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Pollution threat to honey bee survival: An obligatory pollinator for Cross-pollinated crops

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Abstract
Among beneficial forces, honey bees are the excellent pollinators that can enhance the yield of a crop up to 50%. Cross-pollinated crops are also dependent on this insect. Multiple factors are responsible in reducing the honey bee populations. Fuel odor, volatile chemicals and by products like nitric oxide, nitrogen dioxide gases are lethal not only to bee's body but also affect the foraging in bees. Memory impairment, disorientation, behavioral dilemma and somatic abnormalities observed when bees forage on neonicotinoids and unhygienic flora. Predators and parasites like bee-eater birds, hexapods like hornet wasps, predatory ants, and beetles, *Latrodectus* genus spiders and mites of *Tarsonemidae* family threatening bees especially *Acarapis woodi* is a serious pest reported from 20th Century. To highlight some threats in short it was reviewed under different aspects leading it towards extinction. So there is need to protect these natural pollinators from pollutants using eco-friendly agricultural practices to harvest their products.

Keywords: Honeybee, mortality, *Acarapis woodi,* chemicals, crop, pollution

Introduction

Insects of the *Apis* spp are true eusocial hexapods distributed throughout the world and arable to live under a broad choice of environmental conditions (Joshi, Pechhacker, Willam, & Von Der OHE, 2000; Klatt *et al*., 2014; Ruttner & Friedrich, 1992) [48, 51, 77]. Honey bee is native to Africa but dispersed to a wide range of other countries as Asia, northern Europe and Saharan Africa (Meixner & Marina, 2010; Sammataro, Gerson, & Needham, 2000) [57, 80]. Bees of *Apis* genus are living under divers environmental conditions as their ecotypes developed some genotypes staring from African deserts and oases and different fringes of tundra up to the mists of the United Kingdom (UK) and Alps (Marina D Meixner *et al*., 2010; F. Ruttner, 1988) [57, 78]. Honeybees have an old history as mentioned in the stories but a formal book about bee breeding was written by Aristotle from that time has been studied for centuries (Joshi *et al*., 2000) [48]. Historically about two thousand years later, Apis species entered the genomic era as a former insects adopting social behavior (Marina D Meixner *et al*., 2010; Paini, 2004) [57, 67]. Firstly Honey bee was domesticated in African countries and then spread though out the Europe and Asia about thirty five million years in the past (Meixner & Marina, 2010) [57]. It is also reported that in the early 1600's amongst honey bee species, *Apis mellifera* (European honey bee) was pioneer into North America for honey and wax production(Meixner & Marina, 2010; Paini, 2004) [57, 67].

In the world more than seventy percent of the cultivated crops are not self-pollinated but rely on the pollinators as wasps, butterflies, moths, flies and especially honey bees(Sharmah, Khound, Rahman, & Rajkumari, 2015). Therefore, in apiculture industry honey bees being exercise primarily for honey production and secondly interminably to boost up agricultural field crops yield or horticultural crops of the farmers by pollinating them such as maize, cotton, berseem, mango, apples, almonds, orange, watermelons and other vegetable crops (Joshi *et al*., 2000) [48]. Their pollination can increase 50 percent yield of other agriculture crops (Garibaldi *et al*., 2013; Klatt *et al*., 2014; Ruttner & Friedrich, 1992) [31, 51, 77]. In a report it is acknowledged that over $14.6 billion are being added annually by the beekeeping industry in United States (U.S.) but some documented that direct value due to bee pollination is high about $15 billion approximately (Meixner & Marina, 2010; Sammataro *et al*., 2000; Stankus, 2008) [57, 80, 87]. In United Kingdom 32 crops are grown for seed production while, thirty nine crops are grown for fruit production purposes, all are pollinated by these hexapods (Carreck & Williams, 1998) [13]. Some ecologists from educational institutions like from the University of Southampton Professor Guy Poppy documents that honeybees being potential pollinator can appreciably bounce up the yield of agricultural and horticultural crops and share a vital role to the world's economy as £430 million a year to the United Kingdom only (Klatt *et al*., 2014) [51]. Therefore, in Apidae family out of 25,000 bee species classified in 4000 genera four species are very well-known to be industrious and causative agriculture improvement are named as (1) *Apis dorsata* (Dumna, Commonly known as wild bees) (2) *Apis cerana*

(Billa makhi) (3) *Apis mellifera* (European honey bee) (4) *Apis florea* (Chotti makhi) (Joshi *et al*., 2000; Paini, 2004) [48, 67].

