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Periodical prevalence of brood pestilence and epizoan mites in *Apis mellifera* L. underneath stationary and migratory surroundings of Himachal Pradesh

Amritpal Singh Brar, Harish Kumar Sharma and Kiran Rana

Abstract
Field demonstration were orchestrate during July 2015 to June 2016 in *Apis mellifera* L. colonies perpetuated by the Department of Entomology, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, situated at 33.3N° latitude, 70.70 °E longitude and 1256 m above mean sea level (Amsl). The scrutiny was under taken to documentation the seasonal incidence of diseases and enemies of *A. mellifera* under stationary and migratory conditions. The European foulbrood disease infestation array from 0 to 29 per cent in stationary and 1.12 to 4.90 per cent during migratory period. The disease prevalence was assuredly correlated with temperature, colony strength and rainfall. Sac brood disease incidence was evidenced with 8 per cent brood infestation only in the month of April, 2016. The population of ectoparasitic mites i.e. *Varroa destructor* and *Tropilaelaps* clareae was recorded by three different methods viz. sticky paper, per 100 bees and visual examination. The incidence of *V. destructor* and *T. clareae* was observed during summer months when the temperature was high and relative humidity was low under stationary conditions. No mites were remarked during migratory period.

Keywords: Seasonal incidence, *Apis mellifera*, European foulbrood, *Varroa destructor*

1. Introduction
Honey bees are eusocial insects which are straighty lucrative to man and furnish cherished products like pollen, honey, royal jelly, bees wax, propolis and bee venom. The phantom of honey bees wax, brood, pollen, nectar and conducive environmental habitat available intramural the hive invites a number of enemies. The honey bee brood during its developmental stages is subjected to a number of diseases caused by bacteria, fungi, viruses, protozoa and mites et cetera, all of which render the bee colonies too feeble to exist (Chen *et al*. 2006) [12]. The existent of parallel hive products of beekeeping and decorous environmental conditions available inside the hive invite a number of enemies. The haleness and sturdiness of honey bee colonies are jeopardize by numerous pests, predators and diseases. Honey bees are predisposed to a variety of diseases and environmental menaces. While it is recalcitrant to identify a single facet which on its own can account for all colony forfeiture in all regions of the world over a given time period, it is translucent that plethora of biological and environmental constituent acting alone or in combination have the potential to cause premature colony mortality by adversely affecting colony health and lifespan. Among these factors, certain honey bee diseases and parasites have been shown to play a significant role in increased honey bee colony mortality and colony losses (Genersch, 2010) [17]. The introduction of the European honey bee (*Apis mellifera* L.) into Asia increased the total number of distinct species on the continent. On the other hand, parasites like *Varroa destructor* or *Tropilaelaps* spp. have cope to transit from their original hosts to the new honey bee species. So an attempt has been made to study the seasonal incidence of brood diseases and ectoparasitic mites in the stationary and migratory routes of Himachal Pradesh and Haryana with the aim to check the scenario of periodical infestation of diseases and mites.

2. Materials and Methods
Field exploration were conducted in the Apiary of the Department of Entomology at Main Experiment Station of Department of Entomology, Dr. Y.S. Parmar University of Horticulture

and Forestry, Nauni, Solan, Himachal Pradesh, situated at 33.3°N latitude, 70.70°E longitude and 1256 m amsl., to detect the sort of brood diseases and ectoparasitic mites on honeybee (*Apis mellifera*) during July 2015 to June 2016 under both frames (stationary and migratory). Twelve bee colonies of *A. mellifera* were selected randomly for monthly observations to record the type of brood diseases and ectoparasitic mites. The data on 100 brood cells in each of selected colony were examined for recording incidence of brood diseases. Estimation of mite population in brood cells by visual examination method and in adult by sugar dusting method and mites per 100 bees were adopted. The incidence of diseases and mites were correlated with weather (temperature, relative humidity and rainfall) and colony parameters. Field diagnosis of European foulbrood and Sac brood disease was carried out on the basis of standard symptoms. The frequency of ectoparasitic mites (*Varroa destructor* and *Tropilaelaps* clareae) (Fig 1) in brood and adults were recorded in selected colonies of *A. mellifera* by using three different methods (Asha *et al*. 2013, Poonia *et al*. 2014) [3, 23] of mite estimation (visual examination, sugar dusting and per 100 bee methods) during July 2015 to June 2016 in the university apiary, Nauni, Solan as well in migratory colonies in the plains of Haryana.

