Honeybees and Beekeeping: The Global Scenario

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Abstract

Diversity of geographical features particularly in the tropics and subtropics plays a key role in determining the topography, climate, and plant species of the region. Such regions provide abundant opportunities for both migratory and non migratory beekeeping. Current agricultural transformation, once linked to apicultural operations, offers much scope for income generation from beekeeping. Till now only 10 % of the existing potential has been utilized. For instance, India has a potential to keep about 120 million bee colonies that can provide self-employment to over 6 million rural and tribal families. In terms of production, these bee colonies can produce over 1.2 million tonnes of honey and about 15,000 tonnes of beeswax. Organized collection of forest honey and beeswax using improved methods can result in an additional production of at least 120,000 tonnes and 10,000 tonnes of honey and beeswax, respectively. Thus, it is expected to generate income of worth satisfying needs of five million tribal families. The present global status as well as future strategies for conservation of beekeeping is discussed in detail.

Keywords

Beekeeping • Beeswax • Diversity • Honey

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22.1 Introduction

Recent disappearance of honeybees across the globe with the diagnosis of colony collapse disorder has raised concerns about the threats posed to food security and ecosystems (Barrionuevo 2007; UNEP 2010; Mathews 2010). Debates about honeybees loss and its causes continue to rage. In part, the controversy stems from the combined complexity of pollinator relations and suspected multiple, interrelated causes such as chemicals, pests, disease, vegetation changes, weather, etc. The complexity also results in inconsistent manifestations of disappearances from year to year and region to region, leading to further contestations and confusions. The problem and solution(s) continue to haunt and provoke (Thompson et al. 2003).

Beekeeping has turned into an inexorably prominent practice to get tasty nectar as a wellspring of occupation and nourishment security through pollination (Walker and Crane 2000; Agrawal 2014). Honey and honeybees have a long history in India. Honey bees developed in this area a large number of years prior and delivered nectar from nectars of blooming plants that possessed large amounts of rich backwoods surviving everywhere throughout the nation. Nectar was the main sweet nourishment tasted by the ancient Indians meandering in these woodlands. "Honey hunting – is an antiquated practice in India as appeared, for instance, in hole compositions going back to 11,000 BC found in Madhya Pradesh (Suryanarayana 2002) and in Ancient Egyptian drawings and works of art (Crane 1999). The historical backdrop of beekeeping is attached in and connected to nectar chasing and related practices. Assembling wild nectar is still a typical practice in numerous parts of the world; in India it is evaluated that 22,000 tonnes of wild nectar is gathered by nectar seekers yearly – doubling the measure of nectar delivered by the overseen beekeeping area (Wakhle and Pal 2000).

India has properly been known as a "place that is known for nectar." The nation has a portion of the most established records of nectar industry as ancient works of art delineating hives and the soonest endeavors to reap nectar. India has for quite some time been surely understood for its transcendent custom of beekeeping and nectar chasing. Beekeeping is presently settled and thriving as a beneficial agro-woodland-based industry. Beekeeping assumes a vital part in the present connection of commercialization of agribusiness and liberalization of economy. It covers the whole extent of bumble bee assets, honeybee items, beekeeping rehearses, fertilization administrations, and their interface with business frameworks and environment trustworthiness.

22.2 Evolution

Bees are flying insects closely related to wasps and ants. Bees are a monophyletic family within the superfamily Apoidea, now thought as a covered *Anthophila*. There are nearly 20,000 known species of bees in seven to nine recognized families, though many are undescribed and the actual number is probably higher. The majority of species are single/alone laying eggs in tunnels they dig out themselves. In some species small numbers of females may share a single-tunnel system, and in others there may be a semiorganization/social organization involving an order among the females (related to certain bees being ranked above or below other bees). Bees provide a supply of food (honey and pollen) for the larvae, but there is no progressive feeding of the larvae by the adult bees. Bees are found on every continent except Antarctica, in every home/place where something lives, and on the planet that contains insect (brought pollen from one plant to another)-flowering plants. Bees are changed/ready for feeding on nectar and pollen.

Honeybees have a long proboscis (an unpredictable "tongue") that empowers them to get the nectar from blooms. They have radio wires generally comprised of 13 fragments in males and 12 in females, as is common for the superfamily. Minor stingless honeybee species exist whose laborers are under 2 mm (0.079″) long. The biggest honeybee on the planet is *Megachile pluto*, a leaf-cutter honeybee whose females can achieve a length of 39 mm (1.5″). Individuals from the family Halictidae, or sweat honeybees, are the most widely recognized kind of honeybee in the Northern Hemisphere; however, they are little and regularly mixed up for wasps or flies.

It is imagined that honeybees initially advanced from wasps – Crabronidae – in this way predators of different creepy crawlies. Fossil proof is scanty; however, honeybees most likely showed up on the planet about the same time as blooming plants in the cretaceous period, 146–74 million years back. The most seasoned known fossil honeybee, stingless honeybee named *Trigona prisca*, was found in the upper cretaceous of New Jersey, USA, and dates from 96 to 74 million years prior. It is undefined from cutting-edge *Trigona*.

