Research Article

Factors Affecting Honey Bee Population in Western Himalaya of Uttarakhand: An Observational Study

Nagma Parveen[1,*], Kulbhushan Kumar[1], Rashi Miglani[1], Ankit Kumar[2], Uzma Siddiqui[1], Gaurav Rawat[1] and Satpal Singh Bisht[1]

[1]Department of Zoology, D.S.B. Campus, Kumaun University, Nainital, Uttarakhand, INDIA.
[2]Department of Pharmaceutical Sciences, Sir J.C. Bose Technical Campus, Kumaun University, Bhimtal, Nainital, Uttarakhand, INDIA.

Submission Date: 04-06-2022; Revision Date: 17-07-2022; Accepted Date: 05-08-2022.

ABSTRACT

Insect pollinators, especially honey bees, are an essential biotic factor in the reproductive success of plants that rely on insects for pollination. Their extinction would endanger food production and sustainable biodiversity. Climate change, habitat destruction, fragmentation, the prevalence of diseases, parasites, insufficient nutrition, extensive agricultural practices and invasion by foreign and predatory species contribute to the decline of the honey bee population. The present study aims to observe and document the factors affecting the population of honey bees in the study area. Thus, a comprehensive survey of 59 modern and 42 traditional apiaries in the Nainital district of Uttarakhand, India, was conducted. In the present study, the most common nuisances of honeybees were insects, followed by avian fauna and arachnids. Apart from insects and arachnids, four bird species were nesting and roaming around beehives. Few insects and reptiles belonging to the non-pest category were also spotted infesting the hives in the study sites. It has been observed that these factors negatively affect the bee population. Managing these factors is crucial in conserving the native and captive bees to sustain the environment.

Keywords: Honey Bee, Population, Pests, Predators, Parasites, Western Himalaya.

Correspondence:
Ms. Nagma Parveen,
Department of Zoology, D.S.B. Campus, Kumaun University,
Nainital-263001
Uttarakhand, INDIA.

Email: nagmaparveen@kunainital.ac.in

INTRODUCTION

Honey bees are necessary for sustainable development and pollination. Bees are valuable pollinators of forests, agriculture and horticulture, including the procedures of marketable products like honey, wax, propolis and venom. Therefore, different countries worldwide are looking for beekeeping as a vital source for their agriculture and rural development plans.[1-2] Bees are an essential biotic factor in the reproductive success of plants that rely on insects for pollination,[3-4] their extinction threatens food production and biodiversity sustainability.

SCAN QR CODE TO VIEW ONLINE

www.ajbls.com

DOI: 10.5530/ajbls.2022.11.74

Climate change, habitat fragmentation, the prevalence of diseases, parasites, inadequate nutrition, extensive agricultural practices and an infestation of foreign and predatory species are all factors contributing to honey bee population decline.[5-8] Kraus and Page, 1995[9] reported that almost half of North America's European honeybee hives have vanished after their introduction. Both managed and wild bees are currently declining globally.[10-11] In recent years, several areas worldwide have seen a significant drop in honey bee hives.[12] The decline in the bee population in western countries has been shocking in recent years, with agricultural production being one of the leading causes,[13-14] pesticide use,[3] habitat fragmentation,[15] climate change[16] and to some extent the lack of floral diversity[17-18] pests, parasites and predators are also foremost causes.

Honeybees are ectothermic, which means that the temperature of the environment regulates their movement. As a result, climate change, which is characterized by increased temperatures, has the potential to impact their biology, behaviour and distribution significantly. Climate change indirectly impacts bees because as a result, both their floral resources and their natural enemies are adversely affected. Climate-induced mismatches in insect-plant phenology and distribution can have significant demographic effects on the species involved. This is because insects and plants react differently to temperature variations.[19] Climate change can change the floral environment and improve or decrease colony gathering capacity. It can create new honey bee distribution areas and competitive connections among species, races, parasites and pathogens.[20] Bees are unable to return to the hive due to low temperatures and severe winds, resulting in a significant number of deaths.[21]

The *Apis* genera of honey bees, along with all other living organisms, is subject to invasion or attack by its natural predators. Studies show that pests and viruses have caused damage to beehives in recent years.[1] Different stress factors were observed in different studies regarding the causes of bee colony loss. The collapse of a colony is more likely when a variety of unfavourable conditions interact. Bee mortality and genetic diversity are thought to be exacerbated and diminished as a result of a variety of conditions, including stress from inadequate nutrition, fasting, a monocultural diet, rapid weather changes, chronic pesticide poisoning, and impaired honey bee immunity.[7,22-23]

Besides insecticides, used in agriculture, honey bees come across the exposure to acaricides used to manage *Varroa* and other parasites. Bees come into touch with the high residue levels on the waxy cells of the comb. In this situation, it mainly harms the developing larvae, presumably adult honey bees and the queen.[24-26] *A. cerana* and *A. mellifera* populations are declining due to the introduction of *Varroa destructor* and *Varroa jacobsoni*, which feeds on the fat bodies of immature honeybees. Honeybee colonies suffer from abnormal brood development and brood mortality when *V. destructor* feeds on honeybee fat body tissues. *Tropilaelaps* spp. is also a species of mite that infests honey bees and is reported only in Asia, but the worldwide honey trade has the potential to disseminate it to many more.[27-30]

The losses of a honey bee colony are also incurred by pathogens such as the microsporidia *Nosema ceranae*, *Nosema apis*, the more virulent one, and the ectoparasitic mite *Varroa destructor*. Fungi like *Ascosphaera apis*, bacteria like *Paenibacillus larvae* and *Melissococcus plutonius*, amoebae like *Malpighamoeba mellificae,* septicemia and S*piroplasma*, small hive beetles like *Aethina tumida,* wax moths like *Pyralidae* and others cause the loss of bee colonies.[31-33] The greater wax moth (*Galleria mellonella*) is an opportunistic pest that can severely damage honey bee hives' stored combs. *G. mellonella* larvae are thought to have a significant impact on tropical and subtropical honeybee populations, and this is one of the primary causes of the decline of both feral and wild honeybee populations in those regions.[34] It is believed that *Galleria mellonella* and *Achroia grisella*, members of the Lepidoptera family of wax moths, cause the most damage to *Apis mellifera* colonies and beehive products around the globe.[35,29] Beekeepers encounter a wide variety of ant species, which are considered pests. African honey bee populations have been decimated by the spread of invasive species such as Weaver ants (*Oecophylla smaragadina*), Black ants (*Monomorium indicum*), Tramp ant (*Monomorphum destructor*), Carpenter ant (*Camponotus compressus*), Fire ants (*Solenopsis* spp.) and *Formica* spp.[29] Several species of birds specialize in eating honey bees and the goods they produce, such as the Oriental Honey Buzzard (*Pernis ptilorhynchus*) and the European bee-eater (*Merops apiaster*) also cause a nuisance to bees.

