

ENEMIES OF HONEYBEES AND THEIR MANAGEMENT - A REVIEW

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ABSTRACT

Beekeeping remains one of the profitable areas among agriculturists, which has not been exploited to its full potential. Among several limiting factors, honeybee enemies constitute a major factor. Wax moths and wasps cause heavy losses to beekeepers throughout the world, therefore, got maximum attention by researchers. In addition to these pests, bee lice, hive beetles, mites, ants, birds, rodents and mammals occasionally attain the status of serious pests in a particular situation. In the present article work done on various aspects of bee enemies viz., seasonal activity, life history, nature of damage and control measures is reviewed.

Poor management in beekeeping weakens the bee colony-making colony susceptible to pest and predator attack. Although, honeybees have a strong defense mechanism involving 'the sting' against most of the enemies but sometimes they need assistance from beekeeper to defend. Enemies of honeybees are those animals, which cause disturbances and nuisance in functioning of the colony and range widely in size from microscopic mites to large mammals such as bears. These can be broadly classified into two categories: pests and predators of honeybees. Predators are those animals which seize/capture other live animals for food. Rest of the enemies which are not predaceous but nevertheless cause some harm or disturbances in honey bee colonies are considered as pests which can cause heavy damage to bee life as part of their seasonal activity.

Major enemies of honeybees are wax moths, birds, wasps, mites, ants, bee lice, hive beetles, mice, skunks, and bears (Morbe, 1999). Cockroaches, leaf cutter bees, Death's head moth, robber flies, dragon flies, preying mantis, spiders (Thakur and Sharma, 1984) etc. are some of the minor pests which cause nuisance in to bee colony. Present article is an attempt to concise the information available on honeybees pests and predators excluding mites which can be dealt in separate article.

1. Wax Moths

Galleria mellonella L. (Greater wax moth) and *Achroia grisella* F. (Lesser wax moth), *Vitula* spp. (dried fruit moth), *Plodia interpunctella* (Hbn.), *Ephestia kuhniella* (Zell) and *E. cautella* are associated with colonies of honeybees (*Apis cerana* F., *A. mellifera* L.; *A. dorsata* F. and *A. florea* F.) (Kumar, 1996). Among these, two species of wax moths viz. *G. mellonella* L. and *A. grisella* are responsible for enormous damage in beekeeping industry so these are discussed in detail.

(i) Greater wax moth, *G. mellonella*: *Galleria*, although a useful insect in insect pathology and physiology and as a fish bait is responsible for causing heavy losses to beekeepers throughout the world.

Life history: It is present throughout the world with rare exception in high elevations. Its life cycle is completed in four stages viz., egg, larva, pupa and adult stage. Eggs are smooth, spherical in shape; pinkish to creamish white in colour with size ranging from 0.4 to 0.5 mm. Eggs are laid in clusters in small cracks and crevices. Single female lays on an average of 300-600 eggs (max. up to 1800) in its lifetime of two weeks (Milum and Geuther, 1935; Mohamed and Copple, 1983; Khanbash and Oshan, 1997). Larva is white to dirty grey in colour and 3 to 30 mm. long in

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size. It lives in long silken tunnels and after hatching; it feeds on honey, nectar and pollen. Larva makes burrows/tunnels in combs and extends it to the midrib of comb. They spin silken galleries, which gives them protection from bees and traps the newly emerged bees in their cells. This condition is known as Gallariasis. Larva moults 4 to 6 times in its life. Pupa is brownish white (young) to dark brown (old), 14 to 16 mm long in size. Adult moths are heavy bodied, brownish grey, 10-18 mm in length. Females are larger and heavier than males. In females, outer margin of fore wing is smooth while semi-lunar notch is found in males. Labial palp in females is extended forward and head appears beak like. Larval period is between 22 to 60 days (Jyothi and Reddy, 1994; Khanbash and Oshan, 1997) sometimes extending upto 100 days (Allegret, 1975) depending on abiotic factors. Pupal period is 7-60 days (Kapil and Sihag, 1983; Jyothi and Reddy, 1993; Brar *et al.*, 1996). Life cycle completes in six weeks to six months. The effect of temperature, relative humidity and diet on development and metamorphosis of *Galleria* has been observed by various workers (Burkett, 1962; Bogus and Cymborowski, 1977; Chauvin and Chauvin, 1985; Kumar, 2000).

