Peer-Reviewed/ISSN: 2663-1040 AJ Life Sci. 2022, 5 (2): 33-51 Review Article

Abasyn Journal of Life Sciences

Open Access

DOI: 10.34091/AJLS.5.2.5

Effects of environmental factors on the physiology and development of honey bees

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Abstract

Environmental aspects have a substantial impact on the physiological and morphological attributes of social bees. Living organisms including plants, animals, and human are much influenced by the environment. Environmental factors including temperature, nutrition, light, beehive conditions and social interactions are compelling agents in alteration of morphology, development, and health of honeybees. Beekeeping may also be at risk due to climate change effect on agriculture, which appears to be a major concern for the sector. Temperature variations impair the honeybee colony's internal functions, including food storage, brood rearing, and social stability. Colony collapse has been caused by nutritional stress brought on by habitat loss, infestation by various pests and diseases, and chemical exposure. The honeybees decline, queens are replaced, and eventually the colony breaks down and dies by the viruses and parasites. Foraging behaviour is influenced by temperature as activity levels drop as the temperature rises. The foraging activity peaked at 20° C and peaked at 43° C. Like humans, nutrition affects the gut microbiome of bees, makes them more susceptible to disease, shortens their life span, and is the primary factor in the collapse of honeybee colonies. Comprehensive investigation on the influence of environmental changes on honeybee condition and protection against hazardous environmental circumstances. It has been shown that since the start of industrialization, a variety of causes threatened honeybees' lives. The protection of bees and biodiversity is an urgent matter of concern and demands serious efforts from different stake holders to play their legitimate role.

Keywords: Honeybees - Environmental Factors - Temperature - Diet – Behavior

Article Info:
Received:
October 21, 2022
Received Revised:
December 24, 2022
Accepted:
December 24, 2022
Available online:
December 25, 2022

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1. INTRODUCTION

A crucial aspect of an organism's existence is social behaviour, which enables individuals to communicate with diverse biological communities[1], and enabling organisms to endure under various circumstances[2]. Social interaction has physiological, psychological, and economic effects on living things[3]. Hymenopteran insects are more likely to be eusocial than other insect orders[4] in literal terms, "membrane wings"[5], specifically the Apidae family's honeybee, *Apis mellifera*[6]. Colonies are home to honeybees[7], has a queen, workers, and drones[8,9]. The Western honeybee (*Apis mellifera*) belongs Apis genus, which is best recognized for domestication, renowned for their effective plant pollination services. Humans have been associated *A. mellifera* for around 5000 years. *A. mellifera's* natural habitat is in Africa, Europe, and the Middle East, while the remaining nine species of Apis genus are only found in Asia. The most vital agricultural and wild plant pollinators are honeybees, and nearly a third of Unique agricultural crops require pollination by bees. The primary pollinator of numerous food crops is *A. melifera*, comprising fruits, nuts, vegetables, and oilseeds. Since the Apis genus belong to Europe, Asia, and Africa, tropical climates are their promising habitats[10]. They are believed to have been on Earth around 30 million years ago and resemble current honeybees morphologically[10]. *A. mellifera* has 24 distinct subspecies[11], it can be categorized based on morphology[12-14]. They are important pollinators for a variety of plant species and their associated businesses worldwide[10].

Honeybees are the backbone of beekeeping business as well as other sectors including the manufacturing of paper, leather, candles, and cosmetics, textiles, and pharmaceuticals, among others, in addition to pollination[15]. Significant domestic and wild bee damages have been detailed over the previous few years, which bring worrisome consequences for the services they deliver[16]. The movement of the bee is highly impacted by variations in abiotic elements as light, temperature, wind speed, and relative humidity. The primary causes of the decrease of social bees include factors such as host taxonomy and nutrition that have a significant impact on an organism's gut microbial ecology[17]. This article illustrates the consequences of several environmental (biotic and abiotic) variables on the development of the honeybee and its population.

2. FACTORS AFFECTING THE PHYSIOLOGY OF HONEYBEES

Environmental elements are influential in the morphological and physiological traits of social bees18,19 (**Fig.1**). One of the most significant elements impacting honeybees is nutrition, along with temperature, humidity, light intensity, and seasonal fluctuations. The morphology of bees is significantly influenced by topography and altitude20 showed that worker bees in Transylvania's hilly regions had proboscis lengths measured around 6.21 mm longer than those in the lowland regions (5.99 mm). The introduction of different honeybee subspecies into populations resulted in a high level of hybridization21. Additionally, migratory beekeeping intensively contributes to these discrepancies20. The environment seriously shapes the behavior of the honeybee.