A decrease in honey bee performance and the subsequent dissolution of the colony might be the outcome of hornets like *Vespa velutina* and *Vespa tropica*'s predatory activities targeting honey bees.[36-37] The phorid flies (*Apocephalus borealis* and *Braula coeca* and *Braula coeca*) are considered serious killers of honey bees throughout Central America, Europe, the Middle East and South Africa.

In the United States, the majority of bee colony losses are due to adverse weather conditions, starvation, loss of the bee queen, or stress associated with transporting hives over long distances and infection (primarily viruses, bacteria, and fungi) that may contribute to CCD syndrome (Colony Collapse Disorder).[38] Most of the infections in honey bees go undiagnosed because of the lack of clinically identifiable sickness signs, making viruses their secret enemy compared to other pathogens.[39] RNA viruses, such as ABPV, BQCV, IAPV, KBV, DWV, Kakugovirus (KV), Varroa destructor virus-1 (VDV-1), Sacbrood virus (SBV), Slow bee paralysis (CBPV), Lake Saini viruses (LSV) and Bee Macula-like virus (BMLV) are the most common honey bee pathogens.[40]

Bee health is affected by a wide range of parameters, including the host and virus genetic makeup, the immunological response, synergistic and/or antagonistic pathogenic infections, microbial composition, nutritional status, and exposure to agrochemicals, to name but a few. Honey bees can potentially suffer malformations, paralysis, death, or stay asymptomatic as a result of a viral infection.[41-44]

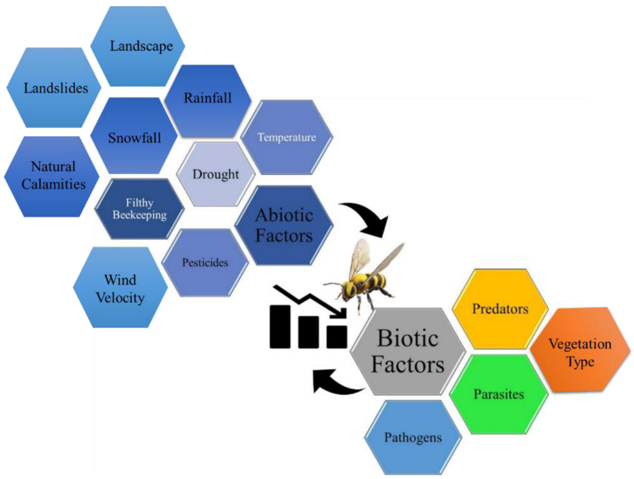

Figure 1: Factors Affecting Honey Bee Population.

Population declines due to Chock brood, wax moths, amoeba, *Nosema, Varroa* mites, ants, lizards and spiders are the most often documented honey bee illnesses and pests recorded so far.[2] Multiple factors affecting bee health are depicted in Figure 1.

The reduction in the honey bee population has been extensively studied in the United States and Europe, but information from South Asian countries, including India, is limited.[45]

MATERIALS AND METHODS

Study Site

The Nainital district is situated at an elevation of 1948 metres (6,385 feet) above sea level, with a latitude of 29°22'48.00" N and a longitude of 79° 27'0.00" E. During the research period, eighteen sites in the Nainital area were surveyed, spanning five blocks (Western Himalayan region) (Table 1).

Data Collection

The survey was conducted from June 2019 to January 2022. 101 (59 modern and 42 traditional) apiaries from 18 sites were surveyed. On-site problems and factors leading to bee population decline were closely observed and documented during every field visit (Figure 2).

RESULTS

In the present investigation on various parasites and predators targeting European honey bee, *Apis mellifera* and Indian honey bee *Apis cerana indica* colonies were carried out and significant facts have been recorded during the entire course of the study.

Insects and arachnids were the most common pests of honeybees, according to an extensive assessment performed in 59 modern apiaries and 42 traditional apiaries in various agro-climatic zones. During the investigation, 4 individuals from Hymenoptera, 2 individuals from Lepidoptera, and 2 from non-insect class, Arachnida are reported. Aside from insects and arachnids, 4 birds have also been spotted nesting and roaming around beehives. These predators, pests and parasites were observed and recorded in apiaries, though, not throughout the year but in different seasons (Table 2).

A- Insect Pests/Predators

[I] Hymenopterans

Hornets are the most active and common predators attacking the study sites' colonies of *A. mellifera* and *A. cerana indica*. *Vespa tropica* (Greater banded hornet), *Vespa velutina* (Asian hornet), *Formica fusca* (Black ant) and *Camponotus compressus* (Carpenter ant) were found in different study sites during the summer season. Amongst these, *Vespa tropica* was found to be the most prominent pest, present in 100% commercial (59) and 100% traditional (42) apiaries, showing similarity with the findings of Chandra and Mattu, 2017, followed by *Camponotus compressus* in 79.60%, *Formica fusca* in 69.49% and *Vespa velutina* in 59.32% modern apiaries (Figure 3 and 4). While in traditional beekeeping, *Vespa velutina* in 80.95%, *Formica fusca* in 47.61% and *Camponotus compressus* in 21.42% of apiaries were observed.

[II] Lepidoptera

The most common wax moth species are *Galleria mellonella* (Greater wax moth) and *Achroia grisella* (Lesser wax moth) found clogging up the *A. mellifera* and *A. cerana indica* colonies, in different agro-climatic regions of the research site. 64.40% of modern apiaries were infected with *Galleria mellonella* (Figure 5) and infestation of *Achroia grisella* was found in 45.76% of modern apiaries. Several researchers have observed these pests in other parts of the world.

B- Non-Insect Pest/Predators/Parasites

[I] Arachnids

Certain arachnids in the research sites generated serious challenges for *A. mellifera* and *A. cerana indica* colonies. Two species of mites were observed during the study period i.e., *Tropilaelaps* spp. and *Varroa* spp. Amongst the total apiaries, the broods and adults of 44.06% and 35.00% of modern apiaries were parasitized with mites of *Tropilaelaps* spp. and *Varroa* spp. Respectively (Figure 6). While no parasitism due to mites was observed in traditional apiaries.

Table 1: Description of Study Sites.