Factors threatening the obligatory pollinator

Presently put a momentary look, in at hand agro ecosystem, plenty of factors are responsible that diminishing populations of honeybees all around the world. Multiple and multidirectional environmental stresses including pollution is leading the bees' fauna towards extinction (Rua, Pilar, Rodolfo, Raffaele, & Irene, 2009; Ruttner & Friedrich, 1992) [76-77]. Balance in natural ecosystems and agricultural development depends on this insect pollinator that play a fundamental job for the continuation or survival purifying through shuffling of gene in numerous species of cross pollinated plants (Garibaldi *et al*., 2013) [31]. These adverse climatic fluctuations are also responsible for change in physiology and behavior itself in hexapods (Khaliq, Javed, Sohail, & Sagheer, 2014) [49]. Certain intra-specific aggressive relationships deviations were observed between colony and their predators, parasitoids and pathogens (Fig. 1).Numerous surveys conducted around the globe concluded that bee colonies are dying day by day (Aizen & Harder, 2009; Chauzat *et al*., 2006; Hayes Jr, Underwood, & Pettis, 2008) [2, 14, 38]. Insect biodiversity and agriculture is drastically affecting due to these plentiful stresses (Rua *et al*., 2009; Sammataro *et al*., 2000) [76, 80]. An estimated eighty percent of the plants will disappear in the absence of honey bee pollinators (Aizen & Harder, 2009; Garibaldi *et al*., 2013) [2] [31]. In case of pollinators disappearance certain Lepidopterous insects like butterflies are supposed to be extinct as vegetables and fruits will be diminished without cross pollination of confident plant species (Aizen & Harder, 2009) [2]. So such destructive disaster of nature is also indirectly harmful for us people. With that speed of ecosystem unbalancing if the biodiversity shrinks the human health prognosis on the long term are worrying threat (Aizen & Harder, 2009; Ruttner & Friedrich, 1992) [2, 77]. For the success of a healthy colony certain features are mandatory part of life as hive maintenance, brood development, mutual interactions, nursing, and communication and successful foraging (Dukas & Visscher, 1994) [25]. Forager bees perform various dances to search and collect new food supplies like flower for pollens, nectars and source of water for other foragers. While increase in environmental pollution is not only disturbs their pheromones secretions but also damage the internal morphological systems of the honeybee especially nervous system (Cresswell *et al*., 2012) [18]. Sometimes bees fail to communicate properly. Results of the research experiments has proved that polluted or infested bee may contaminate to the whole beehive while flying back to its colony (Beekman & Ratnieks, 2000; Pankiw, Tarpy, & Page, 2002) [6, 30, 68].

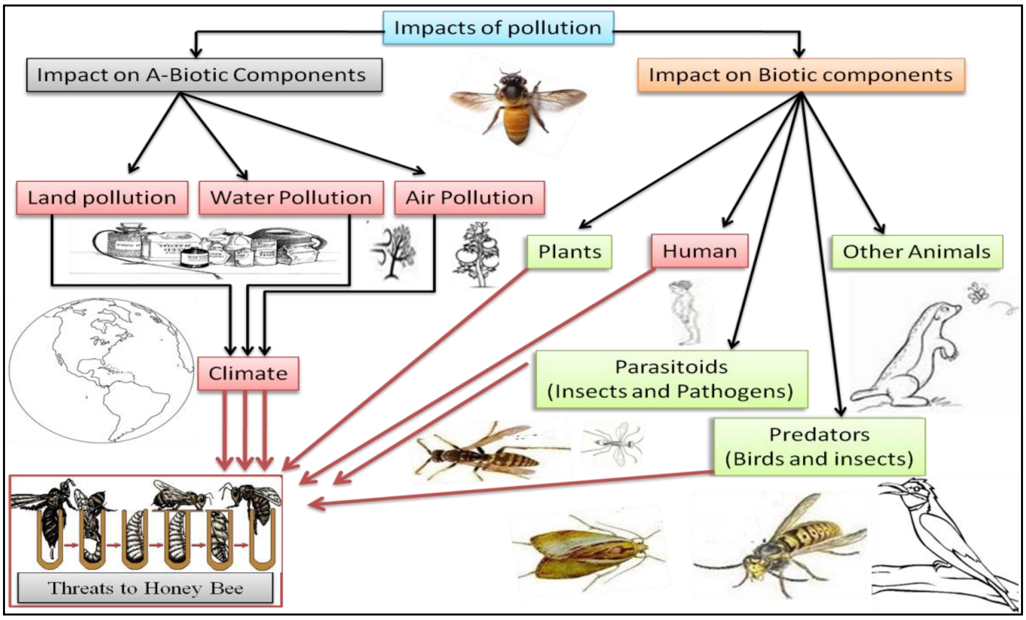

Fig 1: Pictorial demonstration of some pollution impacts on honey bee

Impact of fuel pollution

Increase in fuel exhaust with heavy use of automobiles in modern age threatening very important beneficial insect species, as the honeybee (Girling, Lusebrink, Farthing, Newman, & Poppy, 2013; Goulson, 2003) [19, 32]. A deep research document that volatile chemicals or by products of fuel exhaust can limit the sensory abilities of the honeybees especially their identifying or differentiating ability (Cresswell *et al*., 2012; Pankiw *et al*., 2002) [18, 68]. Fuel odor, volatile chemicals or by products are not only lethal to bees body but also interrupt foraging following by pollination will effect that leads to global food security too (Chiari *et al*., 2005) [15]. Study on eight chemicals involved in the odor of rapeseed flower was tested in the presence of air with and without diesel exhaust showed that two chemicals were completely disappeared in diesel exhaust air while remained unaffected in clean air (D., Girling, Farthing, Newman, & Poppy, 2013) [19, 38]. Exhaust of diesel fuel contains plenty of chemicals like nitric oxide and nitrogen dioxide, or NO_x gases were also observed to be effecting the odor of rapeseed flowers(Bender, Kumberger, & Hesse, 2003; D. *et al*., 2013) [8]. In another work researchers observed that when mixed the odor chemicals of oil rapeseed flowers with fuel gases, eight of the floral chemical chemistry was changed and two were completely lost (Wright & Schiestl, 2009) [105]. Despite the training of forager bees in the controlled conditions of the laboratory to be familiar with the floral fragrance, bees in the presence of exhausted fuel gasses were unable to distinguish the floral scents (Girling *et al*., 2013; Wright & Schiestl, 2009; Wright, Skinner, & Smith, 2002) [19, 38, 105-106].