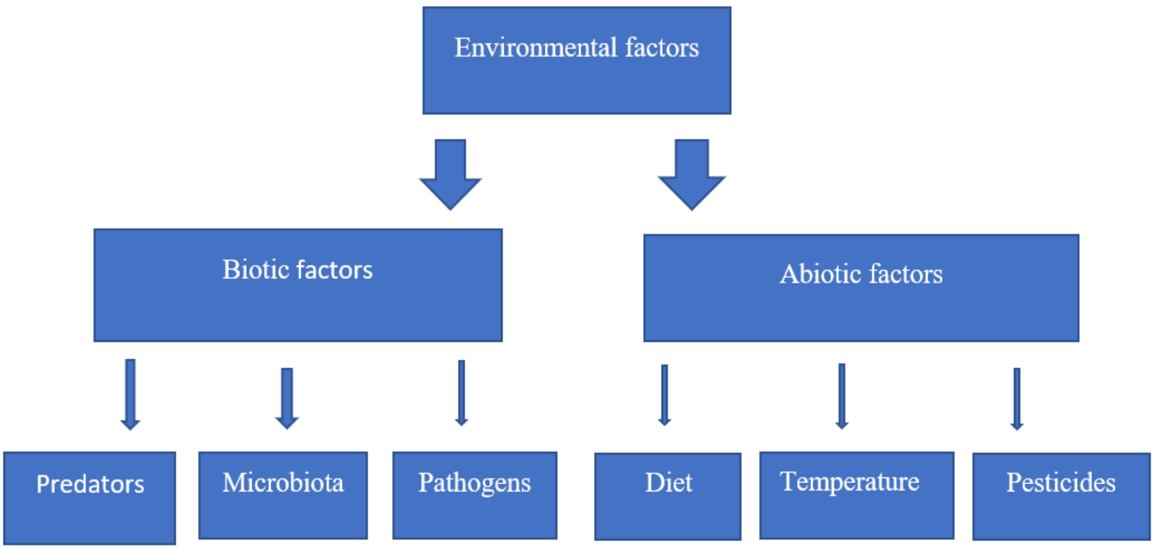

Fig 1: Different factors which have great impact on Honeybee Behaviour

2.1. Role of nutritional factors for honeybees' health

Nutrition is one of the most significant variables impacting an organism's health, function, and activity[22]. The gut microbiome and nutrition are interlinked[23]. It is widely reported that the host's nutrition variety not affect an organism's health status but also altered the composition and operation of the gut miniature community[24]. The primary sources of saccharides that bees consume to meet their energy needs are pollen, lipids, nectar, micronutrients, and honey[25]. A healthy diet is essential for a colony's growth and development[22]. Much of the protein consumed by adult bees comes from pollen, which results the productivity and longevity of honeybee colonies[22,26]. Because honeybees collect pollen grains from different plant species, the nutritional value of pollen differs[27,28]. Honeybees obtain proteins, minerals, vitamins, and fats from pollens for the growth, maturation, and health aspects of brood[29]. The under-developed hypopharyngeal gland (HPG) and poor-quality pollens can result in lower protein content, weight increase, shorter life spans, and a reduction in the production of royal jelly, which may alter the growth of the queen and larvae[22,30,31] reported in a study from Bulgaria that the protein portion of 50 distinct pollen types came 11.5% from flowering plants and 0.5% from grasses. Additionally, a high-protein diet influences honeybees thorax weight. According to[32], Broad bean and clover beebread had substantial protein contents and produced the maximum thorax weight readings, 32.12 and 31.5 mg/bee, respectively.

To satisfy their dietary needs, insects require a variety of nutrients[33]. Their food is mainly composed of proteins, carbs, minerals, fats, vitamins, and water[33]. The duration of hungry phase, which is brought on by a lack of food, clues about how many supplies are used. Brood rearing, honey output, and colony growth and development are all severely suffered by pollen and nectar depletion[34]. The loss of plant diversity might be a major cause in the reduction of bees[35]. Moreover, agricultural pesticides are also to blame for bee losses[36,37], environmental change, malnutrition[38] and the combined impact of a few or more of the aforementioned elements[38,39]. There protein content in pollen from different plants, with an average of 25–45% and a range of 2.5–61 percent[27,40]. Pollen from different plants contains different amounts of nutrients. Bee salivary enzymes and honey are combined to make "bee bread[41]. 10 amino acids included in pollen are thought to be crucial for the honeybee's healthy performances. Threonine, valine, methionine, isoleucine, leucine, phenylalanine, histidine, lysine, arginine, and tryptophan are the amino acids widely discussed[42,43]. Serine, proline, and glycine are less significant amino acids than others. The anterior, midgut, and posterior intestines are the three parts of the honeybee's digestive system[44]. For digestion and food absorption, the midgut digestive system is in charge. This area should have a significantly undulating surface and be brown in hue. The animal's specie, age, nutrition (nutrient content and proportion), habitat, and feeding technique responsible pollen protein digestion and absorption [38,27,45].