The change from bug prey to dust may have come about because of the utilization of prey creepy crawlies which were blossom guests and were incompletely secured with dust when they were bolstered to the wasp hatchlings. This same developmental situation has additionally happened inside the vespoid wasps, where the gathering known as "dust wasps" likewise advanced from savage precursors. As of not long ago, the most established nonpressure honeybee fossil had been *Cretotrigona prisca* in New Jersey and of Cretaceous age, a meliponine. As of a late reported honeybee fossil, of the class Melittosphex, is viewed as "a wiped out genealogy of dust gathering Apoidea sister to the present day honey bees" and dates from the early Cretaceous (~100 mya). Determined elements of its morphology ("apomorphies") is placed unmistakably inside the honeybees; however, it holds two unmodified genealogical attributes ("plesiomorphies") of the legs (two midtibial goads and a thin rear basitarsus), demonstrative of its transitional status.

The oddity is that honeybees are particular as fertilization specialists, with behavioral and physical adjustments that particularly improve fertilization and are by and large more productive at the undertaking than other pollinating bugs, for example, scarabs, flies, butterflies, and dust wasps. The presence of such flower masters is accepted to have driven the versatile radiation of the angiosperms and, thus, the honeybees themselves.

22.2.1 Development of Subspecies

Despite the fact that it has for quite some time been realized that there are numerous sorts of bumble bees, just as of late has a far-reaching order been endeavored considering the contrasts in physical characters among subspecies and their present topographical appropriation, the land proof indicating their causes, and the course of their resulting development and circulation.

Like the stingless honeybees, bumble bees initially developed in tropical conditions. The fossil record appears at times when Europe had a tropical atmosphere. As the atmosphere got cooler, the open settling sorts would not have possessed the capacity to make due with the exception of relocating to the tropical locale of Southern Asia. For most of the tertiary time, Africa was confined from Europe via ocean, and no tertiary sorts of bumble bee reached Africa even after an area scaffold was built up. It is likely that the improvement of cutting-edge warm homeostasis in bumble bees which allowed the control of cool calm zones in this manner happened in Southern Asia, potentially in the Himalayan area. Once settled, the hole-settling cerana-mellifera sort would spread east and west, in the long run involving both tropic and cool and mild zones.

In spite of the fact that cerana honeybees more likely than not imparted a typical progenitor to mellifera, they have developed into isolated species. It is impractical to cross cerana with mellifera notwithstanding utilizing instrumental insemination, on the grounds that the two species are presently hereditarily contrary and feasible eggs don’t come about because of the cross preparation. Different contrasts incorporate their varying responses to illnesses, infestations, and predators.

How far mellifera honeybees infiltrated into Northern and Western Europe amid the warm interims between glaciations of the Pleistocene time frame is a matter of guess; what is sure is that no bumble bees could have existed north of the Mediterranean district, the Iberian promontory, and Southwestern France at Ice Age.

A honeybee taking after *Apis dorsata* yet much littler was available in the upper Miocene. It is felt that *Apis florea* and *A. dorsata* may have existed as particular species as ahead of schedule as the Oligocene time frame. It has not been conceivable to gauge when honeybees of mellifera/cerana sort initially showed up on earth. Mellifera and cerana more likely than not procured separate characters amid the last part of the tertiary time.

Among living honeybee aggregates, the “short-tongued” honeybee family Colletidae has generally been viewed as the most “primitive” and sister taxon to the rest of the honeybees. In the twenty-first century, nonetheless, a few scientists have guaranteed that the *Dasypodaidae* is the basal gatherer, the short, wasp-like mouthparts of colletids being the consequence of concurrent development, as opposed to characteristic of a plesiomorphic condition. This subject is still under open deliberation, and the phylogenetic connections among honeybee families are ineffectively caught on. In some species, groups of cohabiting females may be sisters, and if there is a division of labor within the group, then they are considered semisocial. If, in addition to a division of labor, the group consists of a mother and her daughters, then the group is called eusocial. The mother is considered the queen and the daughters are workers. These castes may be purely behavioral alternatives, in which case the system is considered "primitively eusocial" (similar to many paper wasps), and if the castes are morphologically discrete, then the system is "highly eusocial." Highly eusocial bees live in colonies. Each colony has a single queen, many workers, and, at certain stages in the colony cycle, drones. Honeybee hives can contain up to 40,000 bees at their annual peak, which occurs in the spring (October–February). The true honeybees (genus *Apis*) have arguably have the most complex social behavior among the bees. *A. mellifera* is the best-known bee species and one of the best known of all insects. There are 29 subspecies of *A. mellifera*, native to Europe, the Middle East, and Africa.