Heavy metals in Soil or Water

Soil and water are the strong broad spectrum mediums that can soak up more or less all type of metal elements principally heavy metal elements like lead (Pb), cadmium (Cd), selenium (Se), mercury (Hg) and their derivatives with others (Moron *et al*., 2012; Veleminsky, Laznicka, & Stary, 1990) [63, 100]. Additionally the industrial and tanneries waste water, non-judicious exploit of chemicals on agricultural and horticultural crops also adds aforesaid heavy metal elements in both soil and water medium. Anthropogenic pollutants focusing selenium (Se) contaminate soil, water, may accumulate in plants (Golubkina, Sheshnitsan, & Kapitalchuk, 2014; Hladun, Kaftanoglu, Parker, Tran, & Trumble, 2013) [35, 42]. The four major type of Selenium accumulates in plants viz methylselenocysteine, selenocystine selenate and selenite were responsible for deferred development, modify protein conformation, oxidative pressure and heavy mortality in the honeybee (Golubkina *et al*., 2014; Hladun *et al*., 2013; Pilon-Smits, 2015) [35, 42, 70]. Due to intake of unhygienic flower food (polluted nectar and pollen) is the main foundation as entry gate of this metal. Selenium can also damage the insect's internal vital organs or can cause lake of detoxification by enzymes (Hladun *et al*., 2013; Lambert *et al*., 2012; Schmidt, Ibrahim, & Abdallah, 1991; Veleminsky *et al*., 1990) [42, 56, 81, 100].

Impact of pesticides usage

With the start of the pesticide era, man started blind use of pesticides on every crop grown at that time causing disequilibrium in the ecosystem (Khaliq *et al*., 2014). Paul Molar discovered first formal synthetic insecticide Dichlorodiphenyltrichloroethane ($C_{14}H_9Cl_5$) in 1939 that was excessively used in agro-ecosystem (Coats, 2012) [16]. Therefore, during early 90’s different pesticides especially neonicotinoids and phenylpyrazoles entered the European market. Due to first exposure of these insecticides showed high insect mortality and producing insect resistance and resurgence mechanisms (Coats, 2012; Heroux, 2010; Reynard, 2012) [16, 40, 73]. Biomagnifications greatly affects predators, parasitoids and other beneficial pollinators like honeybees (Nicolas Desneux, Decourtye, & Delpuech, 2007; Reynard, 2012) [22, 73]. Chemistry of Neonicotinoid molecules in soil or water is closely resembles to nicotine found in tobacco (Fickbohm & Trimmer, 2003) [29]. Furthermore, among these first generation chemistry as nitenpyram, Imidacloprid, Acetamiprid, and thiacloprid are superbly toxic to the Apidae family as they specifically targeting the insect nervous system, effects mushroom body of Kenyon cells behaving similar to partial agonist of the nicotinic nAChRs (Déglise, Grünewald, & Gauthier, 2002; Pisa *et al*., 2014; Suchail, David, & Luc, 2001) [21, 71]. The active ingredient of these pesticides hyper-stimulate honeybee nervous system that encourage an ample array of sound effects, starting from a minute signs, sub lethal to lethal effects (Henry *et al*., 2012) [39]. Denying to the statement that pesticides are safe as said by the pesticide companies or other chemical manufacturing industries, it has been observed that the several neonicotinoids concentration both in flower pollen and nectar is about 5-10 ppb is toxic to bees (Belzunces, Tchamitchian, & Brunet, 2012; Pisa *et al*., 2014; Suryanarayanan & Kleinman, 2014) [7, 71, 93]. The resultant is certain mutations or abnormalities like as tempt disorientation, behavioral dilemma and somatic aberrations are illustrate in the outward appearance of learning and memory impairment (Krupke, Hunt, Eitzer, Andino, & Given, 2012) [52]. Another research documented that bees die instantaneously as forage on the inflorescence of the neonicotinoids contaminated plants has estimated to be acute toxic up to 7,000 times more than Dichlorodiphenyltrichloroethane ($C_{14}H_9Cl_5$) (Tew & James, 2008) [44, 96]. Honeybees play dances have vital role in communication and maintenance of the beehive especially for the nourishment of hive mates and ensuring reduction of the food scarcity question (Seeley, 2009) [83]. Laboratory and field experiments working proved that forger bee’s response to sucrose was more after one hour of ingesting Imidacloprid (0.21 or 2.16 nanogram per bee) in food (Belzunces *et al*., 2012; Bortolotti *et al*., 2003; Eiri & Nieh, 2012) [9, 7, 26]. Infested bees showed fewer waggle dance circuits as 10.5 and 4.5-fold for 50% and 30% sucrose solutions, respectively after twenty four hours of the treatment as compared to control (Eiri & Nieh, 2012) [26]. Very small number of pesticides are safe for bees but the majority of the poisons are very perilous and unsafe to honeybee and fish life particularly foragers that directly expose to pesticides as compared to nurse bees serving in beehive. Among the list of pesticides several notorious insecticides nominated after research are Chlorpyriphos, Imidacloprid, Clothianidin Acetamiprid and Thiamethoxam (Belzunces *et al*., 2012; Bortolotti *et al*., 2003; Colin *et al*., 2004; Nicolas Desneux *et al*., 2007; Henry *et al*., 2012; Krupke *et al*., 2012; Pisa *et al*., 2014; Reynard, 2012; Suryanarayanan & Kleinman, 2014; Whitehorn, O’Connor, Wackers, & Goulson, 2012) [71, 9, 17, 23, 39, 52, 71, 73, 93, 103].