Study Sites (District Nainital)	Geographical Coordinates	Altitude (masl)	Geo-climatic Zone	Prominent Plants observed in and around apiaries/Study sites
Jyoli	29°38›08.63» N 79°34'12.64" E	1417		Flowers: *Papaver somniferum* (opium poppy), *Helianthus annuus* (Sunflower), *Lillium philadelphicum* (Wood Lily), *Lillium candidum* (Madonna lily), *Hydrangea macrophylla* (bigleaf hydrangea), *Rosa damascene* (Damask rose), *Gazania linearis* (Treasure flower), *Calendula officinalis* (Pot marigold), Tagetes spp. (marigold), *Hibiscus-rosa sinensis* (Chinese hibiscus), *Bellis perennis* (lawn daisy)
Bhalyuti	29°20›26.93» N 79°28'52.51" E	928	Mid Shiwalik	Fruits: *Pyrus Pyrifolia* (Pear), *Psidium guajava* (Guava), *Mangifera indica* (Mango), *Prunus domestica* (Plum), *Litchi chinensis* (Litchi), *Citrus sinensis* (Malta)
Dhakakhet	29°20›31.51» N 79°29'04.38" E	1276		Grains/Vegetables: *Triticum aestivum* (Wheat), *Oryza sativa* (Paddy), *Zea Mays* (Maize), *Allium sativum* (Onion), *Allium cepa* (Garlic), *Spinacia oleracea* (Spinach), *Trigonella stellata* (Fenugreek leaves), *Solanum tuberosum (Potato)*, *Cucurbita* L. (Pumpkin), *Pisum sativum* (Pea)
Lohariyasal Talla	29°13'33.31" N 79°30'10.56" E	430		**Flowers:** *Helianthus annuus* (Sunflower), *Lillium candidum* (Madonna lily, *Rosa* spp. (Rose), *Gazania linearis* (Treasure flower), *Calendula officinalis* (Pot marigold), *Hibiscus-rosa sinensis* (Chinese hibiscus)
Kathgodam	29°15›07.68» N 79°32'23.56" E	492	Bhabar (foothill area)	
Basantpur	29°09›39.12» N 79°34'13.06" E	348		**Fruits:** *Psidium guajava* (Guava), *Mangifera indica* (Mango), *Musa paradisiaca* (Banana), *Carica papaya* (Papaya)
Kunwarpur	29°11›53.03» N 79°34'07.58" E	400		**Grains/Vegetables:** *Triticum aestivum* (Wheat), *Oryza sativa* (Paddy), *Zea Mays* (Maize), *Spinacia oleracea* (Spinach), *Trigonella stellata* (Fenugreek leaves), *Solanum tuberosum (Potato)*, *Cucurbita* L. (Pumpkin), *Phaseolus vulgaris* (kidney bean), *Pisum sativum* (Pea), *Abelmoschus esculentus* (Ladyfinger), *Raphanus sativus* (Radish), *Capsicum annuum* (Capsicum)
Fatehpur	29°15›40.99» N 79°27'24.36" E	436		
Halduchaur	29°06›43.10» N 79°31'25.39" E	301	Bhabar (foothill area)	
Dewla Talla	29°12›05.80» N 79°34'02.39" E	405		
Bail Parao	29°18›30.10» N 79°12'30.66" E	350		**Flowers:** *Helianthus annuus* (Sunflower), *Lillium Rosa damascene* (Damask rose), *Gazania linearis* (Treasure flower), *Calendula officinalis* (Pot marigold), *Hibiscus-rosa sinensis* (Chinese hibiscus), *Rosa* spp. (Rose), Tagetes spp. (marigold)
Nathupur	29°18›51.02» N 79°07'42.44" E	297		**Fruits:** *Psidium guajava* (Guava), *Mangifera indica* (Mango), *Litchi chinensis* (Litchi), *Citrus limon* (Lemon), *Musa paradisiaca* (Banana), *Carica papaya* (Papaya), *Syzygium cumini* (Jamun)
Neripura Chhoi	29°20›03.86» N 79°08'03.81" E	312		**Grains/Vegetables:** *Oryza sativa* (Paddy), *Zea Mays* (Maize), *Solanum lycopersicum* (Tomato) *Allium sativum* (Onion), *Allium cepa* (Garlic), *Spinacia oleracea* (Spinach), *Trigonella stellata* (Fenugreek leaves), *Solanum tuberosum (Potato)*, *Cucurbita* L. (Pumpkin), *Lagenaria siceraria* (Bottle gourd), *Phaseolus vulgaris* (Kidney bean), *Vicia faba* (broad bean, fava bean) *Pisum sativum* (Pea), *Abelmoschus esculentus* (Ladyfinger), *Raphanus sativus* (Radish), *Capsicum annuum* (Capsicum), *Cucumis sativus* (Cucumber), *Capsicum annuum* (Green Chilli)
Madanpur Kurmi	29°20›44.48» N 79°08'11.43" E	318		
Shivlalpur Pandey	29°23›23.79» N 79°07'00.29" E	341		

continued...

Table 1: Cont'd.

Study Sites (District Nainital)	Geographical Coordinates	Altitude (masl)	Geo-climatic Zone	Prominent Plants observed in and around apiaries/Study sites
Okhalkanda Malla	29°19›30.06» N 79°43’54.88” E	1727	Shiwalik	**Flowers:** *Papaver somniferum* (Opium poppy), *Helianthus annuus* (Sunflower), *Lillium philadelphicum* (Wood Lily), *Lillium candidum* (Madonna lily), *Rosa damascene* (Damask rose), *Gazania linearis* (Treasure flower), *Calendula officinalis* (Pot marigold), *Hibiscus-rosa sinensis* (Chinese hibiscus), *Bellis perennis* (Lawndaisy), *Rosa* spp. (Rose) **Fruits:** *Pyrus Pyrifolia* (Pear), *Psidium guajava* (Guava), *Mangifera indica* (Mango), *Prunus domestica* (Plum), *Litchi chinensis* (Litchi), *Citrus sinensis* (Malta), *Citrus limon* (Lemon), *Musa paradisiaca* (Banana)
Moora	29°23›53.87» N 79°40’34.05” E	2217		**Grains/Vegetables:** *Oryza sativa* (Paddy), *Zea Mays* (Maize), *Brassica* spp. (Mustard), *Allium sativum* (Onion), *Allium cepa* (Garlic), *Spinacia oleracea* (Spinach), *Trigonella stellata* (Fenugreek leaves), *Solanum tuberosum (Potato)*, *Cucurbita* L. (Pumpkin), *Phaseolus vulgaris* (kidney bean), *Pisum sativum* (Pea), *Abelmoschus esculentus* (Ladyfinger), *Raphanus sativus* (Radish), *Capsicum annuum* (Capsicum), *Cucumis sativus* (Cucumber), *Capsicum annuum* (Green Chilli)
Ramgarh	29°26›47.07» N 79°33’34.71” E	1454	Mid Shiwalik	**Flowers:** *Helianthus annuus* (Sunflower), *Lillium philadelphicum* (Wood Lily), *Lillium candidum* (Madonna lily), *Gazania linearis* (Treasure flower), *Calendula officinalis* (Pot marigold), *Hibiscus-rosa sinensis* (Chinese hibiscus), *Bellis perennis* (Lawndaisy), *Rosa* spp. (Rose) **Fruits:** *Pyrus Pyrifolia* (Pear), *Psidium guajava* (Guava), *Prunus domestica* (Plum), Prunus persica (Peach), *Litchi chinensis* (Litchi), *Citrus sinensis* (Malta), *Citrus limon* (Lemon), *Musa paradisiaca* (Banana), *Actinidia deliciosa* (Kiwi), *Prunus armeniaca* (Apricot) **Grains/Vegetables:** *Allium sativum* (Onion), *Allium cepa* (Garlic), *Spinacia oleracea* (Spinach), *Trigonella stellata* (Fenugreek leaves), *Solanum tuberosum (Potato)*, *Cucurbita* L. (Pumpkin), *Phaseolus vulgaris* (kidney bean), *Pisum sativum* (Pea), *Colocasia esculenta* (Taro/Arbi), *Raphanus sativus* (Radish), *Capsicum annuum* (Capsicum), *Cucumis sativus* (Cucumber), *Capsicum annuum* (Green Chilli)