22.2.2 Diversity

Insects evolved 350 million years ago. Some changes in insect fauna were noticed in the Permian, Mesozoic, Triassic, and Jurassic periods. When flowering plants became established in the cretaceous period, many insects were found associated with them. Of the several insect orders, Hymenoptera is the largest group of insects which includes at least a quarter million species including all social insects such as bees, wasps, and ants (except termites). Honeybees have settled almost all over the planet. They live both in regions with cold climates and long severe winters and in the tropics where winters never occur and the summer temperatures are higher. Bee's adaptability to different climates and environments has proved to be genuinely amazing. As a result of specific climatic conditions and peculiarities of nectariferous flora, the group developed different breeds of honeybees during evolutionary history.

22.2.3 Origin and Distribution of Apis

Bees as a gatherer seem to have their focal point of root in Southeast Asia (counting the Philippines), as everything except one of the surviving animal categories is local to that area, including the most primitive living species (*Apis florea* and *A. andreniformis*). The main *Apis* honeybees show up in the fossil record in stores dating around 40 million years back amid the Eocene time frame; that these fossils are from Europe does not as a matter of course demonstrate that Europe is the place the sort began, as the probability of fossils being found in Southeast Asia is little, regardless of the fact that that is the genuine beginning. At around 30 million years before present, they seem to have created social conduct and fundamentally are for all intents and purposes indistinguishable with advanced bumble bees.

The nine major *Apis* species are *Apis mellifera*, *A. cerana*, *A. koschevnikovi*, *A. nigrocincta*, *A. nuluensis*, *A. dorsata*, *Apis florea*, *A. laboriosa*, and *A. andreniformis*. Out of these nine species, five initial species nest in cavities which have a number of combs. The last four that nest in the open have a single comb. *Apis* species are divided into three lineages: the cavity nesting bees, *Apis mellifera*, *A. cerana*, *A. koschevnikovi*, *A. nigrocincta*, and *A. nuluensis*; open nesting, the dwarf bees, *A. florea* and *A. andreniformis*; and giant bees, *A. dorsata* and *A. laboriosa*. Of the nine species, only *A. mellifera* and *A. cerana* have been "domesticated" for a long time (Koeniger 1976). *A. mellifera* is the most studied and economically exploited species. All *Apis* species, except for *A. mellifera*, are native to Southeast Asia. This region is a center of *Apis* diversity and makes scientists pay great attention to the recently recognized species such as *A. nigrocincta* and *A. nuluensis*.

There are nine different species of bees that make honey. The most commonly recognized honeybee species, *A. mellifera*, is native to Africa and Europe and subdivided into about 24 subspecies.

In India, European bees were successfully introduced in 1965. There had been several attempts to bring the exotic bees into different parts of the country through the past eight decades. One can assume that all these stocks perished because no reports on their performances exist. Successful establishment of the European bees was possible due to a combination of several factors. Important among these are selection of appropriate strain of the bee that could adapt to the hot agriculture climate, change in the cropping pattern that helped in ensuring a continuity in bee forage, and scientific methods of introduction of the exotic strain in an alien climate.

22.3 Honeybee Species

India has five types of *Apis*, i.e., the genuine bees – *Apis florea*, *A. cerana*, *A. dorsata*, and *A. laboriosa* Smith and *Apis mellifera*, a European species – and a few types of stingless honeybees of the variety *Trigona* (Fig. 22.1a–f). There are signs that no less than an extra species near *A. florea* exists. Of the *A. cerana*, three subspecies have so far been distinguished. Kshirsagar (1983) and Verma (1992) showed that an aggregate of seven races under three perceived subspecies exists. Notwithstanding this assortment, all the *Apis* species have an amazingly comparable life cycle. The science of the stingless honeybees is likewise practically comparative. *Apis* honeybees have a very much created social association and have comparable standing separation, division of work, searching, guard, and conceptive practices. Of the few bumble bee species, *Apis cerana* and *A. mellifera* are tamed species and fill the need of business beekeeping.

Fig. 22.1 Different types of honeybee species in India: (**a**) *Apis indica*, (**b**) *Apis mellifera*, (**c**) *Apis dorsata*, (**d**) *Apis florea*, (**e**) *Trigona bengalensis*, (**f**) *Trigona* (*Tetragonula*) *iridipennis*

22.3.1 Dwarf Honeybee

As its name suggests, *Apis florea* is the littlest of the genuine bumble bees, both in body size of specialists and home. A home of *A. florea* comprises of a solitary brush, whose upper part extends to frame a peak that encompasses the branch or other article from which the brush is suspended. Smaller person bumble bees home in the open, however not without disguise: most homes are swung from slim branches of trees or bushes secured with moderately thick foliage, for the most part from 1 to 8 m over the ground. The honeybee is for the most part found in fields or swamps in tropics and subtropics. It is once in a while found in heights above 1500 m. The homes are inherent shrubs, thickly leaved little trees in greenhouses and plantations, holes of structures or shielded boxes or divider specialties in urban ranges, and on firmly put stalks of harvest plants like *Sorghum*. The midget honeybee can make due in extremely hot and dry atmospheres with surrounding temperatures achieving 50 °C or more. The brush design is like that in different *Apis* species, aside from the nectar stockpiling parcel that is particular in *A. florea* brush. Additionally, in nectar generation, *A. florea* which is an essential pollinator of yields in dry and semi-dry areas can likewise be used for pollination.