Table 1: Toxic effects of pesticides on bee health around the globe especially in Pakistan

Active Ingredient	Mild toxic to bees	Toxic to bees	Highly toxic to bees	Common/ Trade Names of the product	Remarks
Abamectin (BP)			✓	Vital, Agri-Mek, Sure, Abba, Miechongling, Avert, Abacide, Zoro, Solera, Abacus, Ardent, Avicta, Avid, Epi-Mek, Reaper, Solero, Temprano,Timectin, Agmectin	(Riedl, Johansen, Brewer, & Barbour, 2006; Wang *et al*., 2006) [74, 102]
Acephate (OP)			✓	Admire, Valent, Asophate, Mandate, Bracket,Orthene, Orthonex,	(Danka, Williams, Harmon, Rinderer, & Morris, 1991; Riedl *et al*., 2006) [20, 74]
Acetamiprid (NI)		✓		Mospilan, Assail, Rani,Transport,Rospilan,Tristar, Aventis,	(Brunet, Badiou, & Belzunces, 2005; El Hassani *et al*., 2008; Iwasa, Motoyama, Ambrose, & Roe, 2004)

					[11, 27, 43]
Aldicarb (SCI)			✓	Temik	(Mullin *et al*., 2010; Riedl *et al*., 2006) [74]
Alpha-cypermethrin (PI)			✓	Alpa-C, Fastac, BestoxSimba, Alphafos, Avanti, Checyper, Skolix, Sum, Nestox, Judos, Fastac	(Nicolas Desneux *et al*., 2007) [22]
Aluminum tris*O*-ethyl phosphonate (SOF)	✓			Aliette, Flanker, Linebacker Fosetyl-Al, Chipco, Legion	(Johansen, Mayer, Eves, & Kious, 1983) [46]
Azadirachtin (IPE)		✓		Neemix, Align, Aza, Ecozin, Amazin, Azera, Ornazin	(Naumann, Currie, & Isman, 1994; Peng *et al*., 2000)
Azinphos-methyl (OP)			✓	Guthion,Cotnion-methyl, Gusathion, Guthion, Methyl-Guthion, Carfene, Gusathion-M, Bay 9027	(Chauzat *et al*., 2006; Riedl *et al*., 2006) [14, 74]
Azoxystrobin (F)	✓			Dynasty,Abound, Quadris, Z-isomer, Heritage	(Nicolas Desneux *et al*., 2007) [22]
Bacillus subtilis (BP)	✓			Kodiak, Rhapsody, Serenade, Optiva, Companion, Cease	(Sabaté, Carrillo, & Audisio, 2009; Yoshiyama & Kimura, 2009) [79, 108]
Bacillus thuringiensis (BP)	✓			BT, Agree, Xentari, Ketch, Jackpot, Dipel, MVP, Javelin, Biobit, Thuricide, Condor, Vault, Cutlass, Lepinox, Novodor, Foil	(Krupke *et al*., 2012; Mommaerts, Sterk, Hoffmann, & Smagghe, 2009; Sabaté *et al*., 2009; Yoshiyama & Kimura, 2009) [52, 61, 79, 108]
Beauveriabassiana (BO)		✓		Mycotrol, Botaniguard,Spicariabassian, CRRI-66	(Searle & Doberski, 1984) [82]
Beta-cyfluthrin (PI)			✓	Baythroid, Cyfluthrin, Leverage, Tempo	(Johnson, Ellis, Mullin, & Frazier, 2010) [64, 47]
Bifenazate		✓		Floramite, Acramite, Vigilant	(Johansen *et al*., 1983) [46]
Bifenthrin (PI)			✓	Acramite, Sniper, Brigade, Discipline, Capture, Talstar	(Mullin *et al*., 2010; Riedl *et al*., 2006) [64, 47, 74]
Boscalid (CF)	✓			Emerald, Pristine, Endura	(Johnson *et al*., 2010) [47]
Buprofezin (IGR)	✓			Fuzin, Applaud, Badal, Byzin, Epo, Pride, SitaraCourier,Jawaa, Banzo, Centaur, Courier, Talus	(Johansen *et al*., 1983; Tasei, 2001) [46]
Captan (F)	✓			Merpan, Captan, Rthocide, Captevate, SR-406, Captec, Vancide-89	(Riedl *et al*., 2006) [74]
Carbaryl (CI)			✓	Sevin Bees are unlikely to be exposed to granular and bait formulations	(Nicolas Desneux *et al*., 2007; Riedl *et al*., 2006) [22, 74]
Chlorantraniliprole	✓			Prevathon, Coragen, Altacor, Acelepryn, Grubex	(Gradish, Scott-Dupree, Shipp, Harris, & Ferguson, 2010) [37]
Chlorfenapyr		✓		Pirate, Phantom, Pylon	(Riedl *et al*., 2006) [74]
Chlorothalonil (F)	✓			Ridomil gold bravo, Daconil, Fouronil, Echo, Equus, Bravo, Legend	(Evans *et al*., 2009) [28]
Chlorpyrifos (OP)			✓	Lorsban, Akofos, Galaban, Kurifast, Cobalt, Pyrifos, Shenchlor, Termicide, Dursban	(Chauzat *et al*., 2006; Mullin *et al*., 2010; Riedl *et al*., 2006; Thomas & Phadke, 1994) [14, 64, 47, 74]
Clothianidin (NI)			✓	Poncho, Belay, Sepresto, Nipsit Inside, Clutch, Arena, Poncho	(Henry *et al*., 2012; Iwasa *et al*., 2004) [39]
Copper Hydroxide (F)		✓		Champion, Ridomil copper, Champ, Mankocide, Kocide, Badge, Nu-Cop	(Johansen *et al*., 1983) [46]
Copper Sulfate + lime (F)			✓	Bordeaux Mixture	(Belzunces *et al*., 2012) [7]
Cryolite	✓			Cryolite, Prokil, Kryocide	(Johansen *et al*., 1983) [46]
Cyfluthrin (PI)			✓	Baythroid, Countdown, Aztec, Tombstone, Tempo	(Johnson *et al*., 2010) [47]
Cypermethrin (PI)			✓	Arrivo, Cymbush, Tenkoz, Cyperkill, Kapadin, Lucky, Nurelle, Polytrin, Ripcord, Sherpa, Up-Cyde,	(Riedl *et al*., 2006) [74]
Cyromazine (IGR)		✓		Trigard	(Riedl *et al*., 2006; Tasei, 2001) [74]
Deltamethrin (PI)			✓	Decis, Batallion, Reaper, Grim	(Riedl *et al*., 2006) [74]
Diatomaceous earth		✓			(Riedl *et al*., 2006) [74]
Diazinon (OP)			✓	Diazinon	(Chauzat *et al*., 2006; Riedl *et al*., 2006) [14, 74]
Dicofol (OC)	✓			Kelthane	(Riedl *et al*., 2006) [74]
Diflubenzuron (IGR)	✓			Dimilin	(Tasei, 2001) [95]
Dimethoate			✓	Chemathoate, Cygon, Dimetoxal, Higonet, Perfekthion,	(Chauzat *et al*., 2006; Nicolas

