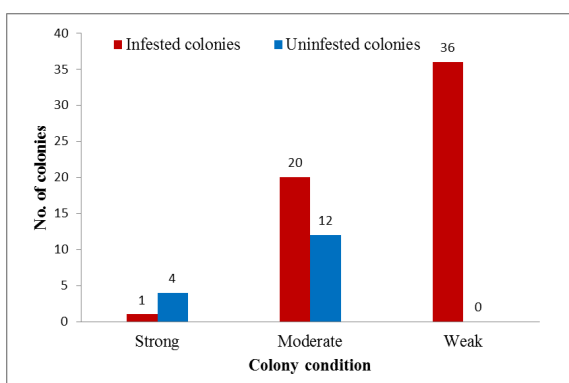


Figure 4. Status of *A. cerana* colonies in the surveyed sites

Pradeepa, 2012). This survey has highlighted the occurrence of both species of wax moths, *G. mellonella* and *A. grisella* in beekeeper-maintained *A. cerana* colonies in all districts of Tamil Nadu though not in all colonies. Observed in both seasons, the infestation was highest in September during the non-swarming dearth season when the colonies were weak. Usually, wax moths prefer to attack the weak colonies and stored combs for their reproduction (Brar *et al.*, 1985; Gupta, 1987). Though active from March to October, their activity



Figure 5. Wax moth larvae in silken tunnels and pupae in cocoons trapped between a screened bottom board and a laminated white seal

reaches a peak from June to October, the dearth period in India (Garg and Kashyap 1998). In the experiments conducted in Trichy and Coimbatore to evaluate the potential of keeping a metal screen over the wooden bottom board (Figure 3), the screened bottom coupled with a laminated white seal was observed to play a dual role. First, it prevented the grown-up wax moth larval instars from climbing up to the wax combs in the chambers above (brood or honey) (Figure 5), forcing them to pupate inside

an enclosure created by the metal screen and the laminated white seal. Compared to the control hives, 52.6 per cent of the wax moth larvae were found trapped in this enclosure (Table 5). Secondly, it was also found to trap the adult moths emerging from the pupae inside this enclosure. However, this data could not be analyzed in comparison with that of the



Figure 6. A laminated white sheet to be placed on the bottom board

data from control hives as the grown-up larvae in the control hives escaped through the hive entrance for pupation outside of the hives. Probably, this is the first report of trapping wax moth larvae in the hive itself, and of the likelihood of trapping their pupae and emerging adults using a screened bottom board coupled with a laminated white seal. Originally, the metal screened bottom was developed by Rinderer *et al.* (2003) for *Varroa* mite management as it prevents the bee-dislodged mites falling down on the wooden bottom board, naturally or after dusting powdered sugar, from re-infestation by clinging to the incoming bees (Fakhimzadeh, 2001; Conrad, 2013). All over the world, the screened bottom board is now used as an improvement to the hive and they are of different types, removable or stationary. In this study, a simple removable model was used along with an additional seal, the laminated white sheet (Figure 6). This white laminated seal not only improved the visibility of the fallen mites (dead or alive among debris) but also facilitated easy removal of the accumulated debris after the examination. Moreover, it prevented the accidental entry into and trapping of any incoming bees inside the enclosure because of its tension. In the absence of such a seal, bees may enter through any gap between the two bottom boards (wooden and screened). Placing a white sheet has been an established practice in mite monitoring (Delaplane *et al.*, 2005). Laminating the white sheet makes it rain-proof and as durable as the metal screen or wooden hive. Coupling it to the metal screen makes it a better structural improvement to the bee hives helpful in monitoring and management of both mites and wax moths.

CONCLUSION

Both the species of wax moths, namely, *G. mellonella* and *A. grisella*, occurred in *A. cerana* colonies in Tamil Nadu. Even though not all colonies are affected, the infestation was evident in all districts where sampling was done. This may be true of other districts as well which needs to be investigated further. Keeping over the wooden bottom board a screened bottom board sealed with a laminated white sheet was found to trap not only wax moth larvae but their pupae and adults that have emerged from them, serving to monitor and control both the species of wax moths and parasitic *Varroa* mites as well.