Figure 2: a-b: Modern Apiaries of ***Apis mellifera*** in Kunwarpur and Bailpadao, c to d-1: Traditional Bee Hives (Wall hives) of ***Apis cerana indica*** in Moora and Ramgarh (Nainital District).

Figure 3: Hornet Species: a: ***Vespa velutina*** (The Asian Hornet) in a wall hive; b: ***Vespa tropica*** (Greater banded hornet) in a modern beehive; c: Hornet Trap in an Apiary; d: Hornets collected and burnt by beekeepers.

Figure 4: a-b: Attack of carpenter ants on Bee Hive, c: ***Camponotus compressus*** (Carpenter ant).

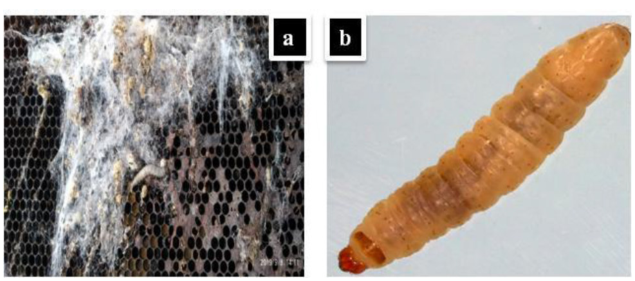

Figure 5: a: Greater wax moth (***Galleria mellonella***) web in a beehive; b: Larvae of ***Galleria mellonella*** (Waxworm)

[II] Aves

Bee-eating birds can take on everything from locusts to aphids and any other flying insect as their feed. On the other hand, Hymenoptera makes up the majority of most bee-eaters' meals. In the present study, *Pernis ptilorhynchus* (Oriental Honey Buzzard) was found in 40.60%, followed by *Lanius schach* (Long-tailed shrike) in 32.20% *Merops orientalis* (Asian green bee-eater) were found in 25.42%, *Dicrurus macrocercus* (Black drongo) was found in 18.64% of modern apiaries (Figure 7). In traditional apiaries, only one species of bird was found roaming around the hives i.e., *Merops orientalis* in 4.76% of apiaries.

In modern apiaries, *Vespa tropica* was found to be the major predator of honey bees and was distributed in

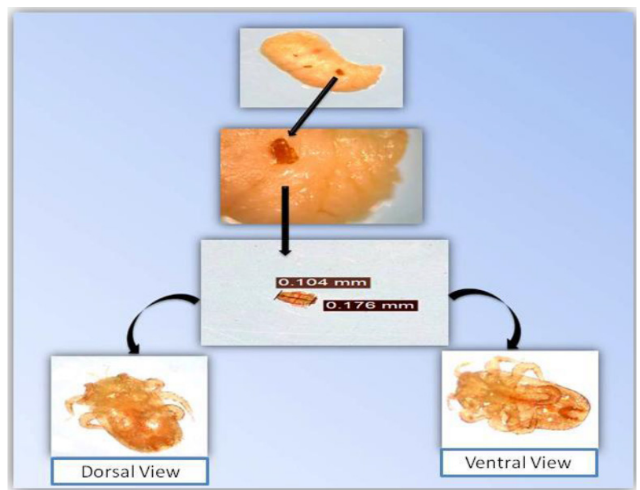

Figure 6: ***Tropilaelaps*** spp. (mite) parasitized the brood of ***Apis mellifera.***

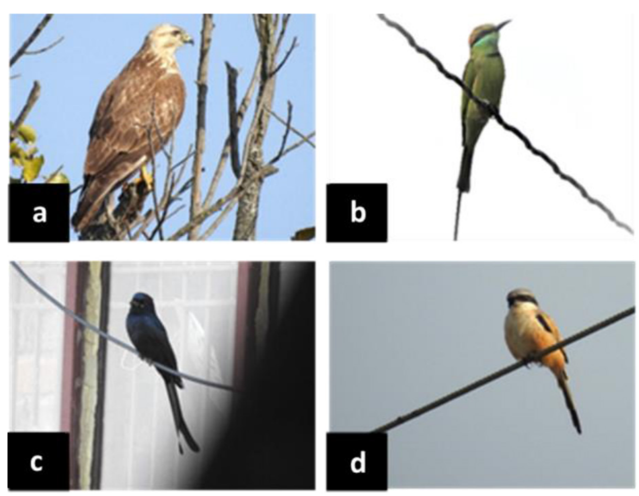

Figure 7: Bee-eater Birds; a: ***Pernis ptilorhynchus*** (Oriental Honey Buzzard), b: ***Merops orientalis*** (Asian green bee-eater), c: ***Dicrurus macrocercus*** (Black drongo), d: ***Lanius schach*** (Long-tailed shrike).

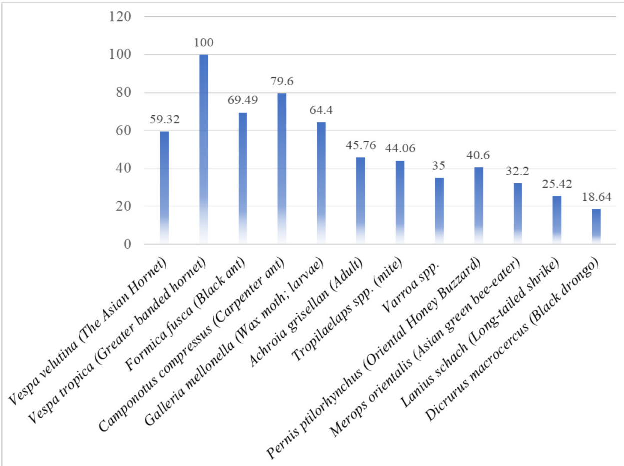

Figure 8: Presence of pests/predators in Modern Apiaries.