Proteases are the enzymes that break down protein in the digestive system of honeybees. Numerous proteases like trypsin and chymotrypsin in mammals may be found in the digestive tracts of insects[46]. Bees that are just emerged have modest levels of proteolytic enzyme activity, which rises with age. The midgut growth of six-day-old bees is correlated with the highest levels of proteolytic activity. Additionally, pollen proteins affect the peritrophic membrane's (PM) thickness[45]. The pharyngeal glands are stimulated to grow by fresh pollen whereas they are 76% less stimulated by stored pollen[47]. The gist of the pollen diet is also seemed to have an impact on the variation in pharyngeal gland development. Bees devoured by Rubus pollen have throat glands more developed than bees fed by Cistus and Erica pollen[34,28] examined the effect of monodies on HPG (hypothalamic-pituitary gonadal) formation. They noticed that the pollen from Castanea and Asparagus species encouraged the growth of HP[40]. By observing how pollen protein portion and pollen variety affect the health and physiology of adult bees in a queen less environment, researchers looked at the impact of pollen quality. It has been demonstrated that whether queen less workers are fed high- or low-protein pollen, there is a correlation between pollen feeding and the activation of the ovaries. Bees fed diets with a lower protein-to-carbohydrate ratio lived longer, but those fed diets including royal jelly had higher ovarian activation, which was caused by the fact that royal jelly also contains other nutrients in addition to protein. Additionally, the other nutrients in pollen, such as lipids and carbs as well as their protein composition affect the pollen's ability to activate the ovaries. Due to its pollen's high nutritional value for bees, *Brassica napus* pollen may be the one exception that is beneficial to insects[48]. Bees get their protein from pollen and their carbs from nectar [33,40]. Pollen selection is a game of chance since foraging bees are unable to determine how much protein is in the gathered material. Workers, for instance, also gather wood humus, coal dust, and sawdust. Pollen ingestion is reflected in a variation in the hemolymph's protein content, which fluctuates with developmental stages[49]. Additionally, workers provided a protein meal had more total proteins in their hemolymph than workers fed on sugar syrup[50].

According to[51], the low ratio of omega 6:3 fatty acids appeared to improve the honeybee's memory and learning capacity. **Table 1** lists the pollen's origin, nutritional content, kind of nutrient, and effects on honeybees in the long run.

Source	Nutrient type	Effects	Values	Reference
Flowering plants (*Chondrilla juncea)*	Protein	Growth of bees increases	27.4%	31
Muskmelon (C*ucumis melo)*	Protein	Growth of bees increases	11.5% -27.4%	31
Broad bread and clover beebread	Protein	Thorax weight increase	32.12 and 31.5mg/bee	32

Table 1: Effect of different sources of diet on honeybee

2.2. Effect of temperature on honeybee

The primary ecological component that is essential to the survival of all living things is temperature[52,53]. Insects are probably associated with bacteria, which might hinder their capacity to adapt to changing environmental conditions[54]. The honeybee colony's internal temperature is vital for sustaining outward activities including worker bee foraging behaviour and drone/queen flying[55] whereas the colony's internal processes, like as food storage, brood raising, and social equilibrium, fluctuates within a reasonable range[56]. Climate change is becoming a concern for biologists and environmentalists in the current situation[57] and profoundly influence communities, species, and the environment. To meet the needs of the colony, social bees forage to obtain pollen, nectar, or water[58]. It appeared that honeybee activity decreases as the temperature drops below 10°C[59]. At 20°C, the maximum foraging activity was noted[60].

In contrast, it was found that foraging activity was lowest at 43°C[61]. In a changing environment, forager bees can maintain a balance between their energy efficiency and intake rate[62]. Foraging bees may live for two to seventeen days[63]. According to[64] When exposed to 42 °C till death, honeybee workers have been found to live between 31 and 91 hours. The flying activity of bees is less affected by relative humidity[59]. Foraging behaviour is significantly influenced by colony strength, brood raising activities, and pollen requirements[65].