The statistics on incidence of diseases and enemies were transformed using the square root transformation as per the method described by Gomez and Gomez (1986) [19], subjected to analysis of variance (ANOVA) and means were compared using a least significant difference test. The randomized block design the least significant difference between treatments was calculated taking all the possible combinations of factors. The treatment effects were tested at 5 per cent level of significance. The correlation of diseases and mites incidence was compared with colony and weather parameters by Pearson Correlation method. The incidence of diseases and enemies was correlated with weather (temperature, relative humidity and rainfall) and colony (brood area and colony strength) parameters. The data on Ambient Temperature, Relative humidity and Rainfall were collected from the Department of Environmental Science, College of Forestry Dr Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan for the Period of experimentation as well as Department of Agricultural Meteorology Chaudhary Charan Singh Haryana Agricultural University Hisar, Haryana.

2.1 Estimation of mite population in brood cells by visual examination method

For evaluating the mite populations in experimental colonies 100 brood cells of *A. mellifera* colony were observed on each selected colonies with the help of lens.

2.2 Estimation of mite population in adult by sugar dusting method

The mite population in experimental colonies was estimated by using sugar dusting @ 15 g/frame. Sugar was kept over the top bar of every frame and was gently dusted with the help of bee brush. Mites falling after dusting got collected on sticky paper of screened bottom board and were counted after 24 hours.

2.3 Estimation of mites per 100 bees

Random samples of about 100 bees from brood nest of selected colonies were collected and put into open mouthed glass bottle. Thereafter, powdered sugar (5g) was dusted over these bees in order to motivate them for grooming and slightly agitating them. After 4-5 minutes, the jar was inverted on a paper and dislodged mites falling on paper were counted.

3. Results and Discussion

3.1 European foulbrood disease

The utterances were recorded on the seasonal incidence of European foulbrood disease under stationary and migratory conditions in *A. mellifera* colonies from July, 2015 to June, 2016. The characteristic symptoms of European foulbrood disease were recorded as, coiled larvae position and spotty brood pattern (Bailey, 1961; Abrol and Ball 2006; Foresgren, 2010) [5, 1, 16].

3.2 Under stationary conditions

The figures on incidence of European foulbrood disease in *A. mellifera* colonies under stationary conditions presented in Table 3 revealed that the incidence of European foulbrood was maximum during 2015 in July (26%), September (29) and June, 2016 (27), statistically same. The high incidence of European foulbrood in September did not show significant reduction in colony strength and brood area. The incidence of European foulbrood reduced significantly in the month of August (7%). The disease was found to disappear from experimental colonies at Nauni, Solan from October, 2015 to April, 2016 when brood was observed healthy. During 2016, European foulbrood disease reappeared in May with 17per cent brood infestation, which increased to 27 per cent in the month of June 2016, values being statistically same.

The facts on correlation of European foulbrood with colony and weather parameters in *A. mellifera* colonies under stationary conditions showed that the incidence of European foulbrood was significantly positive with temperature (r= 0.820) and colony strength (r= 0.608). The incidence of European foulbrood was also positively correlated with relative humidity (r= 0.535), rainfall (r= 0.575) and brood area (r= 0.539), though non-significant.

Rao (2009)[26] has also capitulated maximum incidence of European foulbrood in September (18.52%) in *A. mellifera* colonies at Nauni. He also observed that *A. mellifera* colonies during winter months were free from European foulbrood infestation. Similar extents of damage have been also reported in *A. mellifera* colonies (Moffett (1952) [22]; Giavarini (1956) [18] and Buza& Kovacs, 1969) [8] in other countries by different workers in different parts of world. These workers have also reported positive correlation of incidence of European foulbrood disease in different months of year in relation to bee strength, temperature, rainfall and relative humidity. The reason of absence of disease during winter months could be attributed to the fact that in these months there is lack of glandular food due to less number of nurse bees and as a result larvae appeared starved might have been detected and removed by bees. Bailey (1960) [4] and Simpson (1960) [29] have also reported direct influence of supply of glandular food by nurse bees on appearance and disappearance of European foulbrood in *A. mellifera*. The incidence of disease was positively correlated with colony strength. This again could be due to fact that the nurse bees were able to fullfil the demand of additional food requirement as is already reported by Singh (2005) [30].

1.2 Under migratory conditions

The facts on incidence of European foulbrood disease in *A. mellifera* colonies under migratory conditions presented in

Table 2 revealed that the trend of incidence of European foulbrood was almost similar when these colonies were kept at Nauni, Solan from July, 2015 to November, 2015. The observations further revealed that the disease incidence was also high from July, 2015 to September, 2015 (26.33 to 38.00 %) which reduced subsequently in the month of October, 2015 (16.78%). The European foulbrood incidence was observed in *A. mellifera* colonies in different winter months which were statistically low being 4.90, 1.92 and 2.32 per cent, respectively during November, 2015 January and February 2016. However, the disease reappeared again in the month of April (1.12%). European foulbrood incidence was noticed to further increase in *A. mellifera* colonies during months of May (4.27%) and June (5.17), being statistically same. Correlation of European foulbrood with colony and weather parameters in *A. mellifera* colonies under migratory conditions showed that the incidence of European foulbrood was positively correlated with rainfall (r= 0.733). Further, incidence of European foulbrood in *A. mellifera* colonies under migratory conditions showed positive correlation (non-significant) with temperature (r= 0.561) and relative humidity (r= 0.449) whereas, non-significant negative correlation with colony strength (r= -0.260) and brood area (r= -0.317).