Seasonal activity: Seasonal incidence studies have been conducted by various workers, who have recorded several overlapping generations of wax moth in a year. Stored and deserted combs, improperly cleaned wax and weak or poorly managed colonies are constant source of wax moth populations. Depending on availability of food, temperature, habitat of pests, several overlapping generations can be produced in a year. Wax moths are active from March to October (Garg and Kashyap, 1998) but its peak activity has been observed from June to November (Ramachandaran and Mahadevan, 1951; Brar *et al.*, 1985; Gupta 1987). In

South India, maximum infestation of this pest was noted during the dearth period (Viraktamath, 1989). It hibernates in larval (about 70%) and pupal stages (about 30%) in stored combs.

Nature and extent of damage: Many people consider greater wax moth as a useful insect because its larvae are used as fish bait in many countries; so much so that they are raised commercially to get its larvae. However, it causes major losses to commercial beekeepers every year. Almost all colonies of Asian honeybees are prone to moth infestation (Adalakh and Sharma, 1975; Brar *et al.*, 1985; Viraktamath, 1989). During dearth and monsoon period, damage is increased to many folds in *A. mellifera* and *A. cerana* colonies. In *A. dorsata*, its seasonal infestation pattern differs from the domesticated bees. Wax moth population starts building from March, reaching its peak in August (99- 100%) and then show decline till February (Thakur, 1991). Moth infests all stages of brood, cells, pollen and honey region. Wax moth larvae can reduce the combs to a mass of web and debris. Severe infestation leads to suspension in brood rearing, foraging activity and ultimately desertion of colony from the nest.

Weak colonies (53%) are more prone to wax moth infestation as compared to strong colonies (11%) (Thakur, 1991). Other workers (Newton, 1917; Kreb, 1982; Jyothi *et al.*, 1990) reported cent per cent infestation in deserted combs. Nielson and Boister (1979) found that wax moth attraction was more towards strong, active than weak colonies.

(ii) **Lesser wax moth, *A. grisella*:** The lesser wax moth is far more widespread and abundant than greater wax moth and are found comparatively at higher altitudes. It is troublesome particularly in stored combs. Egg stage varies between 2 to 4 days; larval 34-48 days, pupal 5-12 days and adult longevity is about 7 days. *Achroia grisella* larvae are 15-

20 mm in size, they live segregated in silken tunnels covered with frass and webbings are interspersed whereas greater wax moth larvae congregate. Adult lesser wax moths are silver grey in colour without marking on wings and smaller in size than greater wax moth. They complete 3-4 generations during active season (Singh, 1962).

Control: Once infestation sets in, it is difficult to control the pest. Best defense is to maintain strong, healthy colonies, closing all cracks and crevices of the hive and reduction of entrance, which gives effective control of wax moth (Ramachandaran and Mahadevan, 1951). Unlike *A. mellifera*, the Asian honeybees are very poor propolisers therefore, closing of cracks and crevices through artificial material is often recommended.

Good sanitation be maintained inside the hive particularly bottom board and control of diseases and other pests is must which makes the colony weak. Pesticides reduced the strength of bees, brood area and killed forager bees (Abrol and Kumar, 2000; Menon, 1992; Rana and Goyal, 1991) so their use should be avoided. Excess combs/frames in the hive should be removed especially during dearth period. Destruction of the tunnels is an effective way to kill larvae in initial stages. Destruction of severely attacked combs is also recommended to check wax moth population.

There are few other methods by which wax moth population is controlled in beehives. One is to keep infested combs in hot water (60°C) for 4-5 h to kill all the larvae of *Galleria* sp. Naini and Bisht (1972) recommended 55°C temperature for one hour with 100 Watt bulb in brood and super chambers to kill *A. grisella* larvae and pupae. Providing artificial cold e.g. -7°C for 4-5h, or -12°C for 3 h or -15°C for 2 h is another effective way of killing all stages.