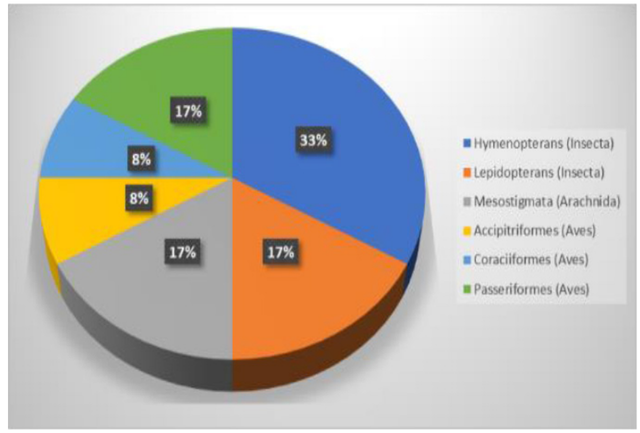

Figure 10: Contribution of different orders of Pests/Predators and parasites.

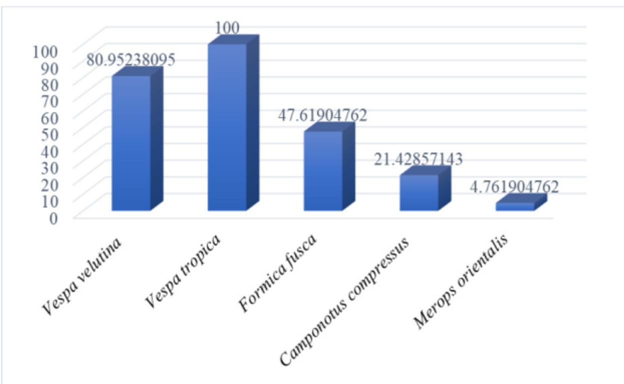

Figure 9: Presence of pests/predators in Traditional Apiaries.

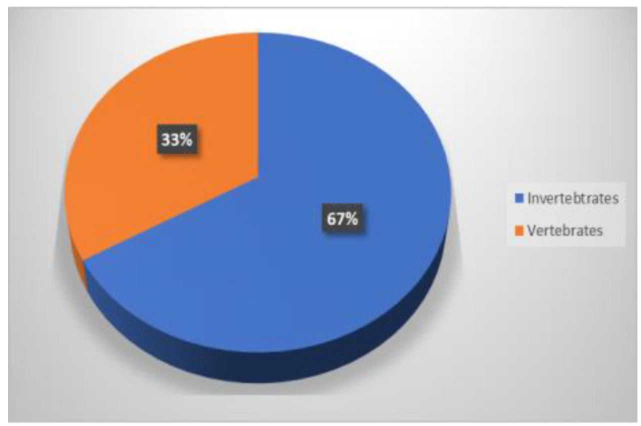

Figure 11: Contribution of Vertebrates and Invertebrates as Pests/Predators and parasites.

100% of apiaries, followed by *Componotus compressus* in 79.60%, *Formica fusca*, which was distributed in 69.49% of apiaries, *Vespa velutina* in 59.32% of apiaries, *Galleria mellonella* and *Tropilaelaps* spp. in 64.40% and 44.06% of apiaries, respectively. On the other hand, *Merops orientalis* and *Dicrurus macrocercus (Black drongo)* were found in 25.42% and 18.64% of apiaries, respectively (Figure 8). While in traditional beehives, five pests and predators were found, *Vespa tropica* was found to be the major pest of honey bees and was distributed in 100% of apiaries, followed by *Vespa velutina* in 80.95%, *Formica fusca* in 47.61%, *Componotus compressus* in 21.42%, and *Merops orientalis* only in 4.76% of apiaries (Figure 9).

The order Hymenoptera, 33% (Insecta) was found to be the most dominant in terms of bee infestation and predation in the study area, followed by the order Lepidoptera (Insecta) 17%, Mesostigmata (Arachnida) 17%, Passeriformes (Aves) 17%, Accipitriformes (Aves) 8% and Coraciiformes (Aves) 8% (Figure 10). 33% of Vertebrates and 67% of Invertebrates were recorded (Figure 11).

Among all of the pests, parasites, and predators studied, *Vespa tropica* was found to be the most common honey bee predator and was identified in all of the study sites 100%, followed by *Vespa velutina* and *Formica fusca*, distributed in 77.77% of the study sites, Componotus compressus in 66.66% of the sites, *Galleria mellonella* and *Tropilaelaps* spp. in 44.44% of the study sites. While *Merops orientalis* (Asian green bee-eater) and *Dicrurus macrocercus* (Black drongo) were found in 22.22% of study sites (Table 3).

C- POSSIBLE DISEASE MEDIATORS AND OTHER INVADERS

[I] *Kashmir Rock Agama*

Rock or whorl-tailed agamas (*Laudakia* Gray, 1845 and its allies) lizards are omnivorous and feed on seeds, fresh shoots, leaves, flowers and fruits of various plant species and to a more significant proportion on several taxa of invertebrates, including spiders, beetles, locusts, and flies.[46] The presence of Kashmir Rock Agama was

Table 3: Status of Honey bee pests, predators and parasites at study sites.

Name of the area	Insects						Arthropods		Chordates			
	Hymenopterans				Lepidopterans		Arachnids		Aves			
	Vespa velutina (The Asian Hornet)	*Vespa tropica* (Greater banded hornet)	*Formica fusca* (Black ant)	*Camponotus compressus* (Carpenter ant)	*Galleria mellonella* (Wax moth; larvae)	*Achroia grisellan*	*Tropilaelaps* spp. (mite)	*Varroa* spp.	*Pernis ptilorhynchus* (Oriental Honey Buzzard)	*Merops orientalis* (Asian green bee-eater)	*Lanius schach* (Long-tailed shrike)	*Dicrurus macrocercus* (Black drongo)
Jyoli	+	+	+	+	-	-	+	-	-	+	+	-
Bhalyuti	+	+	+	+	-	-	+	-	-	+	-	-
Dhakakhet	+	+	+	-	-	-	-	-	+	-	+	-
Lohariyasal Talla	+	+	+	-	+	-	+	+	+	-	+	-
Kathgodam	+	+	+	-	-	-	-	+	+	-	-	-
Basantpur	+	+	+	+	+	+	-	+	+	-	+	+
Kunwarpur	+	+	+	+	+	+	+	+	+	-	+	+
Fatehpur	+	+	+	+	+	+	-	-	-	-	-	-
Halduchaur	+	+	+	+	+	+	-	+	-	-	+	-
Dewla Talla	+	+	+	+	+	-	+	+	+	-	-	+
Bailparao	-	+	+	-	-	-	+	-	+	+	-	+
Nathupur Chhoi	-	+	+	+	+	-	+	-	-	-	-	-
Neripura Chhoi	+	+	+	+	+	-	-	-	-	-	-	-
Madanpur Kurmi	-	+	-	+	-	+	-	-	-	+	-	-
Shivlalpur Pandey	-	+	-	+	-	-	-	+	-	-	-	-
Moora	+	+	-	-	-	-	-	-	+	-	-	-
Okhalkanda Malla	+	+	-	+	-	-	-	-	-	-	-	-
Ramgarh	+	+	+	-	-	-	-	-	+	-	-	-

recorded (Figure 12-a) in two study sites i.e., Jyoli and Moora, both around the bees' traditional hives.