Antithetical to the observations on incidence of European foulbrood disease at Nauni, the incidence of disease was observed during winter months at Hisar (November- March). The possible reason for continual appearance of disease in Haryana could be due to availability of nurse bees and sufficient glandular food which has direct impact on the presence of European foulbrood disease (Bailey, 1960 and Simpson, 1960) [4, 29].

2. Sac brood disease

Sac brood disease occurrence was recorded in *A. mellifera* colonies which were kept at Nauni during April, 2016 with 8 per cent brood infestation. The colonies were found free from this disease during the rest of months from July, 2015 to June, 2016. Appearance of sac brood virus showed typical symptoms in brood cells i.e. scattered brood pattern, sac like structure of brood filled with fluid and sunken perforated capping of brood cells (Bailey, 1981; Berenyi *et al.* 2006; Rana and Rana 2008) [6, 7, 24]. These investigations are supported by the finding of Rana and Rana (2008) [24] who had reported the incidence of sac brood disease during April to May when colony strength and brood area started increasing at faster rate. During the period of present investigations, brood area and bee strength increased from April to June (Table 3). The reason for disappearance of disease during March, May and June could be due to comparatively high humidity in these months (Table 3) which had negative correlation with occurrence of disease (Rana and Rana, 2008) [24]. The occurrences of disease during spring to summer have also been reported by different workers (Chandel *et al.* 1999, Hornitzky and Anderson, 2003; Rana and Rana, 2015) [11, 20, 25].

3. *Varroa destructor* Anderson & Trueman

Incidence of *Varroa destructor* was reckoned by three different methods viz. mite falling on sticky paper after sugar dusting on top bar, per 100 bees and visual examination of 100 brood cells for the presence of *Varroa* mite.

3.1 Under stationary conditions

The widespread generality of *V. destructor* in *A. mellifera* colonies under stationary conditions during July, 2015 to June, 2016 is presented in Table 3. The data on mite population recorded on sticky papers after sugar dusting on top bars of frames showed that the incidence of *Varroa* mite in *A. mellifera* colonies was maximum in summer months at Nauni, Solan. *Varroa* mite appeared in February, 2016 (8mites/ colony) which increased in March (12 mites), April (24 mites), May (29 mites) and reached its peak during June (45 mites).Similar trend in mite population has been observed when 100 bees from a colony were put in a glass bottle with 15g sugar. The mite population was significantly more in June, 2016 (15 mites/ 100 bees) and May (12 mites). The mite population during February, March and April 2016 was 4, 7 and 9, respectively. In remaining months of study (July 2015 to January 2016), no mite population was detected on adult bees.

Varroa infestation guesstimated by examining visually in the open and sealed brood cells also showed the similar trend of their infestation. The mite was noticed in February, 2016 with 5 per cent brood infestation which declined gradually in March (4%) and April (4%). Maximum infestation in brood was observed in June 2016 (10%). Brood was also found free from mite infestation from July, 2015 to January, 2016.The *Varroa* incidence in *A. mellifera* varied greatly from year to year and during different months of the year Asha *et al.*, 2013 and Poonia *et al.* 2014 [23]. Sharma (2010) [27] while screening *A. mellifera* against *Varroa* have reported low to high *Varroa* infestation during different seasons at Nauni. He reported that *Varroa* infestation varied (0.70±0.15 to 12.10±0.57) during different months at Nauni. However, in the present study, *Varroa* has been noticed only in spring and summer months (February to June).

The ammunition on correlation of *Varroa* incidence with colony and weather parameters is presented in Table 4**.** *Varroa* incidence showed significant positive correlation with colony strength {(r =0.807(sticky paper), 0.814 (per 100 bees), 0.717 (visual examination)} and significant negative correlation with relative humidity {(r = -0.624(sticky paper), -0.6.32 (per 100 bees) and -503 (visual examination)}. These observations suggested that the mite population increased with increase in temperature as is observed in present studies, where mite population peaked in June. Further the mite infestation decreased with increase in relative humidity during February to June, 2016 (Table 3). No *Varroa* incidence was recorded during July, 2015 to January, 2016 due to considerable increase in relative humidity. The present finding got are in conformity of different workers who have found the present correlation of *Varroa* incidence with temperature and rainfall (Deosi and Chhuneja, 2012) [15], Asha *et al.* (2013) [3] and Poonia *et al.* (2014) [23] who have also reported positive correlation of *Varroa* incidence with temperature and rainfall.