Fumigation with chemicals is very much in practice to kill the larvae in stored combs in

airtight rooms/chambers. Smouldering sulphur @ 180 g/cu.m, Ethylene bromide @ 20-100 g/1000 litre space or acetic acid, calcium cyanide, methyl bromide, para dichloro benzene (PDB), phosphine etc. are some of the fumigants which provide effective protection against wax moth infestation (Casanova, 1992). PDB crystals are least hazardous but cannot be used on comb honey and they don't kill eggs. Rather they repel moths, prohibit egg laying and also kill young larvae that hatch after the combs are placed in storage. Supers should be aired out before using them on colonies. Alternative is fumigation with carbon dioxide (CO₂).

Use of bio-control agents like *Bacillus thuringiensis*, *Galleria nuclear polyhedrosis virus* (GNPV), oviposition attractants, genetic manipulation etc. provides check against wax moth population. *Apanteles galleriae*, a larval parasite is found effective against wax moth larvae population (Ahmad *et al.*, 1983; Tawfik *et al.*, 1985; Verma *et al.*, 1999). Amongst these major work has been carried out on Bt formulations (Burgess, 1970; Ali *et al.*, 1973a, b; Battu and Singh, 1977; Cantwell and Shieh, 1981). Smaller larvae of *Galleria* were more susceptible to Bt treatment than large larvae (Burgess and Bailey, 1968; Rehman and Chaudhary, 1980). Likewise III instar larvae took more time to get killed than II instar larvae. LC₅₀ values for II and III instar larvae against Bt formulations were calculated by Kumar (2000) which were 2.13 to 2.45 g/l and 2.51 to 3.46 g/l, respectively. Bt formulations were found to be more toxic when injected into haemolymph as compared to its administration in food (Schmid and Berg, 1969; Vankova and Leskova, 1972). Verma (1995) recorded highest wax moth mortality (98.7%) in the comb sprayed with Bt suspension @ 10g per litre of water which remained effective for 5.5 months. However, combs dipped in Bt suspension provided protection against wax

moth for 13 months.

(iii) **Dried fruit moth, *Vitula* spp.:** Dried fruit moth (*Vitula edmansae*) larvae commonly feed on pollen and honey in unprotected store combs, occasionally found in the combs of strong colonies (Okumura, 1966; Grant, 1976; Wilson and Brewer, 1974). They are mottled grey in colour and 20mm long. The development from egg to adult requires about 88 days (Okumura, 1966). They can complete their development on combs without destroying the midrib or the entire comb, unlike *G. mellonella*.

Control: Pheromone traps (Scott *et al.*, 1984) or sulphur dioxide fumigation (Szabo and Heikel, 1987) are promising control measures for dried fruit moth infestation in stored combs.

(iv) **Indian meal moth, *Plodia interpunctella*:** The larvae of Indian meal moth feed on pollen, cocoons or dead brood in stored combs (Eckert and Shaw, 1960; Wilson and Brewer, 1974). The life cycle is completed in 4-6 weeks. In case of severe infestation, a loose flimsy webbing across the face of combs is seen.

Control: Cold storage at subfreezing temperature in airtight containers is the best method of protecting stored pollen from *Plodia* attack (Whitefoot and Detroy, 1968).

(v) **Mediterranean meal moth, *Ephestia* sp.:** Mediterranean meal moth sometimes attacks stored combs that contain pollen but this moth cannot develop on empty brood combs or dead insects (Eckert and Bess, 1952).