[II] *Blatta* spp.

In the present study, *Blatta* spp. was spotted roaming in and around the beehives (Figure 12-b). Food plays a critical role in the spread of infectious pathogens to humans. Due to the lewd behaviour of cockroaches and prevalence in an area where food is kept or un-handled, cockroaches appear to be suitable mechanical transmitters for a wide variety of foodborne microbial pathogens. In addition, cockroaches can pass microorganisms externally via their cuticle.[47]

[III] *Spider* spp.

Spider webs were found (Figure 12-c) in individual apiaries with fewer populations of bees. In these apiaries, the presence of spiders was not documented. Thus, it is concluded that the webs present in the hive are old. However, the possibility of a spider's occurrence in and around the hive cannot be neglected.

[IV] *Lucilia* spp.

In the present investigation, larvae of *Lucilia* spp. (green bottle fly) was reported inside a beehive (Figure 12-d). As per the available reports, there is no evidence of *Lucilia* spp. being the pest of honey bees, they could be considered a vector of diseases due to their feeding habit.

Figure 12: a-Kashmir Rock Agama near the traditional beehive; b-Cockroach at beehive; c- Honey bee trapped in a spider web; d-larvae of ***Lucilia*** spp. collected from beehive.

DISCUSSION

Vespa tropica was discovered to be the most prevalent honey bee predator among all the invaders of honey bees, followed by *Vespa velutina*, *Formica fusca* and *Componotus compressus*. *Tropilaelaps* spp. were the common parasites in the study area. While in Lepidoptera, *Galleria mellonella* and in Aves *Pernis ptilorhynchus* (Oriental Honey Buzzard) were the most common pests**.** Sharma *et al.* (2013)[48] and Chandra and Mattu (2017),[49] have reported almost all of these predators, pests and parasites infestation in the beehives of Himachal Pradesh.

In Asia, the *Galleria mellonella* was initially discovered in honeybee hives of Asian honeybee *Apis cerana*. However, it eventually migrated to northern Africa, Great Britain, other areas of Europe, North America and New Zealand.[34] In traditional apiaries no infestation of lepidopterans was observed. In the present study, apart from these, few other insects, larvae and reptile were found, which could be possible disease mediators/carriers of honey bees.

The omnivorous feeding behaviour of Kashmir Rock Agama was reported by many researchers from the late nineties to the present,[50-51] the recent report of Akram *et al*., 2020[46] enlighten the new predatory behaviour of Kashmir Rock Agama, captured feeding on a scorpion, which was earlier not reported elsewhere as a feed. As to the new report and the previously reported insectivorous feeding habit of this reptile, it can be stated that adverse conditions can lead Kashmir Rock Agama to shift its diet to bees. However, the studies till today do not show any feeding behaviour of Kashmir Rock Agama towards honey bees. Robinson *et al*., 2012[52] and Huey and Nieh, 2017[53] and other researchers considered spiders as a predator of Honey bees. Due to the presence of spider webs in a few beehives in the study area, there is a possibility of spider infestation and attack in the hives.

Cockroaches were found to be a problem in the present study, and since they reproduce rapidly, are adaptable, and are resistant to insecticides, they pose a significant threat to the health of honey bees.[54] It was witnessed that Cockroaches near the beehives adversely affect bees. Another invader of the hive, larvae of *Lucilia* spp. can be considered a disease mediator due to its feeding behaviour. Sharma *et al*., 2013[48] and Chandra and Mattu, 2017,[49] have also reported the presence of *Lucilia* spp. in the beehives of Himachal Pradesh, similar to the findings of the present study.

CONCLUSION

The current findings indicated that *Vespa tropica* and *Camponotus compressus* are the most abundant and significantly distributed predator of *A. cerana indica* and *A. mellifera*. At the same time, *Tropilaelaps* spp. and *Varroa* spp. were reported as the most abundant parasites and *Galleria mellonella* was the major pest, posing a significant threat to beekeeping in the Nainital district, a region of the western Himalayas in Uttarakhand state, India. Four species of bee-eating birds were also recorded during the present study; due to their limited distribution, they are less threatening to bees. Seasonal activities, such as special bee care and good hive management, are recommended to reduce infestation and predation.

ACKNOWLEDGEMENT

The authors are thankful to commercial beekeepers of the Nainital district, Mr. Digambar Dutt Papne and Mr. Kashmir Chandra for their help in the field survey and Dr. Vinay Singh, for his academic help during the study.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

MASL: Meter Above Sea Level; **CCD:** Colony Collapse Disorder; **ABPV:** Acute bee paralysis virus; **BQCV:** Black queen cell virus; **IAPV:** Israel acute paralysis virus; **KBV:** Kashmir bee virus; **DWV:** Deformed wing virus; **KV:** Kakugovirus; **VDV-1:** Varroa destructor virus-1; **SBV:** Sacbrood virus; **CBPV:** Slow bee paralysis; **LSV:** Lake Saini viruses.

SUMMARY

Honey bees are an essential biotic factor in the reproductive success of plants that rely on them for pollination. The extinction of honey bees would endanger food production and sustainable biodiversity. The aim of the present study is to observe and document the factors affecting the bee population in the study area. Insects and arachnids were the most common pests of honeybees, according to an assessment performed in 59 modern apiaries and 42 traditional apiaries in various agro-climatic zones. 4 birds have also been spotted nesting and roaming around beehives. During the present investigation, *Vespa tropica* and *Camponotus compressus* were found to be the most abundant and significantly distributed predator of *A. cerana indica* and *A. mellifera. Tropilaelaps spp.* and *Varroa* were reported as the most abundant parasites and *Galleria mellonella* was the major pest.