3.2 Under migratory conditions

Incidence of *V. destructor* in *A. mellifera* colonies under migratory conditions during July, 2015 to June, 2016 is presented in Table 5. The results indicated that there was no *Varroa* mite population when colonies were kept at Nauni, Solan from July 2015 to October, 2015 and *A. mellifera* colonies also remained free from mite infestation during migration (November, 2015 to March, 2016). The incidence of *Varroa* mite was detected in the month of April, 2016 and was found maximum (18mites/ colony) during June, 2016 in sticky paper method. The mite population per 100 bees was of

4, 8 and 16 mites in April, May and June, 2016. Brood infestation in migratory colonies was noticed in the month of May with significant low infestation (3%) at Nauni. But the infestation increased (7%) in June, 2016.The data on correlation of incidence of *V. destructor* (Table 6) with colony and weather parameters showed significant negative correlation with relative humidity {r= -0.569 (sticky paper)}. Incidence of *Varroa* was positively correlated with temperature {r =0.343(sticky paper), 0.342 (per 100 bees), 0.333 (visual examination)} and rainfall {(r= 0.147(sticky paper), 0.166 (per 100 bees), 0.196 (visual examination)}, though non-significant.

The present finding on absence of *Varroa* mite during migratory period from November to March could be attributed to the prevailing high humidity and low temperature conditions at Hisar. These studies are in conformity to the observations of earlier workers (Poonia *et al.* 2014)[23] who have reported no mite population during winters in Hisar, Haryana. They have also found the positive correlation of *Varroa* incidence with temperature and rainfall. Similar results were also reported by Asha *et al.* (2013) [3], Deosai and Chhuneja (2012) [15], De jong *et al.* (1982) [13], De jong (1990) [14] and Kokkinis and Liakos (2004) [21].

4. *Tropilaelaps clareae*

4.1 Under stationary conditions

The statistics on infestation of *T. clareae* in *A. mellifera* colonies under immobile circumstances are presented in Table7 elucidated that the minimum (6 mites/colony) population of *T. clareae* was observed in *A. mellifera* colonies in the month of February, 2016 at Nauni. Thereafter *T. clareae* population increased gradually in March (8 mites/colony), April (11 mites) and May (12mites). Maximum population of *T. clareae* varied recorded in the month of June (16mites). The population of *T. clareae* was varied from 2 to 5 per 100 bees during February to April. The mite population increased significantly in the month of May (9 mites) and June (12 mites). Perusal of data in Table 7 further revealed that brood infestation of mites was observed initially in the month of April which ranged from 2 to 4 per cent during April to June, 2016. In general, maximum infestation was observed in the month of June in all the methods of estimation of mite population. Experimental colonies were found free from *T. clareae* from July, 2015 to January, 2016 on adult bees and July, 2015 to March, 2016 on brood. The data on correlation of incidence of *T. clareae* with colony and weather parameters presented in Table 8 showed significant positive correlation of incidence of *T. clareae* with colony strength {(r= 0.790(sticky paper), 0.815(per 100 bees), 0.760(visual examination)} and negative with relative humidity (r= -0.646 {(sticky paper), -0.577(per 100 bees), -0.685(visual examination)}. Incidence of *T. clareae* was positively correlated with temperature and brood area and negatively with rainfall, though non-significant.

The span of pervasiveness and correlation statistcs revealed of *T. clareae* showed similar trend as in *Varroa* mite. Like *Varroa* mite, the incidence of *T. clareae* in *A. mellifera* have also been reported to vary greatly from year to year and during different months. The reason for the variations of mite infestation in *A. mellifera* colonies during different months of the year may be attributed to fluctuation of the temperature, rainfall and relative humidity (Camphor and Martin, 2009) [9]. The present study also is line with the finding of Sharma *et al.* (2011) [28] who studied the seasonal variations of ectoparasitic mites in honey bee and observed that *T. clareae* infestation in *A. mellifera* colonies vary from 2.57±0.60 to 56.00±0.31during different months.

4.2 Under migratory conditions

Ubiquitousness of *T. clareae* in *A. mellifera* colonies beneath relocating conditions estimated by different methods is presented in Table 9. The colonies of *A. mellifera* were noticed free from *T. clareae* incidence from July to October, 2015. No mite population was detected on brood and adult bees when colonies were shifted to Hisar from November, 2015 to March, 2016. *T. clareae* incidence was noticed minimum in April (6mites/colony) and May (8 mites). *T. clareae* population was significantly more in June (15 mites) when estimated by sticky paper method. Similar trend of *T. clareae* infestation in respective months was also observed per 100 bees. The infestation of *T. clareae* on brood varied from 1 per cent (April) to 5 per cent (June) in migratory colonies when observed through visual observation at Nauni, Solan.