2. Wasps

Several species of wasps predate on honeybees causing severe damage to bee colonies and leads to loss of entire apiaries (Ghosh, 1936; Dave, 1943; Muttoo, 1949; Subbiah and Mahadevan, 1957, Sharma and Deshraj, 1985). About 20-25 per cent bee colonies desert their nest every year due to

wasp attack (Adalakha and Sharma, 1975). The largest of the social wasps, *Vespa* sp. are physically capable of preying on honeybees with ease. *V. orientalis* L. (Yellow branded brown wasp), *V. magnifica* Smith (large black wasp), *V. cincta* F. (yellow banded wasps), *V. ducalis* Smith and *V. auraria* Smith (golden wasps) are some of the species which destroy the weak and queen less colonies for honey and the brood in apiaries (Kshirsagar and Mahindre, 1975, Sharma *et al.*, 1979) and foragers in field (Abrol, 1994; Abrol and Kakroo, 1998; Sihag, 1992). Sharma *et al.* (1985) reported *V. mandarina*, *V. tropica*, *V. velutina* and *V. basalis* attacking colonies of *A. mellifera* and *A. cerana* in Kangra (H.P., India). Shah and Shah (1991) observed *V. velutina* as a serious pest of honeybees in Kashmir. In New Zealand, *V. germanica* destroyed 3900 colonies and affected more than 10,000 others (Walton and Reid, 1976). Akre and Davis (1978) reported that in Japan a group of 30 *V. magnifica* was able to kill 25,000- 30,000 bees in just three hours at the rate of one bee per hornet every 14 seconds. Hirschfeldar (1952) estimated that a single female wasp consumes 60-80 bees as food during her lifetime. Other wasp species associated with bee colonies include *Philanthus ramakrishnae* T. and *Palarus orientalis* (Kohl), also known as bee hunter wasps (Thakur, 1991). *V. tropica* is a fast flier wasp and mostly catches the forager bees (Garg and Kashyap, 1998).

Seasonal incidence: During spring season, fecundated females make new nest, which becomes populous during monsoon and attains a peak during autumn. Wasps prefer the thorax portion of adult bees and discard the head and abdomen of the bees. Morse and Nowogrodzki (1990) discussed the behaviour of attack of different *Vespa* sp. in detail. Some species wait on the back of the hive and capture bees coming out of crevices, others attack regularly at the entrances of hives to

deplete colony's field force. Some species enter the hive after killing guard bees and feed on the brood and young bees. *V. orientalis* capture bees that approach crevices, alighting board or hive entrance whereas *V. magnifica* adopt group predation strategy (Abrol and Kakroo, 1998).

Rana *et al.* (2000) reported peak predatory wasp activity from August to November in Himachal Pradesh (av. 208-252 wasps/ day) whereas it was July to September in Jammu (av. 13.5 wasps/ day) (Abrol and Kakroo, 1998). *V. auraria* was most abundant in HP and *V. orientalis* was predominant in Jammu. In Punjab, peak population was observed in the month of September. Brar *et al.* (1985) recorded 30- 51 wasps visiting apiary during midday. *V. velutica* starts its activity in the month of July whereas, *V. tropica* appears in August. Two species viz., *V. basalis* and *V. mandarina* starts attacking bee colonies in the month of September till November (Garg and Kashyap, 1998). Bhalla and Dhaliwal (1980) observed peak wasp attack during dearth periods.

Control: Best and only effective way is to kill fecundated females. *Apis mellifera* and *A. cerana indica* bees kill wasps through shimmering behaviour forming balls around wasps. Intruder is killed either being stung or due to high temperature at center of ball (43-46°C) and suffocation. This natural defense mechanism has been studied by various researchers (Abrol and Kakroo, 1998; Matsuura and Sakagami, 1973; Ono *et al.*, 1987; Sharma *et al.*, 1980).

Destruction of wasp nests is also one of the control measures, studied by various workers (Abrol and Kakroo, 1998; Kshirsagar, 1971; Kshirsagar and Mahindre, 1975; Subbiah and Mahadevan, 1957). Sharma *et al.* (1979, 1985) advised burning of nests with kerosene or spraying insecticide at night when all of them are in the nest is another way

of controlling their damage. Davis (1978) suggested use of aerosols from a distance of 3 metres or more for quick knock down of hornets in aerial nests. Calcium cyanide fumigation (0.5g) at the nest entrance gave 100 per cent mortality in hornet nest (Sharma *et al.*, 1979).