22.3.2 Giant or Rock Bee

The giant honeybees (*Apis dorsata*) are predominantly found in or near forests, although at times nests may be observed in towns near forest areas. The bee shares the open-air, single-comb nesting habits of *Apis florea*, suspending its nest from the undersurface of its support, such as a tree limb or cliff. In general, *A. dorsata* tends to nest high in the air, usually from 3 to 25 m above ground. In tropical forests in Thailand, many nests are suspended in *Dipterocarpus* trees from 12 to 25 m high: this tree is probably preferred as a relatively safe nesting site because its smooth bark and its trunk rising for 4–5 m before branching out make it difficult of access to terrestrial predators. Nonetheless, about three-quarters of the worker population of a colony of giant honeybees is engaged in colony defense. While birds are common predators of *A. dorsata*, the workers' large body size protects them reasonably well against ant invasion, so that the sticky bands of propolis characterizing the nests of the dwarf honeybee are not found surrounding the nests of *A. dorsata*, nor are the nests hidden by dense foliage. Nests of *A. dorsata* may exist singly or in groups; it is not uncommon to find 10–20 nests in a single tall tree, known locally as a "bee tree." In Southeast Asian countries like Thailand and Vietnam, tree harboring more than 100 nests is occasionally seen in or near the tropical forests.

Rock honeybees scavenge notwithstanding amid moonlit evenings (Diwan and Salvi 1965). Its flight reach is more than 5 km (Koeniger and Vorwohl 1979). In the ordinary rummage conditions, they have been seen to visit sources 2–3 km far from the home. The honeybees have a normal tongue length of 6.683 mm (Ruttner 1988). These elements give a vast rummaging range, both in territory and assortment of plant species to the stone honeybees. A yearly generation of around 2500 tonnes of honeybees' wax from the wild shake honeybees was accounted for in 1969 (Phadke et al. 1969). Rock honeybee is a critical pollinator of a few products.

22.3.3 Eastern Honeybee

Apis cerana or the Asian bumble bee (or the eastern bumble bee) are little bumble bees of Southern and Southeastern Asia. In the wild, the oriental bumble bees build their different brush homes in dim-walled areas, for example, caverns, rock pits, and empty tree trunks. The typical settling site is, as a rule, near the ground, not more than 4–5 m high. The honeybees' propensity for settling oblivious empowers man to keep them in uniquely built vessels, and for a great many years, *A. cerana* has been kept in various types of hives, i.e., dirt pots, logs, boxes, divider openings, and so

Table 22.1 Comparative morphometric, behavioral, and economic characteristics of *A. mellifera* and *A. cerana*

Characteristics	*A. mellifera*	*A. cerana*
Body weight (mg)	90–120	50–70
Tongue length (mm)	5.7–7.2	4.39–5.53
Nectar load (mg)	40–80	30–40
Pollen load (mg)	12–29	7–14
Flight range (km)	2–5	0.8–2
Egg laying capacity of queen per day	800–1800	300–800
Colony buildup at honey flow	40,000–60,000	25,000–30,000
Swarming	Little	High tendency
Absconding	Very little	Very high tendency
Aggressiveness	Usually calm	Mostly furious
Yield under Indian conditions (kg/colony)	25–30	4–5

Source: Chahal et al. (1995)

on. In spite of the moderately late presentation of mobile edge hives, provinces of *A. cerana* kept in conventional hives are still a typical sight in the towns of most Asian nations. Subsequently, the wild homes of the oriental bumble bee in tropical Asia support less setbacks in being chased by man than those of the smaller person and goliath bumble bees. The honeybee dwelling in an extensive variety of topographical territories from tropical beachfront to the mild Himalayan regions reaches at around 3000 m. Provinces are found in backwoods or agrarian regions in the fields and even in urban regions with great vegetation. The nest consists of several parallel combs with a uniform distance between them. The nests have usually six to eight combs. A wide variation occurs in number depending upon the period of stay of the nest in the location, space available in the nest site, and its shape. Sometimes only three to four combs that are narrow but about a meter long are found. In natural nests that lived for over 2 years, up to 15 normal-sized combs were found that yielded over 10 kg honey (Table 22.1).

The Indian hive bee does not use propolis as the European bees do. This may be an adaptation to tropical climate, where hive ventilation assumes importance. The cracks in the floorboard or gaps in the hive walls or frame joints are not sealed. This may attract pests like wax moth. One of the characteristic features of the hive bee is fanning used for ventilation of the hive. During nectar flow, large quantities of water have to be removed from the dilute honey in combs, before it ripens. In their experiments on introducing queens of the European bee into the colonies of the Indian bee, Dhaliwal and Atwal (1970) observed the workers of both the species fanning side by side, but heads oriented in opposite directions.