(OP)				Rogor, Roxion, Sanitox, Stinger, Systoate, Dimate	Desneux *et al*., 2007; Riedl *et al*., 2006) [14, 22, 74]
Dinotefuran (NI)			✓	Scorpion, Venom, Safari	(Belzunces *et al*., 2012; Iwasa *et al*., 2004) [7, 43]
Emamectin benzoate			✓	Denim, Proclaim	(Johansen, 1977) [45]
Endosulfan (OP)		✓		Endogreen, Endon, Fezdion, Hektonex, Hexasulfan, Mamba, Rocky, Technufan, Thiodan, ThioluxanThionex	(Chauzat *et al*., 2006) [14]
Esfenvalerate (PI)			✓	Asana	(Johansen *et al*., 1983) [46]
Fenbuconazole (F)	✓			Triazole, Benzimidazole, Enable, Indar	(Ahmad, Randhawa, Yusuf, & Khalid, 2011) [1]
Fenpropathrin (PI)			✓	Danitol, Tame	(Belzunces *et al*., 2012; Riedl *et al*., 2006) [7, 74]
Fipronil			✓	Regent	(Riedl *et al*., 2006) [74]
Flonicamid	✓			Beleaf, Carbine	(Johansen, 1977) [45]
Flubendiamide	✓			Belt, Synapse, Tourismo, Vetica	(Gradish *et al*., 2010)
Gamma-cyhalothrin (PI)			✓	Bolton, Cobalt, Declare, Proaxis	(Riedl *et al*., 2006) [74]
Horticultural oil (IPE)		✓		Superior, Supreme, Dormant, Summer	(Stavrinides & Mills, 2009)
Imidacloprid (NI)			✓	Concord, Confidor, Fencidor, Fencidor, Imicon, Ningo, Pestidor, Admire, Alias, Benefit, Brigadier, Couraze, Dominion, Gaucho, Macho, Merit, Nuprid, Pasada, Provado, Premise, Widow	(Cresswell *et al*., 2012; Iwasa *et al*., 2004; Stoner & Eitzer, 2012) [18, 43]
Indoxacarb			✓	Avaunt, Steward	(Riedl *et al*., 2006; Stavrinides & Mills, 2009) [74, 88]
Iprodione (F)	✓			Rovral, Dovetail, Nevado, Tazz	(Riedl *et al*., 2006) [74]
Lambda-cyhalothrin (PI)			✓	Warrior, Cyzmic, Demand, Voliam	(N. Desneux, Pham, & Kaiser, 2004) [23]
Malathion (OP)			✓	Malathion, Atrapa, Fyfanon	(Ahmad *et al*., 2011) [1]
Naled (OP)	✓			Dibrom, Stride, Systhane, Laredo, Sonoma, Rally, Spera	(Gradish *et al*., 2010; Stavrinides & Mills, 2009) [37, 88]
Neem oil (IPE)	✓			NeemGard, Turbo, Trilogy	(Johansen, 1977; Riedl *et al*., 2006) [46, 74]
Oxamyl (CI)			✓	Vydate	(Riedl *et al*., 2006) [74]
Oxydemeton-methyl (OP)			✓	Metasystox-R, MSR	(Riedl *et al*., 2006; Thomas & Phadke, 1994) [74]
Paraquat (F)	✓			Gramoxone super, MSR, Gramoxone Max, Metasystox-R,	(Belzunces *et al*., 2012) [7]
Permethrin			✓	Pounce, Ambush, Bee Gone, Arctic, Permastar	(Belzunces *et al*., 2012) [7]
Phorate(OP)			✓	Thimet, Phorate	(Riedl *et al*., 2006) [74]
Phosmet (OP)			✓	Imidan	(Chauzat *et al*., 2006) [14]
Potassium bicarbonate (F)	✓		✓	Greencure, Armicarb, Kaligreen	(Belzunces *et al*., 2012; Gradish *et al*., 2010) [7, 37]
Propargite (M)	✓			Comite, Omite	(Riedl *et al*., 2006) [74]
Propiconazole (F)	✓			Stratigo, Tilt, Banner Maxx, Bumper, Dorado, Kestrel, Propicure, Protocol, Quilt	(Ladurner, Bosch, Kemp, & Maini, 2005) [55]
Pyrethrin (IPE)			✓	Azera, Natria, Pyganic, Pyrenone, Pyrocide, Rotinone, Pyrethrin, Pyrethrill	(Belzunces *et al*., 2012) [7]
Pyriproxyfen (IGR)	✓			Admeral, Esteem, Distance, Knack, Pitch, Seize, Terva, Nyguard	(Tasei, 2001) [95]
Spinosad		✓		Tracer, Bull's Eye, Success, SpinTor, Entrust, Natular, Protector Pro	(Riedl *et al*., 2006) [74]
Sulfur (E)	✓			Sulfur	(Hillmann, 1972) [41]
Thiamethoxam (NI)			✓	Gammon, Cruiser, Actara, Adage, Cruiser, Agri-flex, Centric, Durivo, Endigo, Flagship, Helix XTra, Meridian, Platinum, Voliam	(Cresswell *et al*., 2012; Nicolas Desneux *et al*., 2007; Henry *et al*., 2012; Iwasa *et al*., 2004; Stoner & Eitzer, 2012) [18, 22, 43, 39]