Correlation data on incidence of *T. clareae* (Table 10) with colony and weather parameters revealed the significant negative correlation with relative humidity {(r= -0.578(sticky paper), -0.589(per 100 bees), -0.577(visual examination)}. The incidence of *T. clareae* with temperature and rainfall was positively correlated but statistically found to be non-significant. Colony strength and brood area was negatively correlated with incidence of *T. clareae*, though non-significant.

The present finding on absence of *T. clareae* mite during migratory period from November to March could be attributed to the prevailing high humidity and low temperature conditions at Hisar. These studies are in conformity to the observations of earlier workers (Aggarwal and Kapil, 2013) [2] who have reported no mite population during winters. The present studies are in line with findings of Chahal *et al.* (1986) [10], who have also found positive correlation of *T. clareae* incidence with temperature and rainfall.

Table 1: Incidence of European foulbrood disease in *A. mellifera* colonies and its correlation with weather and colony parameters under stationary conditions (Nauni, Solan) during July, 2015 to June, 2016

Period	EFB incidence (%)	Colony parameters		Weather parameters		
		Colony strength (bee frame)	Brood area (cm^2)	Temperature ($^{\circ}C$)	Relative humidity (%)	Rainfall (mm)
July, 2015	26.00 (3.09)*	5.33	1790.00 (42.27)	24.10	79.00	294.40
August	7.00 (1.75)	3.67	746.67 (27.29)	24.00	80.00	102.20
September	29.00 (3.26)	4.67	860.00 (29.30)	30.40	68.00	41.60
October	0.00 (1.00)	4.00	597.67 (24.34)	19.00	58.00	34.60
November	0.00 (1.00)	3.67	508.00 (22.40)	15.50	57.00	7.60
December	0.00 (1.00)	3.33	312.00 (16.45)	11.00	59.00	42.50
January, 2016	0.00 (1.00)	2.67	473.33 (21.77)	10.85	56.00	4.00
February	0.00 (1.00)	4.00	972.00 (29.99)	13.05	56.00	35.60

March	0.00 (1.00)	4.67	1053.33 (32.39)	16.65	55.00	87.50
April	0.00 (1.00)	5.67	2023.00 (44.96)	21.45	45.00	25.60
May	17.00 (2.35)	6.67	3379.33 (57.84)	23.65	57.00	56.50
June	27.00 (3.15)	6.33	2296.67 (51.67)	25.55	60.00	110.50
$CD_{0.05}$	0.80	1.16	7.72			

*Figures in parentheses are square root (x+1) transformed values

Pearson correlation Matrix (r) =

Temperature × EFB incidence = 0.820*
Relative Humidity× EFB incidence = 0.535
Rainfall × EFB incidence = 0.575
Colony Strength × EFB incidence = 0.608*
Brood Area× EFB incidence = 0.539
(*Significant at 5%)

Table 2: Incidence of European foulbrood disease in *A. mellifera* and its correlation with weather and colony parameters under migratory (Hisar, Haryana) and stationary (Nauni, Solan) conditions during July, 2015 to June, 2016

Period	EFB incidence (%)	Colony parameters		Weather parameters		
		Colony strength (bee frame)	Brood area (cm^2)	Temperature (°C)	Relative humidity (%)	Rainfall (mm)
July, 2015	38.00 (6.24)*	4.67	1663.33 (40.75)	24.10	79.00	294.40
August	36.67 (6.10)	4.00	756.00 (27.46)	24.00	80.00	102.20
September	26.33 (5.22)	4.33	893.33 (29.67)	30.40	68.00	41.60
October	16.78 (4.21)	4.00	564.33 (23.71)	19.00	58.00	34.60
November**	4.90 (2.40)	4.00	826.67 (28.76)	20.00	67.00	0.00
December**	0.00 (1.00)	5.00	1584.67 (39.78)	14.20	71.00	0.00
January, 2016**	1.92 (1.64)	6.00	2207.00 (46.98)	13.40	80.00	0.00
February**	2.32 (1.74)	7.00	3193.67 (56.51)	15.70	71.00	0.00
March**	0.00 (1.00)	8.00	5140.67 (71.63)	21.80	67.00	0.00
April	1.12 (1.42)	2.33	346.00 (18.36)	21.45	45.00	25.60
May	4.27 (2.29)	3.67	708.00 (26.58)	23.65	57.00	56.50
June	5.17 (2.47)	4.33	1130.00 (33.59)	23.55	60.00	110.50
$CD_{0.05}$	0.75	0.87	4.21			

*****Figures in parentheses are square root (x+1) transformed values
**Months of migration period of colonies to Haryana

Pearson correlation Matrix (r) =

Temperature × EFB incidence = 0.561
Relative Humidity× EFB incidence = 0.449
Rainfall × EFB incidence = 0.733*
Colony Strength × EFB incidence = -0.260
Brood Area× EFB incidence = -0.317 (*Significant at 5%)