REFERENCES

1. Sarwar M. Prevalence of multiple viral diseases associated with honey bees colony collapse and control of disorders. Int J Zool. 2016;1(2):29-34.
2. Ambaw M, Teklehaimannot T, Workye M. The prevalence of wax moth and associated risk factors in selected districts of Arsi Zone. J Entomol Zool Stud. 2020;1:200-5.
3. Miglani R, Parveen N, Bisht SS, Verma A. Pesticide toxicity to insect pollinators with concern to declining population of Honey-Bees (Insecta: Hymenoptera). Experimental animal science – birds and insects. 2020;247-55.
4. Parveen N, Miglani R, Sharma N, Bisht SS. Socio-economic analysis of traditional and modern beekeeping in Western Himalayan Region Uttarakhand, India. Int J Zool Inv. 2021;7(2):713-22. doi: 10.33745/ijzi.2021.v07i02.055.
5. VanEngelsdorp D, Meixner MD. A historical review of managed honey bee population in Europe and the United States and the factors that may affect them. J Invertebr Pathol. 2010;103;Suppl 1:S80-95. doi: 10.1016/j.jip.2009.06.011, PMID 19909973.
6. Crotti E, Sansonno L, Prosdocimi EM, Vacchini V, Hamdi C, Cherif A *et al*. Microbial symbionts of honeybees: A promising tool to improve honeybee health. New Biotechnol. 2013;30(6):716-22. doi: 10.1016/j.nbt.2013.05.004, PMID 23727340.
7. Goulson D, Nicholls E, Botías C, Rotheray EL. Bee declines driven by combined stress from parasites, pesticides and lack of flowers. Science. 2015;347(6229):1255957. doi: 10.1126/science.1255957, PMID 25721506.
8. DeGrandi-Hoffman G, Corby-Harris V, DeJong EW, Chambers M, Hidalgo G. Honey bee gut microbial communities are robust to the fungicide Pristine® consumed in pollen. Apidologie. 2017;48(3):340-52. doi: 10.1007/s13592-016-0478-y.
9. Kraus B, Page Jr RE. Population growth of Varroa jacobsoni Oud in Mediterranean climates of California. Apidologie. 1995;26(2):149-57. doi: 10.1051/apido:19950208.
10. Potts SG, Biesmeijer JC, Kremen C, Neumann P, Schweiger O, Kunin WE. Global pollinator declines: Trends, impacts and drivers. Trends Ecol Evol. 2010;25(6):345-53. doi: 10.1016/j.tree.2010.01.007, PMID 20188434.
11. Graystock P, Blane EJ, McFrederick QS, Goulson D, Hughes WOH. Do managed bees drive parasite spread and emergence in wild bees? Int J Parasitol Parasites Wildl. 2016;5(1):64-75. doi: 10.1016/j.ijppaw.2015.10.001, PMID 28560161.
12. Hristov P, Shumkova R, Palova N, Neov BS. Honey bee colony losses: Why are honey bees disappearing? Sociobiology. 2021;68(1):e-5851. doi: 10.13102/sociobiology.v68i1.5851.
13. Björklund J, Limburg KE, Rydberg T. Impact of production intensity on the ability of the agricultural landscape to generate ecosystem services: An example from Sweden. Ecol Econ. 1999;29(2):269-91. doi: 10.1016/S0921-8009(99)00014-2.
14. Kremen C, Williams NM, Thorp RW. Crop pollination from native bees at risk from agricultural intensification. Proc Natl Acad Sci U S A. Proceedings of the Nat ACA sci. 2002;99(26):16812-16. doi: 10.1073/pnas.262413599, PMID 12486221.
15. Cane JH, Minckley RL, Kervin LJ, Roulston TH, Williams NM. Complex responses within a desert bee guild (Hymenoptera: Apiformes) to urban habitat fragmentation [Hymenoptera: Apiformes] to urban habitat fragmentation. Ecol Appl. 2006;16(2):632-44. doi: 10.1890/1051-0761(2006)016[0632:crwadb]2.0.co;2, PMID 16711050.
16. Hegland SJ, Nielsen A, Lázaro A, Bjerknes AL, Totland Ø. How does climate warming affect plant-pollinator interactions? Ecol Lett. 2009;12(2):184-95. doi: 10.1111/j.1461-0248.2008.01269.x, PMID 19049509.
17. Kearns CA, Oliveras DM. Environmental factors affecting bee diversity in urban and remote grassland plots in Boulder, Colorado. J Insect Conserv. 2009;13(6):655-65. doi: 10.1007/s10841-009-9215-4.
18. Sharma VP, Kumar NR. Changes in honeybee behaviour and biology under the influence of cellphone radiations. Curr Sci. 2010;98(10):1376-8.
19. Reddy PVR, Verghese A, Rajan VV. Potential impact of climate change on honey bees (*Apis* spp.) and their pollination services. Pest Manag Hortic Ecsyst. 2012;18:121-7.
20. Le Conte Y, Navajas M. Climate change: Impact on honey bee populations and diseases. Rev Sci Tech. 2008;27(2):485-510. doi: 10.20506/rst.27.2.1819, PMID 18819674.
21. Neov B, Georgieva A, Shumkova R, Radoslavov G, Hristov P. Biotic and abiotic factors associated with colonies mortalities of managed honey bee (*Apis mellifera*). Diversity. 2019;11(12):1-17. doi: 10.3390/d11120237.
22. Johnson R, Corn ML. Bee health: Background and issues for congress. Washington, DC: Congressional Research Service; 2015. Available from: https://fas.org/sgp/crs/misc/R43191.pdf.
23. Straub L, Williams GR, Vidondo B, Khongphinitbunjong K, Retschnig G, Schneeberger A, *et al*. Neonicotinoids and ectoparasitic mites synergistically impact honeybees. Sci Rep. 2019;9(1):8159. doi: 10.1038/s41598-019-44207-1. PMID 31164662.
24. Martel AC, Zeggane S, Aurières C, Drajnudel P, Faucon J, Aubert M. Acaricide residues in honey and wax after treatment of honey bee colonies with Apivar® or Asuntol® 50. Apidologie. 2007;38(6):534-44. doi: 10.1051/apido:2007038.
25. Zhu W, Schmehl DR, Mullin CA, Frazier JL. Four common pesticides, their mixtures and a formulation solvent in the hive environment have high oral toxicity to honey bee larvae. PLOS ONE. 2014;9(1):e77547. doi: 10.1371/journal.pone.0077547, PMID 24416121.
26. Sanchez-Bayo F, Goka K. Impacts of pesticides on honey bees. In: Chambo, editor, Beekeeping and bee conservation: Advances in research; 2016. p. 77-97. doi: 10.5772/62487.
27. Di Prisco G, Annoscia D, Margiotta M, Ferrara R, Varricchio P, Zanni V, *et al*. A mutualistic symbiosis between a parasitic mite and a pathogenic virus undermines honey bee immunity and health. Proc Natl Acad Sci U S A. 2016;113(12):3203-8. doi: 10.1073/pnas.1523515113, PMID 26951652.
28. Ramsey SD, Ochoa R, Bauchan G, Gulbronson C, Mowery JD, Cohen A, *et al*. Varroa destructor feeds primarily on honey bee fat body tissue and not hemolymph. Proc Natl Acad Sci U S A. 2019;116(5):1792-801. doi: 10.1073/pnas.1818371116, PMID 30647116.
29. Sharif ZM, Jiang X, Puswal SM. Pests, parasitoids, and predators: Can they degrade the sociality of a honeybee colony, and be assessed via acoustically monitored systems? J Entomol Zool Stud. 2020;8(3):1248-60.
30. Millán-Leiva A, Hernández-Rodríguez CS, González-Cabrera J. New PCR–RFLP diagnostics methodology for detecting Varroa destructor resistant to synthetic pyrethroids. J Pest Sci. 2018;91(3):937-41. doi: 10.1007/s10340-018-0964-2.
31. Genersch E, Von der Ohe W, Kaatz H, Schroeder A, Otten C, Büchler R, *et al*. The German bee monitoring project: A long-term study to understand periodically high winter losses of honey bee colonies. Apidologie. 2010;41(3):332-52. doi: 10.1051/apido/2010014.