Use of protective screens either in the form of wire screen/cage (Kuranta, 1980; Rana *et al.*, 2000; Sharma *et al.*, 1985; Thakur and Kashyap, 1999) or queen gate/ queen guard board (Subbiah and Mahadevan, 1957) fitted at hive entrance provided physical barrier against wasp attack. However, this method was not found useful against *V. auraria*, which easily adapted to this modification and started lifting bees just outside the cage (Rana *et al.*, 2000). Elimination of alighting board is also recommended to reduce wasp attack (Sharma *et al.*, 1979).

One of the other common control measures is use of flap in apiary. Abrol and Kakroo (1998) observed the reduction in wasp visit from 66-76 wasps/day to 37-20 wasps/day. They noticed that continuous flapping for half an hour keeps hornets away from apiary for more than three hours.

Different types of baits as lures (Adams, 1986; Higo, 1983; Kshirsagar and Mahindre, 1975; McGovern *et al.*, 1970; Mizone, 1983; Shah and Shah, 1991; Spurr and Elliott, 1996; Wagner and Reirson, 1969) or poison baits (baits mixed with insecticides) (Ennik, 1973; Mishra *et al.*, 1989; Sharma *et al.*, 1979; 1985; Wang *et al.*, 1985) have been used with limited to high success in different parts of the world. McGovern *et al.* (1970) reported esters as highly attractive to wasps. Higo (1983) used fermented honey as bait and trapped 10,000 *V. xanthoptera*, 100 *V. mandrina* and 8 *V. insularis* workers during August to November in Japan.

Muzzaffer and Ahmed (1986) used sucrose solution (50%) instead of honey for

hornet trapping in Pakistan. Shah and Shah (1991) could trap 11,483 hornets in Kashmir in mixture of fermented honey and water, resulting in reduction of wasp attack from 1-25 to 0-3 wasps/hive. Rana *et al.* (2000) tried different baits in form of fermented honey, honey solution (50%) and ether extract of *V. auraria* with fermented honey but found fresh fish as most attractive bait in which 61.5 wasps/day (*V. auraria* and *V. basalis*) were captured followed by mutton bait (30 wasps/day). However, Abrol (1994) and Abrol and Kakroo (1998) reported rotten fish and chicken meat as preferred bait to predatory wasps. Grape juice fermented for 3 days, when used as trap, attracted and caught 200 hornets in 7 days (Lim *et al.*, 1989).

Among the poison baits, Ennik (1973) used an encapsulated formulation of diazinon mixed with tuna fish food, which resulted in reduction in wasp population by 75-90 per cent within 2 days. Sharma *et al.* (1985) used powdered aluminium phosphide on the sticker (nail polish) and applied to tergal parts of hornets. The bait (4-5 tablets of 0.6g each) were effective in controlling *V. mandarina*. Mishra *et al.* (1989) prepared poison bait in jaggery with 1000 mg fenitrothion/kg. Sixteen loads (110mg/load) of poison bait was sufficient to reduce *V. cincta* visits from 630 (pretreatment count) to 0 on the 6th day of the treatment. Wang *et al.* (1985) smeared the captured hornets with poison dust @ 1-2g/hornet. When these were released, whole colony was poisoned which resulted in complete control.

Some biotic agents have been known to affect wasp colonies, which have been reviewed by Gupta *et al.* (1998). In Turkey, Denizli chickens were raised on regular chicken feed mixed with dead hornets. Such chickens when placed in apiary gradually started feeding on live hornets and provided good control (Adsay, 1950). Poinar and Ennik (1972)

reported *Steirnerma carpocapsae* as biocontrol agent of wasps but propagation of these parasites need 100%RH, which is not available in nests. Donovan and Read (1987) used *Sphécophaga vesparum* for social wasp control but effects were not significant. Donovan (1989, 1996) reported use of *Sphécophaga*, *Bareogonalos* sp., *Metoecus paradoxus* (beetle) for the control of *V. germanica* but propagation of biotic agents is a major hindrance. A parasitic mite, *Pyemotes venricosus* is also known to attack wasp larvae and pupae. Captured hornets artificially infested with this mite returned to their nests, where these parasitic mites reportedly controlled the hornet colony successfully (Ahmed *et al.*, 1986; Muzzaffer and Ahmed, 1986).