Table 3: Incidence of *Varroa destructor* in *A. mellifera* colonies under stationary (Nauni, Solan) conditions during July, 2015 to June, 2016

Period	Incidence of *Varroa destructor*			Colony parameters		Weather parameters		
	Sticky paper (no./colony)	Per 100 bees (no.)	Brood infestation# (%)	Colony strength (bee frame)	Brood area (cm^2)	Temperature (°C)	Relative humidity (%)	Rainfall (mm)
July, 2015	0.00 (1.00)*	0.00 (1.00)	0.00 (1.00)	5.33	1790.00 (42.27)*	24.10	79.00	294.40
August	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	3.67	746.67 (27.29)	24.00	80.00	102.20
September	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	4.67	860.00 (29.30)	30.40	68.00	41.60
October	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	4.00	597.67 (24.34)	19.00	58.00	34.60
November	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	3.67	508.00 (22.40)	15.50	57.00	7.60
December	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	3.33	312.00 (16.45)	11.00	59.00	42.50
January, 2016	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	2.67	473.33 (21.77)	10.85	56.00	4.00
February	8.00 (3.00)	4.00 (2.10)	5.00 (2.30)	4.00	972.00 (29.99)	13.05	56.00	35.60
March	12.00 (3.60)	7.00 (2.80)	4.00 (2.20)	4.67	1053.33 (32.39)	16.65	55.00	87.50
April	24.00 (4.90)	9.00 (3.10)	4.00 (2.30)	5.67	2023.00 (44.96)	21.45	45.00	25.60
May	29.00 (5.40)	12.00 (3.50)	6.00 (2.60)	6.67	3379.33 (57.84)	23.65	57.00	56.50
June	45.00 (6.80)	15.00 (4.00)	10.00 (3.30)	6.33	2296.67 (51.67)	25.55	60.00	110.50
$CD_{0.05}$	0.65	0.47	0.58	1.16	7.72			

*Figures in parentheses are square root (x+1) transformed values, #by visual examination.

Table 4: Pearson correlation coefficient (r) between incidence of *Varroa destructor* with colony and weather parameters under stationary conditions

Methods / Parameters	Sticky paper	Per 100 bees	Brood infestation
Temperature	0.300	0.278	0.202
Relative Humidity	-0.624#	-0.632#	-0.503
Rainfall	0.021	0.004	0.013
Colony strength	0.807#	0.814#	0.717#
Brood area	0.350	0.431	0.270

(# Significant at 5%)

Table 5: Incidence of *Varroa destructor* in *A. mellifera* colonies under migratory (Hisar, Haryana) and stationary (Nauni, Solan) conditions during July, 2015 to June, 2016

Period	Incidence of *Varroa destructor*			Colony parameters		Weather parameters		
	Sticky paper (no./colony)	Per 100 bees (no.)	Brood infestation# (%)	Colony strength (bee frame)	Brood area (cm^2)	Temperature (°C)	Relative Humidity (%)	Rainfall (mm)
July, 2015	0.00 (1.00)*	0.00 (1.00)	0.00 (1.00)	4.67	1663.33 (40.75)	24.10	79.00	294.40
August	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	4.00	756.00 (27.46)	24.00	80.00	102.20
September	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	4.33	893.33 (29.67)	30.40	68.00	41.60
October	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	4.00	564.33 (23.71)	19.00	58.00	34.60
November**	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	4.00	826.67 (28.76)	20.00	67.00	0.00
December**	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	5.00	1584.67 (39.78)	14.20	71.00	0.00
January, 2016**	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	6.00	2207.00 (46.98)	13.40	80.00	0.00
February**	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	7.00	3193.67 (56.51)	15.70	71.00	0.00
March**	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	8.00	5140.67 (73.39)	21.80	67.00	0.00
April	6.00 (2.80)	4.00 (2.10)	0.00 (1.00)	2.33	346.00 (18.36)	21.45	45.00	25.60
May	12.00 (3.70)	8.00 (2.90)	3.00 (1.89)	3.67	708.00 (26.58)	23.65	57.00	56.50
June	18.00 (4.30)	16.00 (4.20)	7.00 (2.81)	4.33	1130.00 (33.59)	25.55	60.00	110.50
$CD_{0.05}$	0.35	0.40	0.43	0.72	3.92			

*Figures in parentheses are square root (x+1) transformed values, **Months of migration period of colonies to Haryana, #by visual examination

Table 6: Pearson correlation coefficient (r) between incidence of *V. destructor* with colony and weather parameters under migratory conditions

Methods / Parameters	Sticky paper	Per 100 bees	Visual examination
Temperature	0.343	0.342	0.333
Relative Humidity	-0.569#	-0.481	-0.316
Rainfall	0.147	0.166	0.196
Colony strength	-0.353	-0.306	-0.179
Brood area	-0.287	-0.256	-0.180