The effects of climate change on agriculture seem to be a big issue for the industry as a whole, and beekeeping also be at risk as well. In particular, it has been identified as a potential reason of the loss of pollinators, such as honeybees, and a disruption in the timing of pollinator activity and blooming[66]. Honey bees (*Apis mellifera*) can regulate their body temperatures socially, which allows them to maintain colonies all year round. Honey bees engage in internal operations within the colony, including brood raring, food storage, and social homeostasis which regulates the temperature to a comfortable level[56]. Honey bee brood is likely to be vulnerable to overheating when temperatures go on to more than 36^{o} C on individual basis. Even under typical colony circumstances in adults, the induction of a heat shock protein is initiated to better withstand any passive impacts[67]. Worker bees subjected for one hour to a range of temperatures between 4 and 50 C produced more heat shock proteins[68]. When the temperature rises over 36 degrees Celsius, honey bee workers start to fan themselves to reduce the heat load. To maximize efficiency during fanning, workers take precise positions[69]. Bees engaged in social homeostasis, which maintains a pleasant temperature in the colony, rearing brood, storing food, and other internal activities. Furthermore, a heat-shielding system was described by[70], where worker bees hide the honey and brood combs to protect them from outside heat sources. Compared to eggs or larvae, pupae in sealed cells are especially susceptible to low temperatures[71,72].

The adult brain can be impacted by brood temperature as well. Bees grown at 34.5°C have the most micro glomeruli in the mushroom body compared to those grown at 1°C of this temperature[73,74] found that honey bee pupae were raised at temperatures between 31 and 37°C and 52% relative humidity. They discovered that adult employees' short-term learning and memory capacities were negatively impacted by high temperatures (other than the ideal) due to modest brain abnormalities. Brood temperature can also affect wing shape. According to[75], elevated temperature levels have an impact on the color of emerging honey bee queens. At 31.1°C, emerged queens were darker than those raised at 34.4°C. Chuda-Mickiewicz and Samborski [76] found that the pre-imaginal development of queens incubated at 32°C was delayed by 27h in comparison to those incubated at 34.5°C, but that the quality parameters of body weight, ovariole number, volume of spermatheca, and starting of oviposition were the same for emerged queens at both temperatures. Honey bees decrease foraging excursions below 10°C[59]. Queens mostly mate when the temperature is below 25°C[77]. Therefore, extremes of temperature impose an adverse effect on queen flight[78]. It is also known that temperature affects honey bee colour patterns. By regulating the temperature of *Apis cerana* japonica Radoszkowski, honey bees during their growth[79] experimental replication of the seasonal colour difference between black (winter) and yellow (summer) bees was successfully demonstrated.

2.3. Effect of pesticides on Honeybees

Instead of being reliant on the presence of flowers in the immediate area, the production of honey and wax now appears to be closely related to the caliber of the food that the bees gather. It is now cleared that honey bee colonies are negatively impacted by pesticide-contaminated blooms, resulting in a drop in output[80]. Because spray solutions contain concentrated dosages of these chemicals, a single droplet of pesticide may be enough to kill a bee, the common reasons for bee deaths recorded in the literature[81]. Bees are exposed to pesticides by ingesting residues from pollen and nectar of contaminated plants, whether they are agricultural plants or weeds growing in nearby fields[36]. Foragers from honeybees, bumblebees, and wild bees like drinking from puddles, irrigation ditches, ponds, and streams. If these fluids are tainted with chemical residues, the forager bees consume them as well[82]. The forager bees absorb these fluids as well if they include chemical residues[83] primarily having an impact on growing larvae[84] and most likely the queen and mature honeybees. Stress may result bees being exposed to neurotoxic pesticides at sublethal dosages[85] without harming the bees, analyze or correct improper behavior[86]. Honey bee larvae fed on chlorpyrifos-contaminated pollen produced extremely few queens when exposed repeatedly[87].

2.4. Gut microbiota influence on honeybee health

Animal gut microbes can aid with digestion, detoxification of toxic compounds, provision of important nutrients, defense against invasion by diseases and parasites and modulation of growth and immunity for their hosts[88]. The microbiota in honeybees helps to preserve bee health because it defends the host against a variety of poisonous parasites[88]. Simple intestinal microbiota with only a few microaerophilic core species or anaerobic bacterial species makes up the gut microbiota of social bees, which may have an impact on pathogenic resistance and bee health[89]. Regarding host pathogen resistance, weight gain, behavior, and insulin signaling, gut flora is crucial[90]. Some *Lactobacillus spp. Gilliamella apicola*, *Parasaccharibacter apium*, *Snodgrassella alvi*, and a Bifidobacterium species coevolve specifically with corbiculae bees as their hosts[91]. *Frischella perrara* and *Bartonella apis* are species that are unique to the genus Apis. Bees which have just emerged get microbiota by oral transmission or interaction with other hive members[92]. By giving its host short-chain fatty acids, the typical honeybee gut microbiota creates a low pH level and an oxygen gradient, which causes the host to acquire weight more quickly[93]. According to genetic analyses, the numerically dominating species *Gilliamella apicola* aids honeybees in the breakdown of potentially harmful monosaccharides[94]. The second-most prevalent bacterial species, *Snodgrassella alvi*, could not be able to metabolize complex carbohydrates[89]. *Parasaccharibacter apium* showed resistance to Nosema infection[91]. Contrarily, *Frischella perrara,* which causes tissue necrosis in the pylorus, makes the common intestine bacterial species of honeybees neither useful nor necessary [21]. **Table 2** describes various kinds of gut microbiota of honeybees and their role in the gut. Individuals of wide range of bumble bee species in China were discovered to have two unique gut microbial populations, or enterotypes.The influence of the gut microbiota on the generation of growth hormones, fat deposition, monosaccharide breakdown, and many other parameters in honeybees is illustrated in this Table.