3. Bee lice

Braula coeca, the bee louse as it is called, is actually a wingless fly. The adults are small (slightly smaller than the head of a straight pin), and reddish brown in color (Bradbear, 1988; Smith and Caron, 1984). While several adult flies may live on a queen, usually only one will be found on a worker. Smith and Caron (1984) observed that *B. coeca* prefer young worker bees to older ones, queens to workers or drones and mated queens to virgin queens. It moves rapidly over the body surface, setting on the dorsal surface at the junction of the bee's thorax and abdomen. They remain there until a hunger response causes them to crawl up to the bee's head near its mouthparts. This movement seems to cause the bee to regurgitate a drop of nectar. The bee louse then inserts its mouthparts into those of its benefactor and takes its food. The louse lays its eggs on the capping of honey storage cells. Upon hatching the young larvae burrow into the cappings. As the larvae grow, their tunnels lengthen and broaden. The infestation is easiest to observe. The larva pupates inside the tunnel. Soon after emergence, the young adult crawls upon a bee. It completes its life cycle from 16-

23 days (Hassanein and Abd El-Salaam, 1962) to 63-67 days (Dukov, 1964).

Control: Effective way to get rid of lice is to blow tobacco smoke in hive (Phillips, 1925), remove floor immediately and clear it off with blowlamp. Atakishiev (1971) recommended cutting the capping of infested combs to control immatures of lice. Some internal parasite of the fly is also observed but there is not much work on it.

4. Hive beetles

The small hive beetle (*Athina tumida*) is small (about one-third the size of a bee), black and covered with fine hair (Lundie, 1940) and is considered as a minor pest of honeybees (Caron, 1990). The beetle lays its eggs on or near beeswax combs. The eggs hatch, producing small larvae, similar in appearance to wax moth larvae having three sets of legs just behind the head, but larvae lack the series of paired prolegs that run the length of the wax moth larva's body.

Small larvae consume pollen, comb and larval honeybees. After completing the larval stage, they crawl out of the hive and pupate in the soil. Mating and egg laying occurs in warmer months. Taber (1999) recorded egg, larval and pupal period as 2-3, 10-20 and 25-60 days, respectively. Adult beetles feed on honeybee eggs (Eischen, 1999). Hopkins *et al.* (1999) reported more than 100 adult beetles on a single frame and found that beetle larvae and adults feed voraciously on bee brood primarily drone brood. Beetle larvae do the most damage, as their diet is mostly the same as of the wax moth larvae. Compounding the losses of comb structure, food reserve, repellent nature of beetle feces and 'slime layer' to adult honeybees force the bees to abscond from the hive to seek a more suitable nesting site (Slanghellini *et al.*, 2000). The beetle also defecates in the honey and in some way alters the honey causing it to ferment and run out of the combs. Most vulnerable are weak

hives with stored honey or full honey supers either in storage or above bee escapes. Apiaries adjacent to various fruit trees (mainly citrus) were found to be heavily infested with beetles (Eischen, 1999). In absence of their preferred food, they were observed feeding on selected fruits.

Platybolium alvearium and *Bradymerus* sp. (Tenebrionid beetles) also thrive well under unhygienic conditions of the hives (Thakur, 1991). *Protetaia aurichalcea*, *P. impavida* and *Anomala dimidiata* were also found feeding on stored pollen in *A. mellifera* and *A. cerana* hives.

Control: In strong colonies, bees remove the beetle larvae from the combs. Clean and tidy hives together with regular examination of empty combs will reduce the beetle incidence. Reduction of hive entrance also checks the entry of beetles in hives. Taber (1999) advocated two effective control measures against beetles. Firstly, by placing fume boards over the colony results in flying out of beetles through hive entrance. Secondly, since beetle larvae pupate in soil, placing the infested colony on a concrete floor or black roofing paper/plastic sheet would prevent the larvae finding soil ultimately causing cent per cent mortality.