(# Significant at 5%)

Table 7: Incidence of *Tropilaelaps clareae* in *A. mellifera* colonies under stationary (Nauni, Solan) conditions with during July, 2015 to June, 2016

Period	Incidence of *Varroa destructor*			Colony parameters		Weather parameters		
	Sticky paper (no./colony)	Per 100 bees (no.)	Brood infestation# (%)	Colony strength (bee frame)	Brood area (cm^2)	Temperature (°C)	Relative Humidity (%)	Rainfall (mm)
July, 2015	0.00 (1.00)*	0.00 (1.00)	0.00 (1.00)	5.33	1790.00 (42.27)	24.10	79.00	294.40
August	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	3.67	746.67 (27.29)	24.00	80.00	102.20
September	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	4.67	860.00 (29.30)	30.40	68.00	41.60
October	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	4.00	597.67 (24.34)	19.00	58.00	34.60
November	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	3.67	508.00 (22.40)	15.50	57.00	7.60
December	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	3.33	312.00 (16.45)	11.00	59.00	42.50
January, 2016	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	2.67	473.33 (21.77)	10.85	56.00	4.00
February	6.00 (2.60)	2.00 (1.70)	0.00 (1.00)	4.00	972.00 (29.99)	13.05	56.00	35.60
March	8.00 (2.90)	3.00 (2.00)	0.00 (1.00)	4.67	1053.33 (32.39)	16.65	55.00	87.50
April	11.00 (3.50)	5.00 (2.30)	3.00 (1.90)	5.67	2023.00 (44.96)	21.45	45.00	25.60
May	12.00 (3.60)	9.00 (3.10)	2.00 (1.60)	6.67	3379.33 (57.84)	23.65	57.00	56.50
June	16. 00 (4.00)	12.00 (3.50)	4.00 (2.10)	6.33	2296.67 (51.67)	25.55	60.00	110.50
$CD_{0.05}$	0.63	0.48	0.56	1.16	7.72			

*Figures in parentheses are square root (x+1) transformed values, #by visual examination

Table 8: Pearson correlation coefficient (r) between incidence of *Tropilaelaps clareae* with colony and weather parameters under stationary conditions

Methods / Parameters	Sticky paper	Per 100 bees	Visual examination
Temperature	0.242	0.311	0.307
Relative Humidity	-0.646#	-0.577#	-0.685#
Rainfall	-0.016	-0.034	-0.001
Colony strength	0.790#	0.815#	0.760#
Brood area	0.413	0.384	0.301

(# Significant at 5%)

Table 9: Incidence of *Tropilaelaps clareae* in *A. mellifera* colonies under migratory (Hisar, Haryana) and stationary (Nauni, Solan) conditions during July, 2015 to June, 2016

Period	Incidence of *Tropilaelaps clareae*			Colony parameters		Weather parameters		
	Sticky paper (no./colony)	Per 100 bees (no.)	Brood infestation# (%)	Colony strength (bee frame)	Brood area (cm^2)	Temperature (°C)	Relative humidity (%)	Rainfall (mm)
July 2015	0.00 (1.00)*	0.00 (1.00)	0.00 (1.00)	4.67	1663.33 (40.75)	24.10	79.00	294.40
August	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	4.00	756.00 (27.46)	24.00	80.00	102.20
September	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	4.33	893.33 (29.67)	30.40	68.00	41.60
October	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	4.00	564.33 (23.71)	19.00	58.00	34.60
November**	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	4.00	826.67 (28.76)	20.00	67.00	0.00
December**	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	5.00	1584.67 (39.78)	14.20	71.00	0.00
January 2016**	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	6.00	2207.00 (46.98)	13.40	80.00	0.00
February **	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	7.00	3193.67 (56.51)	15.70	71.00	0.00
March**	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)	8.00	5140.67 (73.39)	21.80	67.00	0.00
April	6.00 (2.40)	3.00 (1.90)	1.00 (1.30)	2.33	346.00 (18.36)	21.45	45.00	25.60
May	8.00 (2.90)	5.00 (2.30)	4.00 (2.00)	3.67	708.00 (26.58)	23.65	57.00	56.50
June	15.00 (3.90)	11.00 (3.30)	5.00 (2.20)	4.33	1130.00 (33.59)	25.55	60.00	110.50
$CD_{0.05}$	0.73	0.77	0.71	0.72	3.92			

*Figures in parentheses are square root (x+1) transformed values, ** Months of migration period of colonies to Haryana, #by visual examination

Table 10: Pearson correlation coefficient (r) between incidence of *Tropilaelaps clareae* with colony and weather parameters under migratory conditions