Thiodicarb (CI)		✓		Larvin	(Thompson, 2003) [98]
Zeta-cypermethrin (PI)			✓	Furry, Stallion, Mustang, Mustang Maxx, Hero	(Johansen, 1977; Johansen *et al*., 1983; Riedl *et al*., 2006) [74, 46]

(E: Element, M: Miticide, CI:Carbamate insecticide, BP: Bio-Pesticide (derived from naturally occurring bacterium), F: Fungicide, IPE: Insecticidal plant extract, NI: Neonicotinoid insecticide, OP: Organophosphate insecticides, PI: Pyrethroids insecticide, QI: Quinolone insecticide, SCI: Systemic carbamate insecticide, SOF: Systemic organophosphate fungicide, BO: Biological organism (Entomopathogenic fungus), CF: Carboxamide fungicide, IGR: Insect growth regulator, CI: Carbamate insecticide, OC: Organochlorine)

Parasites and Predation Threats

According to quotation "survival of the fittest" a species connected to food chain and food web must compete with the intruders that rob, kill or occupy for space. A plenty of pathogens including protozoa, fungi, bacteria and viruses caused a numerous diseases such as chalk brood and American foulbrood are the notorious diseases attack bees (Morin & Otis, 1993; Sammataro *et al*., 2000) [62, 80]. In a study *Apis* genus is reported to be face eighteen different viral strains. Most of these viral strains some are highly anecdotal or extremely prolific causing trembling and paralysis among the bees in the apiary. various serious parasites and predators such as Wax Moth Larva (*Galleria mellonella*), hornet wasp (*Vespa crabro*) Varroa mites (*Varroa destructor*), ants, acarina mites and the little African hive beetle (*Aethina tumida*) giving much loss of honey bees(Rinderer, Harris, Hunt, & De Guzman, 2010; Sammataro *et al*., 2000) [75, 80]. Among these bees are facing a serious pest named tracheal mite, *Acarapis woodi* documented in 20th century that hunting lodge itself in the respiratory system(trachea) of the body of worker bees to suffocate and for breeding (Melathopoulos *et al*., 2000; Morin & Otis, 1993) [62, 60]. forager bees have to face bounty of predatory insects and spiders hunt for the duration of flower visiting or moving back to beehive (Foster, Gulliver, & Ratnieks, 2002; Kimsey & Carpenter, 2012; Subbiah & Mahadevan, 1958) [30, 50, 6]. Many other species of vertebrates also relay on honeybees such as honey badger (*Mellivora capensis*) and bee-eaters (*Merops apiaster*). These birds wait outside the hive on tree bunches, hanging wires or near the water sources (pond, stream, canal or water channel). As honey bee fly for forging, they catch and eat it during flight (Sammataro *et al*., 2000) [80].