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Table 2: Effect of Microbiota on Honey`s bees health, growth and performance

Microbiota	Effect on honeybees	References
Gilliamella apicola	Degradation of monosaccharides	94
Frischella perrara	Scab formation	21
Snodgrassella alvi	Maintain anoxic environment in gut	90
Parasaccharibacter Apium	Resistance to Nosema infection	91
Lactobacillus spp.	Fermentation of suger into short chain fatty acids	90
Snodgrassella alvi	Harbors on genes for glycolysis	94
Gut microbiota	Increase the load of the parasite Lotmaria passim	95
B type asteroids	Trigger the production of host hormones and signaling molecules	96
B. apis	Increase disease resistance	94
Enterobacteriaceae	Cause bee mortality	97
Chronic bee Paralysis virus	Trembling inability to fly, bloated abdomens, black hairless bees	97
Microalgae	Attractive feed source to supplement honeybee nutrition	98
Chlorella (green microalgae)	Complement of EAAs	99
microalga *Chlorella sorokiniana*	Positively impact honeybee colony growth and individual nutritional physiology (fat body protein content,*vitellogenin* messenger RNA levels, and hypopharyngeal gland size),	100
Arthrospira	Incorporated into a PS formulation that led to improved colony performance compared to unfed control colonies	101
Chlorella sorokiniana	Increase fat deposition in honeybees	100
Algae	Supplement macro nutrition and micronutrition	102
Bee microbiota	Influence bee metabolism, behavior, and immune function	1
microalga *Porphyridium*	Impact honeybee gut health through a non-prebiotic mechanism	103
Microbiota (Honeybee gut)	Enhance metabolism, immunity, and overall fitness	1
Lactobacillus sp.	Ubiquitous fermentative of honeybees	96
Spirulina	Promote bee health by stimulating the abundance and metabolism of beneficial gut bacteria (*Lactobacillus*)	104
Pollen and royal jelly	Result in high expression of Vg, prolonged the lifespan of workers, provide essential nutrient components for optimal survival	105
Nosema apis and *Nosema ceranae*	Infect gut, robbing bees of nutrients and causing digestive problems that can reduce life span	106
Nosema Ceranae	Cause immunosuppression	107,108
Sac brood virus (SBV)	Reduced pollen collection	109
Varroa mites	Result in smaller bees with lower hemolymph volume	110

Deformed wing virus	Deformed wings in emergent bees, premature aging of adults	97
Acute bee paralysis virus (ABPV)	Paralysis, trembling, inability to fly, darkening and loss of hair on thorax and abdomen	111
Chronic bee Paralysis virus	Trembling inability to fly, bloated abdomens, black hairless bees	97

2.5. Effect of parasites and pathogens on honeybees

Many species of viruses attack honeybees, some among them have been associated with population decreases. The deformed wing virus (DWV) is one of them[112], the acute bee paralysis virus (ABPV) and the Israeli acute paralysis virus (IAPV)[113,114], of which the mite Varroa destructor typically spreads[115,116]. Some of them have been discovered in the brain tissues of honeybees, indicating that bee viruses have a significant influence on cognitive abilities[117]. The microsporidia of the Nosema genus infest the ventricular epithelial cells of honeybees, where they proliferate and release spores in the excretions[118-120]. By feeding on their hemolymph, the mite *V. destructor*, an obligatory ectoparasite of honeybees, infests and weakens both larvae and adults. High infestation levels diminish the size of the brood and the number of adults, which have an impact on the colony's ability to reproduce[121]. In addition, DWV and other honeybee viruses spread by *Varroa destructor* can shorten worker lifespans and even lead to colony collapse. *Acarapis woodi* and other mites can also infest honeybee colonies, however they ever cause colony collapse[122]. Although diseases and parasites mostly influence bees' physiology, there is mounting evidence that behavior and cognition may also be impacted. The capacity of bees to fly and engage in foraging are both impacted by diseases and parasites[123]. When compared to conspecifics which are not affected by the microsporidia Nosema spp., honeybees with these infections perform worst while foraging. Foragers which have been parasitized behave more actively[124-126], by making more short-distance foraging excursions with frequent breaks between them [124,127-129], as well as spending more time away from the colony [129]. Additionally, when tested in a flying mill arm, honeybees infected with the DWV virus exhibit shorter flight lengths and durations [126]. These variations in flight behavior have been linked to the energetic stress brought on by parasites and viruses that feed off their host's resources but lack the nutrients necessary to carry out their jobs effectively themselves. **Table 3.** provides examples of many pathogens/parasites, their modes of transmission, and how they affect honeybee behavior, activity, and flight, among other things.