5. Ants

Ants are not usually serious pests in honeybee colonies. Occasionally, however, certain species may enter colonies to search for food or establish nesting sites. Ants are typically found between the inner and outer covers of the hive and in pollen traps. Various workers have observed different ant species, which attack honeybee colonies for honey, pollen and brood. (Subhpradhan, 1961; Akwatanakul, 1986; Buys, 1990; Woodward and Jones, 1991; Abrol, 1997; Abrol and Kakroo, 1994). Argentine ants, *Iridomyrmax humilis* Mayr, are capable of destroying strong, populous colonies. In South Africa, it is known

as serious pest of honeybees (Buys, 1990). Persistent attacks by ants induce absconding in *A. mellifera* and *A. cerana* colonies. Poneroid ants especially *Eciton* sp., *Anomma* sp. and *Dorylus* sp. kill honeybees. Ants attack in groups of thousands, which can destroy an entire apiary within few hours (Dubois and Collart, 1950). *Camponotus compressus* F. (carpenter ant) is occasionally a serious pest of bee colonies in India (Singh, 1962; Thakur, 1991) and USA (Walshaw, 1967). In India, Singh and Naim (1994) also reported *Tetraponera rufonigra* as pest of honeybees, whose attack resulted in partial (8-18%) to complete (8-9%) destruction of *Apis cerana* colonies. The small red household ant, *Dorylus labiatus* and small black ants, *Monomorium indicum*, *M. destructor* are some of the other ant species which visit bee colony for food purposes. Even though majority of ants species seldom disturb the bees, these can be nuisance to the beekeeper.

Control: Honeybees are capable of defending hives against ants by fanning. They use propolis to fill cracks and crevices; closing through artificial material (resin) is also advisable. Regular maintenance of strong colonies keeps ants away. Subhapradhan (1961) advocated the use of 30-50cm high hive stands. Effective control of ants were recorded when legs of stands were smeared with corrosive mercuric chloride sublimate (May, 1961) or spent engine oil and grease (Abrol and Parmer, 1998). Legs of the stand in broad earthen cups containing water also check upward movement of ants.

Abrol and Parmer (1998) suggested destruction of ant nests. Use of chemicals like ethyl or methyl alcohol, sodium fluoride, borax powder, salt or powdered sulphur for ant control is also available in literature (Nikiel, 1972; Ramsey, 1946). Carbon disulphide fumigation (2-4 tsp.) or 0.1% Aldrin solution to destroy underground nests of ant (Thakur

et al., 1981) is also in practice. Woodward and Jones (1991) recommended the use of pyrethroids and organophosphates for the control of ants.

Natural repellants like *Nepeta cataria*, *Chrysanthemum*, *Juglans regia* (Bond, 1947) and dusting with turmeric powder (Abrol and Kakroo, 1998) is also used by many workers to keep ants away from the hives.

6. Birds

Various types of birds predate on honeybees (Fry, 1983, Cramp, 1999). Major birds associated with honeybees are *Merops apiaster* (European bee-eater), *M. orientalis* (Small green bee-eater) *M. leschenaulti* (Chestnut headed bee-eater) *M. superciliosus persicus* (Blue checked bee-eater), *M. philippinus philippinus* (Blue tailed bee-eater) *Indicator indicator* (Honey guides), *I. variegatus* (Honey guides).

Minor birds are *Picus viridis* (Green woodpecker), *Picoides major* (Great spotted or variegated woodpecker), *Parus major major* (Common great tit), *P. caeruleus* (Blue tit), *P. major karelini* (South Caspian tit), *Aegithalae caudatus major* (Caucasian long tailed tit) *Passer domesticus* (House sparrow), *Dicrurus macrocerus*, *D. aster* (Drongo/king crow).

According to their feeding habits, they are broadly classified into two categories: Bee-eaters and honey guides. Out of 74 families of Indian sub continent, 47 are insectivorous of which 24 families largely feed on insects. Major portion of their diet is honeybees or bee wax (Cobb, 1979).