Table 2: Some important parasites of honeybees in Asia

Name of Bee mites	Host species	Living Mode	Habitat	Remarks
Varroa destructor	*A. cerana* *A. mellifera*	Parasite	Brood cell, adult bee	(Rinderer *et al*., 2010; Sinia, 2013) [75, 86]
Euvarroasinhai	*A. florae*	Parasite	Brood cell, adult bee	(Morin & Otis, 1993) [62]
Tropilaelapsspp	*A. dorsata* *A. mellifera*	Parasite	Brood cell, adult bee	(Anderson & Morgan, 2007) [3]
Acarapiswoodi	*A. mellifera* *A. cerana*	Parasite	Brood cell, adult bee Trachea of the adult bee	(Melathopoulos *et al*., 2000) [60]
Neocypholaelapsspp	*Apisspp*	Parasite	Trachea of the adult bee, Pollen- storage cell	(Baker & Delfinado-Baker, 1985) [5]

Table 3: List of some predators attacking the honeybees

Name of Predator	Location	Remarks
Vespa orientalis	India, Pakistan	(Glaiim & Murtadha, 2009) [33]
Vespa mandarina	India, Burma, Thailand, Lao, Viet Nam, Democratic Kampuchea, China, Republic of Korea, Japan	(Sudo, Tsuyuki, Ito, & Tani, 2001) [92]
Vespa tropica	Tropical Asia	(Gobbo, Biondi, Filira, Rocchi, & Piek, 1995) [34]
Vespa velutina	Tropical Asia	(Tan *et al*., 2007) [94]
Vespa cincta	Tropical Asia	(Subbiah & Mahadevan, 1958) [90]
Vespa affinis	Tropical and sub-tropical Asia	(Kularatne, Gawarammana, & De Silva, 2003) [53]
Vespula vulgaris	Japan and perhaps all temperate Asia	(Donovan, 1984) [24]
Vespa mongolica	Japan and perhaps all temperate Asia	(Kimsey & Carpenter, 2012) [50]
Vespulalewisii	Japan	(Nakajima, Wakamatsu, & Mukai, 2000) [60, 65]
Vespa crabro	Republic of Korea	(Foster *et al*., 2002) [30]

Impact of floral change

In inflorescence, food-deceptive flowers are visited by pollinators for pollination as floral signals having visual and olfactory cues, appearing as monomodal or multimodal jointed spurs (Kunze & Gumbert, 2001) [54]. Environmental fluctuations influences not only the foraging activity of the bee directly but also effect flower development with nectars and pollens production in plants as indirectly influence bee colonies (Beekman & Ratnieks, 2000) [6, 30]. Similarly in adverse environmental conditions like shortage of food or winter, foraging bees have to collect sufficient food (nectars and pollens) to meet their brood development and body energy (Viuda, Ruiz, Fernandez, & Perez, 2008) [101]. Even in the hive nurse bees feeding the young ones with pollens by using the secretions of their pharyngeal glands. Climatic changes influence plant adoptability for flower production, development, survival, distribution and diversity in both genotypicaly and phonotypical (Klatt *et al*., 2014;

Thompson, 2003) [51, 98]. A well known example, in case of rain on the inflorescence of acacia plant, nectars or pollens of the flower may wash out leaving no attraction for forger honeybees. On the other hand, development of new flush and reproductive stages will be diminished under drought or dry climatic conditions that why lavender inflorescence will also produce less or no bee food (nectars or pollens) in such hard period. Sometimes climatologically fluctuations have great impact on food quality as plant in drought stress, stunt growth or flower shedding along with its production even bees can die of starvation (Lambert *et al*., 2012; Moron *et al*., 2012) [56, 63]. *Apis dorsata* have a strong adoptability against stimulus illustrates special genetic retorts to flowering disruption or patterns and seasons by immediate migration or long search (Joshi *et al*., 2000) [48]. Studies on aforesaid experiments it was recorded that *Apis dorsata* can fly about a distance of two hundred kilometers to escape from starvation or predation. Furthermore, it was observed that honeybees do not come back in absconded or infested hive for more than a few months leading to 1-2 years (Bailey, 1958) [4]. Diversity in the flora has a range of plant species that can tolerate a wide range heavy metals or salts concentration like halophytes. A plenty of plant species have the capability to collect the range heavy metal elements in their vegetative and reproductive parts like Se, Zn, Cd, Pb, Ni, Cu, As, Cr and Hg that proves toxic even can be fatal to the beneficial fauna especially to the pollinators as given in the table no.1 (Garibaldi *et al*., 2013; Golubkina *et al*., 2014; Quinn *et al*., 2011; Schmidt *et al*., 1991; Wuana & Okieimen, 2011) [31, 35, 72, 81, 107]. Several broad leave multi venal di-cotyledon plants (like *Brassica* sp., *Pennisetum* sp. and *Cystus sp*.) along with many other higher plants belongs to Poaseae, Pyrtaceae, Asteraceae, Piperaceae, Zingiberaceae, Lauraceae, Cupressaceae, Lamiaceae, Rutaceae and Apiaceae accumulate heavy metals use against other organisms (Hladun *et al*., 2013; Lambert *et al*., 2012; Marina Doris Meixner, 2010; Moron *et al*., 2012; Pilon-Smits, 2015; Wuana & Okieimen, 2011) [42, 56, 57, 70, 63, 107].