32. McMenamin AJ, Brutscher LM, Glenny W, Flenniken ML. Abiotic and biotic factors affecting the replication and pathogenicity of bee viruses. Curr Opin Insect Sci. 2016;16:14-21. doi: 10.1016/j.cois.2016.04.009, PMID 27720045.
33. Parveen N, Miglani R, Kumar A, Dewali S, Kumar K, Sharma N, *et al*. Honey bee pathogenesis posing threat to its global population: A short review. Proc Ind Natl Sci Acad. 2022;88(1):11-32. doi: 10.1007/s43538-022-00062-9.
34. Kwadha CA, Ong'amo GO, Ndegwa PN, Raina SK, Fombong AT. The biology and control of the greater wax moth, *Galleria mellonella*. Insects. 2017;8(2):61. doi: 10.3390/insects8020061, PMID 28598383.
35. Mandal S, Vishvakarma R. Population dynamics of greater wax moth (*Galleria mellonella* L.) infesting *Apis mellifera* L. combs during dearth period. Ecoscan. 2016;9:93-8.
36. Farinós-Celdrán P, Zapata VM, Martínez-López V, Robledano F. Consumption of honey bees by *Merops apiaster* Linnaeus, 1758 (Aves: Meropidae) in Mediterranean semiarid landscapes: A threat to beekeeping? J Apic Res. 2016;55(2):193-201. doi: 10.1080/00218839.2016.1195630.
37. Laurino D, Lioy S, Carisio L, Manino A, Porporato M. Vespa Velutina: An alien driver of honey bee colony losses. Diversity. 2019;12(1):5. doi: 10.3390/d12010005.
38. VanEngelsdorp D, Caron D, Hayes J, Underwood R, Henson M, Rennich K, *et al*. A national survey of managed honey bee 2010-11 winter colony losses in the USA: Results from the bee informed partnership. J Apic Res. 2012;51(1):115-24. doi: 10.3896/IBRA.1.51.1.14.
39. Ullah A, Tlak Gajger IT, Majoros A, Dar SA, Khan S, Kalimullah, *et al*. Viral impacts on honey bee populations: A review. Saudi J Biol Sci. 2021;28(1):523-30. doi: 10.1016/j.sjbs.2020.10.037, PMID 33424335.
40. Tantillo G, Bottaro M, Di Pinto A, Martella V, Di Pinto P, Terio V. Virus infections of honeybees *Apis Mellifera*. Ital J Food Saf. 2015;4(3):5364. doi: 10.4081/ijfs.2015.5364, PMID 27800411.
41. Chen YP, Siede R. Honey bee viruses. Adv Virus Res. 2007;70:33-80. doi: 10.1016/S0065-3527(07)70002-7.
42. Genersch E, Aubert M. Emerging and re-emerging viruses of the honey bee (*Apis mellifera* L.). Vet Res. 2010;41(6):54. doi: 10.1051/vetres/2010027, PMID 20423694.
43. McMenamin AJ, Genersch E. Honey bee colony losses and associated viruses. Curr Opin Insect Sci. 2015;8:121-9. doi: 10.1016/j.cois.2015.01.015, PMID 32846659.
44. Brutscher LM, Daughenbaugh KF, Flenniken ML. Antiviral defense mechanisms in honey bees. Curr Opin Insect Sci. 2015;10:71-82. doi: 10.1016/j.cois.2015.04.016, PMID 26273564.
45. Pannure A. Bee pollinators decline: Perspectives from India. Int Res J Nat Appl Sci. 2016;3(5):1-10.
46. Akram M, Mecke S, Dhakate PM, Vashistha G. Predation of a scorpion by a Kashmir rock Agama (*Laudakia tuberculata*) in Nainital, India. Herpetol Notes. 2020;13:1095-7.
47. Donkor ES. Cockroaches and food-borne pathogens. Environ Health Insights. 2020;14:1178630220913365. doi: 10.1177/1178630220913365, PMID 32425541.
48. Sharma N, Vashisth S, Sharma PK. Diversity and distribution of pests and predators of honeybees in Himachal Pradesh, India. Ind J Agric Res. 2013;47(5):392-401.
49. Chandra A, Mattu VK. Studies on major pests and predators of *Apis cerana* F and *Apis mellifera* L. in the Chamba valley of Himachal Pradesh. J Entomol Zool Stud. 2017;5(6):728-31.
50. Tikader BK, Sharma RC. Handbook Indian lizards. Zoological Survey of India. Calcutta: Government of India. 1992;pp 1-250.
51. Nawani S, Das A, Das I. A new item in the diet of the Kashmir Rock Agama (*Laudakia tuberculata*). IRCF Rept Amphi. 2020;27(2):275-6.
52. Robinson JW, Nieh JC, Goodale E. Testing honey bees' avoidance of predators. Am Biol Teach. 2012;74(7):452-7. doi: 10.1525/abt.2012.74.7.5.
53. Huey S, Nieh JC. Foraging at a safe distance: Crab spider effects on pollinators. Ecol Entomol. 2017;42(4):469-76. doi: 10.1111/een.12406.
54. Pan X, Wang X, Zhang F. New insights into cockroach control: Using functional diversity of *Blattella germanica* symbionts. Insects. 2020;11(10):696. doi: 10.3390/insects11100696, PMID 33066069.

Cite this article: Parveen N, Kumar K, Miglani R, Kumar A, Siddiqui U, Rawat G and Bisht SS. Factors Affecting Honey Bee Population in Western Himalaya of Uttarakhand: An Observational Study. Asian J Biol Life Sci. 2022;11(2):543-53.