A. cerana has some of the special qualities such as:

(a) It is gentle to handle, industrious, and well adapted to the ecological conditions of South and Southeast Asia.
(b) It is less susceptible than *A. mellifera* to nosema disease, is not seriously affected by *Varroa*, and is less prone to the attack of predatory wasps.
(c) It can effectively defend against diseases, parasites, and predators and does not require chemical treatments as compared to *A. mellifera*.
(d) Its variety of geographical races/populations that exists in South and Southeast Asia provides excellent opportunities for the genetic improvement of this native species through selective breeding.
(e) Through genetic engineering techniques, it may be possible to introduce desirable genes from *A. cerana* into *A. mellifera*.
(f) It is sympatric in distribution and coexists with the two other species of Asiatic honeybees, *A. dorsata* and *A. florea*, without any adverse ecological consequences.
(g) For pollination purposes, it is superior to *A. mellifera* as it is more suitable for cross-pollinating entomophilous crops grown in the small holdings because of shorter flight range and longer foraging hours.

Use of bee hives for pollination of agricultural and horticultural crops is another field gaining importance in recent years. There is an increasing demand for bee colonies by orchardists growing apples, litchi, and citrus fruits; by producers of cucumber and other cucurbits, seeds, cole crops, spices, onion and vegetable crops, and flower seeds; and also by farmers growing sunflower. Payment by the farmer to the beekeeper for pollination service is also becoming a common practice. Bee colonies migrated to farm and orchard areas, to tide over adverse periods, can be utilized for crop pollination. Such migrations can be doubly beneficial to the beekeeper.

22.3.4 The European Honeybee

The Western honeybee or European honeybee (*Apis mellifera*, Linnaeus, 1758) is a species of honeybee comprised of several subspecies or races. European bees were successfully introduced in India in 1965. The European bee is similar to the Indian hive bee in biology, nesting, foraging, colony defense, and other behavior features, with minor differences. According to Chahal et al. (1995), the European bee possesses definite superiority over the indigenous bee in Punjab. It can colonize areas where the indigenous bee is not present or cannot do well. It can yield four to five times as much honey as the Indian bee (Table 22.1). However, the performance of *A. mellifera* may not be the same in other agroclimatic conditions. For example, *A. mellifera* doing well in Punjab may not survive the new climatic and vegetation conditions in other regions (Table 22.1).

22.3.5 Stingless Bees

Normally known as dammar honeybees (*Trigona* spp.), these are very little in size and look like little mosquitoes or flies. They are circulated in tropics, subtropics, and mild locales. The honeybees construct homes in dull fenced in areas like pits in branches or trunks of trees, ant colonies, termite burrows in the ground, divider fissure, or any deserted repository like logs, pots, and tins. The homes of *Trigona* are bunches of little, uniform, globular cells of wax. These pots are the cells in which the young are raised. The pots are firmly stacked touching each other or isolated; every cell or group of cells being associated with others by braces or mainstays of wax. Dust and nectar are put away in prominently huge oval cells built near the brood cell groups or at their outskirts well separated from them. The brood cells of *Trigona* [*Tetragona* (now called *Tetragonula*) *iridipennis* Smith] from Castle Rock, Karnataka (Kshirsagar and Chauhan 1977), were overall 3.12 mm expansive and 4.09 mm high. The nectar pots were around 6.64 mm wide and about the same in stature. The dust cells were like nectar cells in expansiveness yet were 6.78 mm in stature. In the wake of selecting a reasonable settling site, another swarm shuts all splits, openings, and hole in the home with paste like sticky propolis. The home is connected with the outside air just through a little opening. The opening is regularly made into a passage utilizing wax and propolis. The passage opening is closed by propolis each night after all the outside work is finished for the day. It is opened each morning empowering the foragers to continue their field obligations. Taking care of the dammar honeybees is moderately simple. Not at all like the genuine bumble bees, these honeybees don't sting as the resistance component, yet built up a similarly viable gnawing conduct, in shielding their home. At the point of exasperation, the honeybees assault the adversary in huge numbers, more often than not selecting delicate organs like eyes, the nose, and ears as their objective. Gnawing with the mandibles is very bothering for a few of the targets of dammar honeybees yet can be effortlessly ensured against by man.

Honey of the dammar bee is dark amber in color and shows a highly positive polarization. In the five samples of dammar bee, honeys from Castle Rock, Karnataka, and Indore, Madhya Pradesh (Phadke (1968)), were found containing levulose about 32 % and dextrose only 20 %. However, dextrins were nearly 6 %. The proportion of ash was also quite high, indicating a high mineral content. Neto (1949) emphasizing the need for taxonomic work on the dammar bees reports the remarks of H. S. Schwarz, a world specialist, thus "the number …. (of the species of the dammar bees) … when the size of India is taken into consideration is notably small." In Malaysia 29 species of Meliponinae (stingless bees) were recorded. India which has a larger geographic area and variety of vegetations and climates should have a larger number of species. Rasmussen (2013) in a recent study on the diversity and taxonomy of stingless bees of Indian subcontinent reported nine species of stingless bees which include *Lepidotrigona arcifera* (Cockerell), *Lisotrigona cacciae* (Nurse), *Lisotrigona mohandasi* Jobiraj and Narendran, *Tetragonula* aff. *laeviceps* (Smith), *Tetragonula bengalensis* (Cameron), *Tetragonula gressitti* (Sakagami), *Tetragonula iridipennis* (Smith), *Tetragonula praeterita* (Walker), and *Tetragonula* *ruficornis* (Smith). Vijayakumar and Jeyaraaj (2014) also reported *Tetragonula iridipennis* belonging to *Tetragonula* subgenus in Nellithurai Village, Tamil Nadu, India.