Table 3: Effect of Parasites / Pathogens on Honeybees

Pathogens/sites	Transmission	Effect on behavior	References
Apocephalus borealis	Parasitoids directly infest the host by laying eggs there.	Altered circadian clock, strange night-time behavior, and disorienting flying patterns because of light attraction	130
***Conopid* species**	Direct bee attack	Disrupted circadian cycle, staying far from the nest at night, altered floral preferences (prefers blossoms that are simple to detect with easy access to pollen).	131
Varroa destructor	Interaction between hosts physically	Diminished homing ability and impaired olfactory non-associative learning	129
Acarapis woodi	Direct interaction between hosts and its effect	Irregular flight (due to muscle reduction) increased dietary intake	132
Nosema apis	Influence the bees by causing copulation, trophallaxis, or spore intake (e.g., from cleaning duties or contaminated	Perform more frequent, shorter-haul flights each day.	128

	surfaces) (from drones to queens)		
Nosema ceranae	Influence the bees by causing copulation, trophallaxis, or spore intake (e.g., from cleaning duties or contaminated surfaces) (from drones to queens)	Less often occurring trophallaxis in honeybees	133
Crithidia bombi	Parasite eating by bees	Lowered foraging behavior (visit fewer flowers, spend more time handling flowers, and spend more time flying between flowers)	134
Deformed wing virus (DWV)	The vector Varroa destructor is to blame for the indirect invasion	Take honeybees on shorter-range, shorter-duration flights	126
Israeli acute paralysis virus (IAPV)	Horizontal: oral consumption; indirect: Varroa destructor-mediated transmission	Decreased homing skills	135
Kakugo virus (KV)	Vertical: oral consumption (e.g., trophallaxis)	More assertiveness	117
ectoparasitic mite:Varroa destructor	Via bee venomous fluid	Cause physiological deficits that lower the colony's success rate during overwintering	126
Varroa mite	As a result of consuming viral particles	Throughout a season, a rise in the colony's bee mortality	136
Nosema microsporidia	Attack bee nests directly	Adversely affect the health of honeybee colonies	97

2.6. Effects of Predator (Vespa velutina) on Honeybees

Although there is ongoing discussion extensively over the reasons for and severity of the present pollinator decline137-139. Bee populations are declining in the northern hemisphere140,141. One potential reason for this reduction is the introduction of foreign parasite or predator species142-144. The first invasive hornet species from Vespidae family to prey on honeybees is the yellow-legged hornet (*Vespa velutina*). Vespa velutina's biological invasion has caused a number of major issues since it preys on domestic honeybees (*Apis mellifera*), disturbs their ecological function, may change biodiversity, damages commercial beekeeping, and may be fatal to humans with allergies145,146. *Vespa velutina* predation on honeybees has surely a direct economic impact on apiculture, but social and economic studies that quantify this impact are limited, presumably because the invasion is young. According to one instance, *Vespa velutina* predation caused a beekeeper to lose up to 80 % of total of his hives (Cazenove).

3. DECLINATION OF HONEYBEE POPULATIONS

Bees employ a variety of inputs, including visual and olfactory combinations, to locate appropriate host plants for pollination[147]. During their early foraging excursions, they mostly rely on olfactory cues, and as they get more experienced, visual cues become more significant in determining the location of host plants[148]. However, as it enables bees to distinguish between blooms that will provide rewards and those that would not, floral aroma continues to be a significant stimulation for seasoned bees[149]. Social bee populations are drastically diminishing. Global pollinators like honeybees are in decline for several causes, including climate change, increasing pesticide use, fragmentation, virus transmission, diminished resource diversity, and alien species[150]. Smoke pollution from vehicles may be main source such bee reduction [148]. Radical compounds known as nitroxyl and hydroxyl, also known as reactive species, easily react with volatile chemical molecules (VOCs)[151] and influence VOC-mediated plant-insect interactions as well as flower fragrance. The bee colony produces around 5 to 8 kilograms of honey on average each year[152]. Each colony's capacity for producing honey declines with time, and this decline is unrelated to colony age. Due to competition for floral resources, the rise in colonies over the past 10 years may have decreased the amount of honey produced by each colony[153]. Bees ability to produce honey might also gradually decline over time as a result of the partition of bigger colonies into smaller ones, which prevented colonies from expanding forever[154]. Honey and other items' production decreases when honeybee colonies disappear[150] **(Fig 2)**.