Methods / Parameters	Sticky paper	Per 100 bees	Visual examination
Temperature	0.338	0.340	0.342
Relative Humidity	-0.578#	-0.589#	-0.577#
Rainfall	0.146	0.166	0.153
Colony strength	-0.369	-0.311	-0.306
Brood area	-0.291	-0.256	-0.264

(# Significant at 5%)

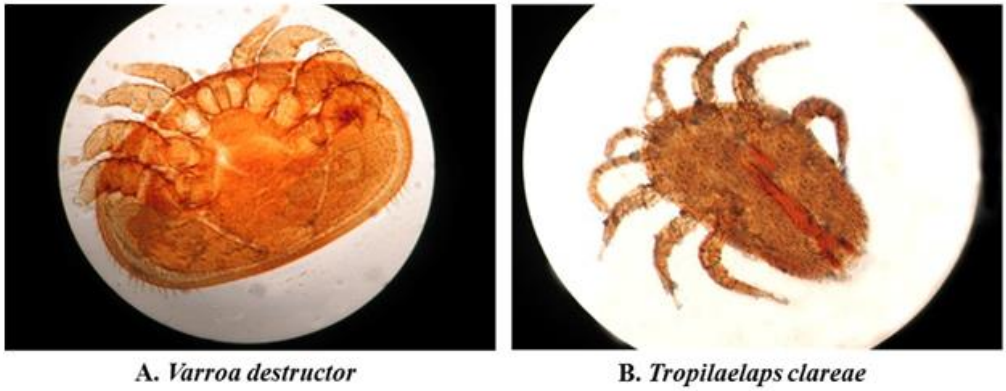

Fig 1: Ectoparasitic mites [*Varroa destructor* and *Tropilaelaps clareae*]

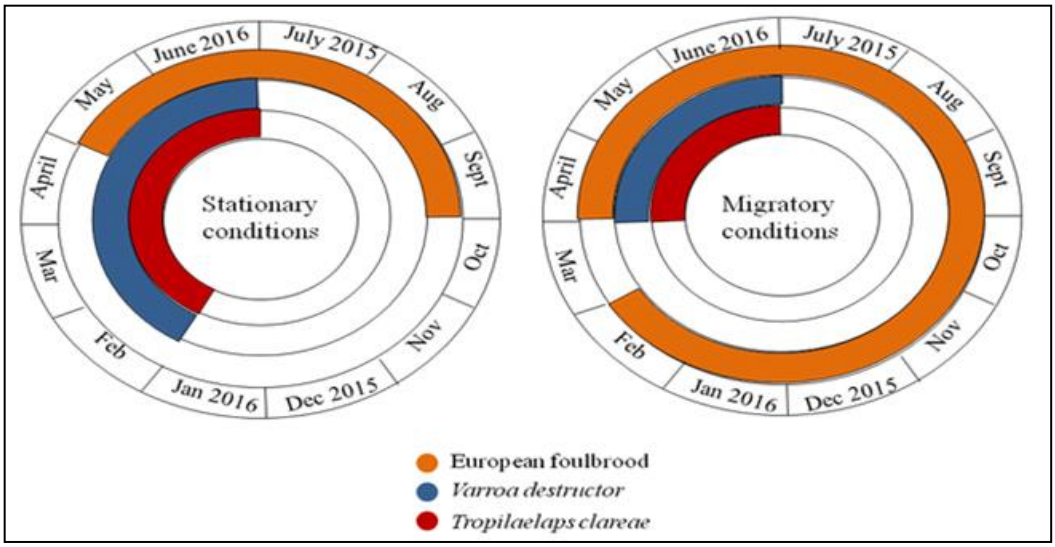

Fig 2: Incidence of European foulbrood and ectoparasitic mites [*Varroa destructor* and *Tropilaelaps* clareae] in *A. mellifera* under stationary and migratory conditions.

5. Conclusion

A. mellifera beekeeping in Himachal Pradesh is fruitful beneath migratory habitats, since colonies gained strength and produced surplus honey and can also be divided when migrated to tremendous enrich floral belts. Incidence of brood diseases and ectoparasitic mites under migratory and immobile conditions remained low to moderate without any significant effect on colony strength and its development suggesting that the incidence of diseases and mites can be reduced by adopting scientific beekeeping. Incidence of diseases and mites has significant relation with relative humidity and temperature showing that these factors can play important role in outbreak of diseases and enemies.

The European foulbrood incidence disease ranged from 0 to 29 per cent in stationary and 1.12 to 4.90 per cent during migratory period. The disease incidence was positively correlated with temperature, colony strength and rainfall. The population of ectoparasitic mites i.e. *Varroa destructor* and *Tropilaelaps clareae* was recorded by three different methods viz. sticky paper, per 100 bees and visual examination. The incidence of *V. destructor* and *T. clareae* was observed during summer months when the temperature was high and relative humidity was low under stationary conditions. No mites were observed during migratory period.

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