ACKNOWLEDGEMENT

The authors wish to thank Department of Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore for permission to inspect the bee colonies. This research was financially supported by the University Grants Commission, Rajiv Gandhi National Fellowship, New Delhi, which is gratefully acknowledged.

REFERENCES

- Brar, H. S., Gatoria, G. S., Jhaji, H. S. and B.S. Chahal. 1985. Seasonal infestation of *Galleria mellonella* and population of *Vespa orientalis* in *Apis mellifera* apiaries in Punjab. *Indian J. Ecol.*, **12**: 109-112.
- Caron, D.M. 1999. *Honey Bee Biology and Beekeeping*. Wicwas Press, Cheshire, CT, USA. 368 pp.
- Conrad, R. 2013. *Natural Beekeeping: Organic Approaches to Modern Apiculture*. Chelsea Green Publisher. 304 pp.
- Delaplane, K. S., Berry, J.A., Skinner, J.A., Parkman, J.P. and W. M. Hood. 2005. Integrated pest management against *Varroa destructor* reduces colony mite levels and delays treatment threshold. *J. Apic. Res.*, **44** (4): 157-162.
- Ebadi, R., Gary, N.E. and K. Lorenzen. 1980. Effects of carbon dioxide and low temperature narcosis on honey bees, *Apis mellifera*. *Environ. Entomol.*, **9**: 144-147.
- Fakhimzadeh, K. 2001. Powdered sugar dusting for the control of varroosis. In: *Proceeding of the 37th International Apiculture Congress*, 28 October – 1 November 2001, Durban, South Africa.
- Garg, R. and N. P. Kashyap. 1998. In: *Perspectives in Indian apiculture* (Ed.) Mishra, R.C. Agro Botanica, Bikaner. p. 290–303.
- Gulati, R. and H. D. Kaushik. 2004. Enemies of honey bees and their management: a review. *Agric Rev.*, **25** (3): 189-200.
- Gupta, M. 1987. Wax moth in *Apis mellifera* L. in Hargana, India. *Indian Bee J.*, **49**: 26-27.
- Hamdi, C., Balloi, A., Essanaa, J., Crotti, E., Gonella, E., Raddadi, N., Ricci, I., Boudabous, A., Borin, S., Manino, A., Bandi, C., Alma, A., Daffonchio, D. and A. Cherif. 2011. Gut microbiome dysbiosis and honey bee health. *J. Appl. Entomol.*, **135**: 524-533.
- Huang, Z. Y. and T. Giray. 2012. Factors affecting pollinators and pollination. *Psyche*, 2012: 1-3. doi:10.1155/2012/302409
- Mathialagan, M. 2018. *Probiotics-Centered Stress Management in Honey Bees*. Ph.D. Thesis, Tamil Nadu Agricultural University, Coimbatore, India. 175 pp.
- Mitchell, E. A. D., Mulhauser, B., Mulet, M., Mutabazi, A., Glauser, G. and A. Aebi. 2017. A world wide survey of neonicotinoids in honey. *Science*, **358**: 109-111.
- Naug, D. 2009. Nutritional stress due to habitat loss may explain recent honey bee colony collapses, *Biological Conservation*, **142**: 2369-2372.
- Neumann, P. and N. L. Carreck. 2010. Honey bee colony losses. *J. Apic. Res.*, **49**:1-6.
- Oldroyd, B. P. and P. Nanork. 2009. Conservation of Asian honey bees. *Apidol.*, **40** (3): 296-312.
- Pradeepa, S. D. 2012. *Studies on Colony Performance Index (CPI) and Its Usefulness in Management of Abscending in Apis cerana indica Fabricius*. Ph. D. Thesis, University of Agricultural Sciences, Bangalore. 103 p.
- Pokhrel, S., Thapa, R.B., Neupane, F.P. and S. M. Shrestha. 2006. Abscending behaviour and management of *Apis cerana* F. honey bee in Chitwan, Nepal. *J. Inst. Agric. Anim. Sci.*, **27**: 77-86.
- Rinderer, T. E., De Guzman, L.I., Delatte, G.T. and C. Harper. 2003. An evaluation of ARS Russian honey bees in combination with other methods for the control of *Varroa* mites. *Americ. Bee J.*, **143** (5): 410-413.
- Singh, S. 1982. *Beekeeping in India*. Indian Council of Agricultural Research, New Delhi, India. 214 pp.