Pugh (1947) from Assam gave a short account of the species of stingless bees. He distinguished these as types of *Melipona*. These are most likely *Trigona*, since no *Melipona* is known to exist in India. A fascinating element of all the three species is their similitude in size and appearance to the diminutive person honeybee. Ngap siwor, recognized by Pugh as *Melipona tunneli*, is unique in relation to the next two in having yellowish spots on the stomach area. *Melipona khasiana*, privately known as ngap hamang, is somewhat littler than *M. tunneli* and does not frame the long passage at the home passageway. Yield from these honeybees from a couple of accumulations is around one kilogram. Both these species are kept in earthen pots set in the open cells of houses in towns. Ngap khyndew, *M. terrestris*, is the third species that lives in underground depressions made by termites. Nectar is likewise gathered a few times from their homes and somewhat over a kilogram of nectar is got in a year. Dammar honeybees are tough and work in harsh climate conditions. Disregarding their short scrounging range, they can misuse a few little blossomed plants like weeds and create nectar. They can be kept in any container that gives satisfactory space to home building. They withstand unpleasant circumstance, taking care of and repairing rapidly the home that is harmed. They recoup quickly after unfavorable conditions that drain the state quality. They require little care by the beekeeper. The settlements can be separated by basic division of the brood group. The part of the bunch without the ruler raises promptly another ruler and an undeniable new province gets set up. These components make dammar honeybees perfect for keeping for nectar generation, or for fertilization of agrarian and agricultural crops that have little blossoms, and can't be helpful to other bigger honeybees. Dammar honeybee nectar is much sought after for its high therapeutic worth.

Stingless honeybees assume an incredible part in the economy of the nation. Notwithstanding when a few types of *Apis* are utilized for nectar generation, the stingless honeybees can be kept by ranchers for nectar creation and for enhanced yields of their harvests. The honeybees require little consideration. They are safe, not at all like the bumble bees, whose sting is entirely excruciating. The hive for stingless honeybees is very straightforward and does not request any incredible craftsmanship. Consequently at any rate, raising of stingless honeybees should be supported.

22.4 Beekeeping Industry

Honey industry involves honeybee, flowering plants that provide food to the bees, and beekeepers who manipulate bees according to the climate and vegetation for their own benefit. With the evolution and advancement of human societies, the association between man and honeybees gradually changed from one of hunting and killing to that of an organized industry, in which honeybees were nurtured and made to produce honey and other valuable, nutritive, medicinal, and industrial materials (Crane 1990).

Nectar is the sweet fluid delivered by bumble bees from nectars and other sweet substances on plants by expanding their digestive proteins and by aging the resultant blend. Nectar is along these lines a result of collaboration of bumble bees, the exceedingly propelled creepy crawly gatherers, and plants. Honeybees get nectar, the sugar sustenance from blossoms, and utilize it for their vitality necessity. Honeybees additionally gather dust grains, the male conceptive units of blossoming plants that comprise of life-supporting proteins and amino acids. Dust gives the honeybees all prerequisites of proteins for egg creation, larval development, and general quality of the apiary. Honeybees rely on plants for their presence and development. Nectar industry includes bumble bees, blooming plants, and man.

Wild bee states have been abused for gathering of nectar in India and in a couple of other Southeast Asian nations. The normal bumble bee settlers that have been struck are those of the monster bumble bee, *A. dorsata*, and the oriental hive honeybee, *A. cerana*. Tribal populaces and woodland tenants in a few sections of India have been nectar gathering from wild honey bee homes as their conventional calling. The wild honey bee has been the regular and real wellspring of nectar. Maybe as a result of this, most references in antiquated Indian writing, likewise in Ayurveda, identify this honeybee. The strategies for gathering of nectar and beeswax from these homes have changed just marginally throughout the centuries. Planned insurance of honeybee homes in stamped tree depressions and occasional collecting of nectar was the initial phase in beekeeping. The following stride may have been effective to draw in honeybees into logs that had been emptied out, so that a cavity was shaped to oblige the apiary, and to keep such log hives in secured honeybee gardens.