Table 4: Hyper accumulation of some heavy metals in plants

Plant	**Metal**	**Concentration (mg kg^{1})**
Dicotyledons		
Cystusladanifer	Cd	309
	Co	2,667
	Cr	2,667
	Ni	4,164
	Zn	7,695
Thlaspicaerulescens	Cd	10,000–15,000
	Zn	10,000–15,000
Arabidopsis halleri	Cd	5,900–31,000
Alyssum sp.	Ni	4,200–24,400
Brassica junica	Pb	10,000–15,000
	Zn	2,600
Betula	Zn	528
Grasses	Zn	0.03
Vetiveriazizaniodes		
Paspalumnotatum		
Stenotaphrumsecundatum		
Pennisetumglaucum		

Honeybee care

Apidae species are the important source of medicinal and energetic food products like honey, royal jelly and wax (Viuda *et al*., 2008) [101]. That's why it is very imperative to diverge them from way of extinction by conserving, inoculating or protecting their niches and habitats and not contaminating the floral fauna. Extensive application of pesticides like bactericides, insecticides, acaricides, herbicides, nematicides, fungicides and avicides must be avoided (Henry *et al*., 2012) [39]. In order to ascertain a safe and eco-friendly insect population, pesticides should be used at peak requirement time where it is necessary (Thompson & Maus, 2007) [99]. Annual along with perennial horticultural flowering plants or agricultural crops must be grown-up at the bank of the agricultural fields, gardens or in the orchards. Organic farming is supposed to be effective in support of bee population build up. Special involvement of government and other nongovernmental organizations (NGOs) and their funding to a common bee keeper will helpful to spread it at village level as good profession (Brown, 2006; Shi, Cui, & Zang, 2014) [10, 85]. Entomology courses for cottage industry particularly bee keeping or apiculture should be taught to graduate and post graduate students, progressive farmers, professional and interested community (Camargo & Joao, 1972) [12]. Under supervision of a complaining technical committee a number of demonstrative apiaries should be developed for open exposure to everyone. Also give awareness that completion of reproductive stage in many plant species and their yield honey bees play awfully vital role as pollinators (Aizen & Harder, 2009; Garibaldi *et al*., 2013; Klatt *et al*., 2014) [2, 31, 51]. Awareness through active mass media from both print and audio video aids can help in apiculture safety and development. Survival of such advantageous, beneficial and valuable insects is very necessary for the health, wealth and endurance of humanity. These gorgeous insects especially honey bee serving man from ancient time now need its mandatory attentions. Because human is ruthless enemy interrupting bee's natural and agro-ecosystem pushing towards extinction (James & Pitts-Singer, 2008; Marina Doris Meixner, 2010; Shi *et al*., 2014; Winston, 1991) [44, 96, 57].

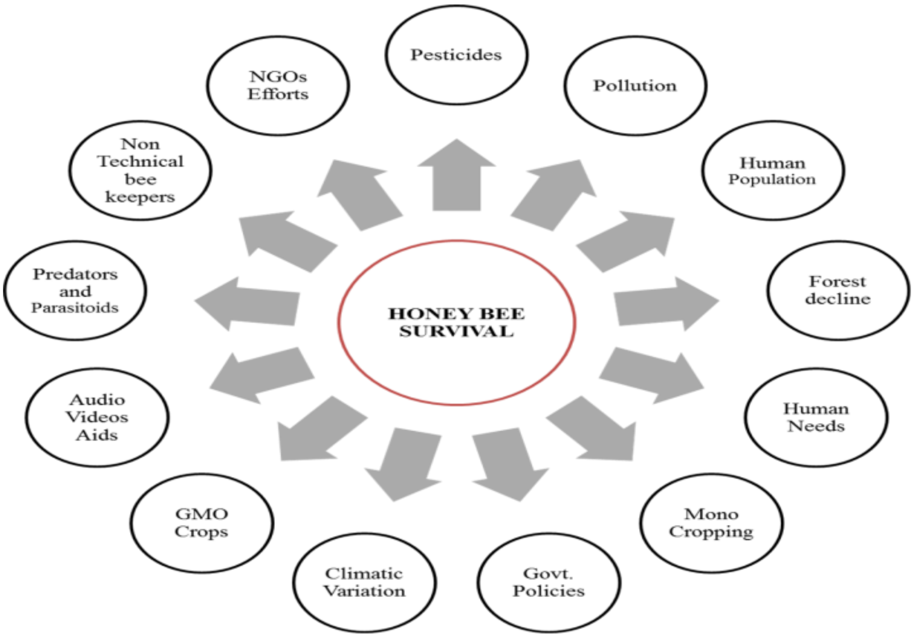

Fig 2: Mutual interaction of some factors and honeybee survival

Conclusions

Honeybee is leading to be extinct because of fragility in its species that can be shunned by increasing hostile environment and ecosystem imbalance. Plentiful contributing features in this phenomenon are boosting day by day such as pathogenic diseases, hazardous chemicals, genotypic variability and host responses, human involvement or eradication of natural habitats, human population and climatic hassles along with other ecological factors. Intensive chemical sprays in the agro ecosystem leaving residues and serious accumulation of the metals like tannery wastes in the irrigation water not only influencing the flora of the bees but also a solemn threat to their survival. The emerging ecosystem disequilibrium is leading towards a horrible fate of the bees that will endanger them near in future. There is a significant need to regulate the careful use of sources for the betterment of this beneficial fauna for their own survival and agriculture as well.

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