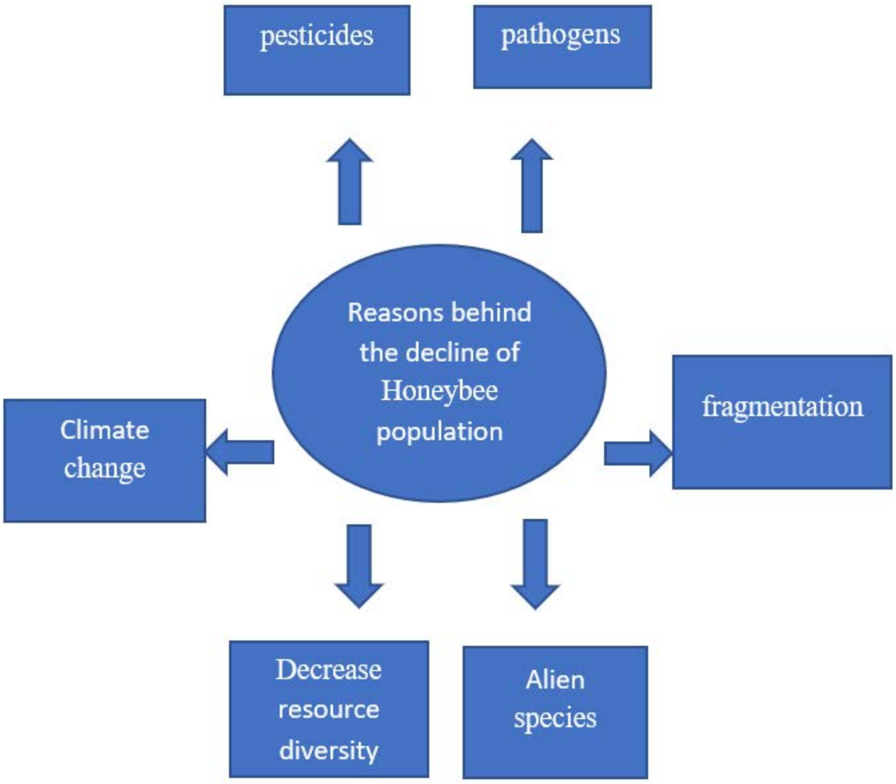

Fig 2: Illustrating different reasons of Honeybee Declination

Declines in pollinating insects are ominous for the safety of human food and may have implications beyond apiculture[155] risks to agriculture or both, including anthropological ones[156,157]. It has been established that pesticides are to blame for the worldwide bee population drop[126,158-163,155], habitat loss[142,164,165,161], agriculture, industries, as well as parasites/pathogens [157-158], global warming [162,36,166], as well as a scarcity of food [158-160,167,168,163]. Researchers have shown that viral infections are the primary cause of septicity and a major threat to the health of honeybee colonies [167-170] at individual and colony level [165]. Additionally, it was recognized that honey bees and at least 24 viruses were connected [168, 156,170-172]. This continued to be a significant risk to *A. mellifera's* health and well-being[171] furthermore to other honeybees in the world[156,172]. According to studies, single strand positive (SS+) sense RNA viruses bring majority of the infectious agents that affect honey bees[156,164,173]. In addition, the following viruses most frequently harm the health of bees: Acute bee paralysis virus (ABPV), Kashmir bee virus (KBV), Israeli acute paralysis virus (IAPV), and black queen cell virus are examples of dicistro viruses (BQCV)[167]; Deformed wing virus (DWV), Slow bee paralysis virus

(SBPV), Sac brood virus (SBV), and Varroa destructor virus (VDV1) are examples of filoviruses. Taxonomically unsystematic viruses include Lake Sinai viruses (LSV) and Chronic bee paralysis virus (CBPV). Compared to other pathogens, viruses may be the secret enemy of honeybees[174], as most infections do not lead to the clinical development of typical illness symptoms[175,176]. However, viral invasions were seemed a major worry for bees[177], because it harms honeybees at all stages of development, including egg, larva, pupa, adult worker, drone, and queen[178,179]. There are two ways that viral particles propagate in honeybees: vertical transmission and horizontal transmission[111,180]. The horizontal transmission pathway, viral particles spread among colony members of the same age generation. In the vertical transmission route, viruses multiply from the queen (trans-ovarial) or drones (trans-spermal) to the offspring's or during their mating (venereal)[111,167,178] relationship between the same caste and others (oral or by contact) **Fig 3**.