Swarms of bees were attracted to receptacles made of clay, logs of wood, or niches in the outer walls of dwellings. At the end of the flowering seasons, honey was harvested by driving away the bees with smoke and squeezing out honey from the combs. No effort was made to prevent bees from leaving the hive in the process. In some remote inaccessible forest areas, beekeeping may have changed but little from that practiced centuries ago.

Among the hive items are nectar, beeswax, honeybee-gathered dust, illustrious jam, honeybee venom, and propolis. Today a few nations in Asia, Africa, the USA, and Australia have very much created apicultural industry with an extensive variety of honeybee items including dietary, helpful, and restorative arrangements from honeybee-gathered dust, regal jam, propolis, and honeybee venom, other than nectar and beeswax.

Apiaries neither interest extra land space nor do they contend with farming or creature cultivation for any information. The beekeeper needs just to save a couple of hours in a week to take care of his honeybee provinces. Beekeeping is along these lines preferably suited to him as low-maintenance occupation. Beekeeping constitutes an asset of manageable pay era to the country and tribal agriculturists. It gives them important nourishment as nectar, protein-rich dust, and brood. Honeybee items additionally constitute critical elements of society and conventional drug. Apiculture has been connected with farming and agriculture and truth be told contributes, not inconsequential, to the environmental equalization of the area including the neighborhood developed and regular verdure.

More recently, beekeeping industry in India has got major blow due to spread of *Varroa destructor* which has annihilated more than 80 % of the bee stocks of *Apis mellifera* (Abrol 2009a). Honey industry in India is at present in utter chaos. Production of honey has already been dwindling in the past few decades due to indiscriminate deforestation and consequent depletion of sources of food to the honeybees. Similar situation is now found in other Asian and African countries.

Honeybees suffer from various viruses, bacteria, protozoa, parasitic mites, wax moths, predatory Arachnida, wasps, birds, and mammals. In most instances, the appearance of disease is abrupt and instantaneous which plays havoc with honeybee colonies in apiaries.

All the diseases and enemies of honeybees present in other countries have been recorded from India also (Table 22.2) (Singh 1962, 1979; Chhuneja et al. 2002; Abrol 1997, 2007, 2009b; Abrol and Kakroo 2003; Abrol and Sharma 2007, 2009). The two viral diseases *Apis iridescent virus* and *Thai sacbrood virus* have played havoc with Indian honeybee *Apis cerana* during the last decade.

Table 22.2 Brood and adult diseases of honeybees, their causative agents, and occurrence in India

Disease	Causative agent	Bee species affected	Symptoms/color of the brood	Locations
Brood diseases				
American foulbrood (AFB)	Bacteria, *Bacillus* larvae	*Apis cerana indica*	Dull-white dead brood becoming brown to white	Nainital (Uttar Pradesh)
European foulbrood (EFB)	Bacteria, *Melissococcus plutonius*	*A. cerana indica*	Dull-white dead brood turning yellow to dark brown	Mahabaleshwar Maharashtra Karnataka (around Castel rock near Goa border) Jammu, Punjab, Himachal
Sacbrood disease (SBV)	Virus, *Morator aetatulus*	*A. mellifera*	Grayish or straw colored becoming brown, grayish black, or black or blackhead or blackhead end darker	Not recorded from India so far
Thai sacbrood virus (TSBV) disease	Virus, *Morator aetatulus* (Thai strain)	*A. cerana indica*	Grayish or straw colored becoming brown, grayish black, or black or blackhead end darker	Whole India except Andhra Pradesh and Orissa

(continued)

Table 22.2 (continued)

Disease	Causative agent	Bee species affected	Symptoms/color of the brood	Locations
Chalkbrood disease (CB)	Fungus, *Ascosphaera apis*	*A. cerana indica*	White chalklike mass sometimes referred to as mummy	Not recorded from India so far
Store brood (SB)	Fungus, *Aspergillus flavus*	*A. cerana indica*	The fungus forms a characteristic whitish-yellow color like ring near the head end of the infected larvae after death. Infected larvae become hardened and difficult to crush, hence called "stone brood"	Not recorded from India so far
		A. mellifera		
Adult diseases				
Nosema disease	Protozoan, *Nosema apis*	*A. cerana*	Shining swollen abdomen	Uttar Pradesh, Himachal Pradesh, Jammu and Kashmir Punjab, Assam Orissa, Nagaland
	Nosema ceranae	*A. mellifera*	Shining swollen abdomen	Not recorded from India so far
Amoeba disease	Protozoan, *Malpighamoeba mellificae*	*A. mellifera*	Cysts in Malpighian tubules	Not recorded from India so far
Bee paralysis	Filterable virus	*A. mellifera*	Black hairless shiny bees	Not recorded from India so far
Septicemia	Bacterium *Pseudomonas apiseptica*	*A. mellifera*	Destruction of connective tissue of legs, wings, and the antennae	Not recorded from India so far
Clustering disease	Iridescent bee virus	*A. cerana indica*	Bees leave combs and form clusters on the wall of hive or outside the hive become sluggish; queen stops egg laying and drawlers appear around the colony	Jammu and Kashmir, Himachal Pradesh, Punjab Maharashtra

Abrol (2009a, b)

22.5 Brood Diseases

A number of mite species have also been reported associated with honeybees in India which include parasitic mites, phoretic mites, and stored provision mites (Abrol and Kakroo 1997, Table 22.3). Of all these mites, *Varroa destructor* is most serious which has wiped out more than 90 % of the stocks wherever it was detected. The other predators and enemies which attack honeybees are listed in Table 22.4. Of the various pests and predators, wax moths and wasps cause considerable damage in the Orient and Africa.