(i) **Bee eaters:** Bee-eater birds belong to Meropidae family and include 24 species. Most of the species are migratory in nature and are found in temperate, tropical and sub-tropical regions (Dyer and Fry, 1980). They remain in flocks of 15-20 and feed on venomous Hymenoptera with the exception of *M. nubicus* and *M. albicollis*, which feed on

locusts and flying ants, respectively. A bee-eater attacks or catches the flying bees, devouring them by beating against perch. Breeding season of *M. orientalis* and *M. leschenaulti* is from February to June. They form nests in the form of tunnels in earth mound or sandy cuttings (Khan, 1996). Eggs are 4-9 in number, pure white to white, oval to round oval with an average size varies from 19.3 - 26.2 × 17.3 - 21.9 mm.

Green bee eater, *M. orientalis* is the commonest and most serious enemy of honeybees (Latif and Yunus, 1950). Sharma and Khan (1995) studied the predation rate of small green bee eater on *A. mellifera* foragers and found that on an average, 708±111.2 foragers/day are eaten by bird. Predation was maximum between 10 to 13 hrs whereas it was minimum between 16-19 hrs.

Control: Scaring the birds is most effective in checking their visits to beehives which include sound in high pitch with different notes, beating the drums and empty tins or throwing pieces of stones/pebbles through Gulel or hand (Mishra and Kaushik, 1993). Use of sulphur-potash mixture, hanging of 2-3 dead bee-eaters at 5m heights and producing distress call/voice of injured bee eater by recording audio cassette and played on the amplifier is another way of controlling their visits.

Reflective tapes are also in use to distract birds. Reflective tapes of different colours (1m×3.5cm) fixed on string at a distance of 20-30 cm at a height 5 m on two poles/stems are generally used. It is beneficial to keep beehives under thick canopy of trees and restrict their flight activity by provision of water near apiary and provide enough ventilation by fixing wire gauge screen (Mishra and Kaushik, 1993).

(ii) **Honey guides:** This is the second major bird group of predators of honeybees

which comprises 11 species under 4 genera. Among them, 9 species are found in Africa and 2 species in Asia of which one is found in Nagaland and Manipur while other is found in Thailand, Burma, Sumatra and Malaya (Khan, 1996). They exhibit guiding behaviour and symbiotic relationship with mammals. They prefer bee's wax to honey or honeybee larvae.

Control: These are not of serious nature because of limitation to symbiosis.

(iii) **Wood peckers and tits:** They are present throughout the world except Madagascar and Australia. Green woodpeckers are found in Haryana, Rajasthan, Gujarat and Orissa whereas Great spotted wood peckers are found in North eastern hill states.

Control: Woodpeckers are generally beneficial so no control is required. They can be frightened or screened away from apiary as no one advises to destroy tits.

(iv) **Drongos/king crows:** These are known as occasional predators of honeybees. In Hisar region, they are observed as regular predators of bees.

(v) **Tyrants:** *Tyrannus tyrannus* (the eastern king bird or bee marten) is a major problem in queen rearing operations in USA where it predaes on larger drones and queen but not on workers (Khan, 1996).

7. Bears

Damage by bears has been reported in Autumn and winter in hilly areas (Thakur *et al.*, 1981; Mishra, 1987). Cheap wall enclosure's or keeping hives in the walls of dwelling houses (Thakur *et al.*, 1981) or suspending hives from the horizontal branches of trees (Rao, 1968) are some of the effective control measures against bear attack.

Among the minor pests, small animals may nest in or burrow under bee colonies. Reducing the colony entrance and placing bees on hive stands can reduce this problem.

Foraging bees may wander into the clutches of several types of predatory insects such as preying mantis, bugs or beetles. Strong, healthy colonies can afford to suffer occasional losses to such pests. If some insect becomes locally abundant, the usual solution is to move the apiary site.

The key to protect the honeybees from predators and pests begins with a strong colony that can defend itself. Another line of

defense is a secure hive with no cracks or holes in hive bodies. As per IPM programme, use of non-chemical methods to keep pest population densities below their economic injury level should be preferred over chemical treatment. Appropriate chemicals in prescribed quantity and at proper time should be applied only when the other methods (cultural, mechanical etc.) prove insufficient.

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