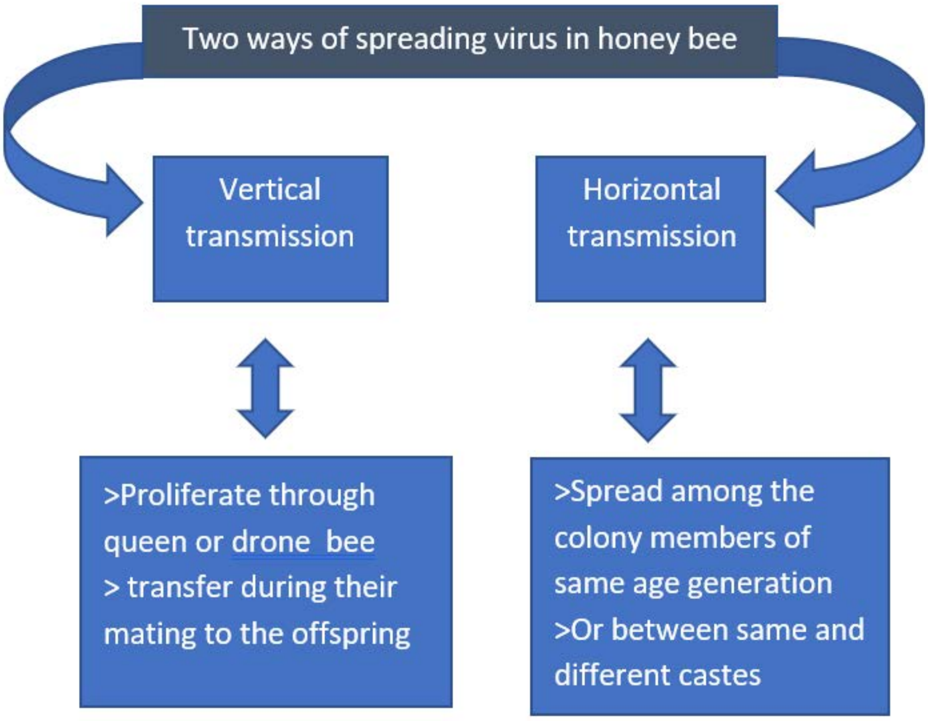

Fig 3. Showing the two different ways of spreading virus in honeybees

There are several illnesses that affect honey bee colonies that are brought on by different pathogens [158,156] and made many changes to the environment[181]. There are several environmental variables that have an adverse impact on bee health, including intensive agriculture with regular pesticide use, a lack of essential food and habitat loss, diseases, and pests [166,170,164,182]. Additionally, viruses pose serious risks to the health of honeybee colonies[156]. Honeybees are predominantly affected by the slow bee paralysis virus (SBPV), which is also present in low amounts in the thorax, midgut, hindlegs, and rectum as well as the head, salivary gland, mandibular and hypopharyngeal glands, crop, and fat body[111]. Because of a variety of interrelated factors, such as parasite and disease load, managed honey bee populations are in decline[183], exposure to pesticides [163,182,184], and land redevelopment as well [163,169,185]. According to reports, honey bee viruses can spread to other bee species [175] and are accountable for their deterioration[186]. Body deformity is one result of viral infection in wild bee[187] reduce capacity for reproduction, the effectiveness of septic disease, and mortality risk[168].

4. CONCLUSIONS

The morphology, development, and health conditions of honeybees are greatly influenced by environmental variables such as temperature, nutrition, light, beehive conditions, and social interaction. The continual exposure to extreme temperatures shortens the lifetime of honeybees. Young bees' wings develop in a variety of ways owing to temperature increases, which may make it challenging to distinguish between different species of bees. Environmental factors may also have an impact on the nutritional value of the food of bees, which may reduce immunity and reduce honey output. By reducing the pH, creating an oxygen gradient, and feeding its host bee short chain fatty acids, the gut microbiota makes its host bee heavier. Constantly high temperatures can destroy a variety of important gut microbes, which can stifle an insect's body's natural functions and ultimately lead to an organism's demise. Due to the fewer colonies, which also means less honey being produced, this might potentially cause financial loss. Future research should pay greater attention to how different environmental factors affect honeybee survival and health. The link between shifting environmental factors, honeybee health, and their survival rate is the subject of very few research. Bee morphology and growth, when considered together, give us a new benchmark for assessing the consequences of environmental change. There are many ways to save hone bees. By planting a bee garden, we can create a habitat corridor with plants that are rich in pollen and nectar. Synthetic pesticides, fertilizers, herbicides, and neonicotinoids are harmful to bees, wreaking havoc on their sensitive systems. Avoid treating your garden and green spaces with synthetics. Instead, use organic products and natural solutions such compost to aid soil health and adding beneficial insects that keep pests away like ladybugs and praying mantises.

CONFLICT OF INTEREST

No conflict of interest

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