Studies clearly establish that beekeeping industry is at great risk due to the attack of several diseases and enemies which call for regular monitoring to manage these diseases well in time to save the beekeeping industry for food security. European foulbrood brings on microorganism *Melissococcus pluton* which has been changed to *Melissococcus plutonius*. Another strain of Nosema sickness *Nosema ceranae* (microsporidian protozoan) that causes an ailment of the eastern honey bee, *Apis cerana*, has been recognized connected with spring diminishing, "vanishing infection, fall breakdown, honey bee elimination disorder, or Province Collapse Disorder (CCD)" in *A. mellifera*. Obviously this pathogen has hopped host from *Apis cerana* to *Apis mellifera* in the past 10 years and is spreading quickly. *Nosema ceranae* has a pathology that is not quite the same as *Nosema apis*. The causative specialist for Nosema in the USA is *Nosema apis*, which seldom causes real misfortunes in contaminated provinces. Nonetheless, high death rate exhibits that *N. ceranae* is exceptionally pathogenic to *Apis mellifera*. Honeybees succumb inside eight days after introduction to *N. ceranae* which is quicker than honeybees presented to *N. apis*. Some new infections and microorganisms have been found. Evidently, regular

Table 22.3 Occurrence of various species of mites associated with honeybees in India

Mite species	Bee host	Occurrence in India
Acarapis woodi (endoparasitic mite)	*A. cerana*	Present
Varroa jacobsoni (ectoparasitic mite)	*A. cerana*	Present
Varroa destructor (ectoparasitic mite)	*A. mellifera*	Present
Euvarroa sinhai (ectoparasitic mite)	*A. florea*	Present
Tropilaelaps clareae (ectoparasitic mite)	*A. cerana*	Present
	A. mellifera	
	A. dorsata	
Tropilaelaps clareae (ectoparasitic mite)	*A. cerana*	Present
	A. mellifera	
	A. dorsata	
Tyrophagus longior (provision mite)	*Apis cerana*	Present
	A.mellifera	
Neocypholaelaps indica (phoretic mite)	*A.cerana*	Present
	A.mellifera	
	A.dorsata	

Abrol (2009a, b)

Table 22.4 Occurrence of various pests, predators and enemies of honeybees in India

Category enemy/animal	Disease/enemy	Causative agent	Bee species affected
Moths	*Achroia grisella*	Lesser wax moth	*A.cerana*
	Galleria mellonella	Greater wax moth	*A.florea*
			A.cerana
			A.florea, *A. mellifera*
			A.dorsata
	Acherontia styx	Hawk moth	*A.cerana*
			A.mellifera
Pseudoscorpion	*Ellingsenius indicus*	False scorpion	*A.cerana*
			A. mellifera
Wasps	*Vespa orientalis*, *V. cincta*, *V. velutina*, *V. magnifica*, *V. mandarinia*, *V. tropica*, *V. ducalis*, *V. analis*, *V. asiatica*, *V. austriaca Vespa auraria*, *V. basalis*, *V. nursei*, *V. flaviceps*, *V. structur*, *Vespula vulgaris*, *V. germanica*	All are predatory wasps	All the honeybee species
Birds	*Merops orientalis*	Predatory bird	All the honeybee species
	Merops apiaster	Predatory bird	All the honeybee species
	M. superciliosus	Predatory bird	All the honeybee species

Abrol (2009a, b)

surveillance of honeybee diseases is needed to save the beekeeping industry so that diagnosis of diseases is initiated well in time before any catastrophe occurs because care and management of diseases is easier in early stages of infection or attack (Abrol 2001).

22.5.1 World Honey Production Scenario

China is the biggest maker (40 %) and exporter (35 %) of nectar on the planet followed by Mexico, Argentina, Ukraine and Mexico supplying 20 for each penny though and Argentina supplying 15–20 for every penny. Germany is the world's biggest purchaser, importing 90,000 tonnes of nectar items every year with per capita utilization 1.5 kg/individual when contrasted with India 3–5 g (Table 22.5).

In India honey production is about 70,000 tonnes/year and exports 25,000–27,000 tonnes/year to >42 countries, e.g., the European Union, the Middle East, and

Table 22.5 Comparative honey consumption pattern in different countries of the world

Sl. No.	Country	Honey consumption per person per year
1	India	3–5 g
2	Greece	1.8 kg
3	Australia	1.6 kg
4	Germany	1.5–2.0 kg
5	EU countries like Italy, Spain, France, and Hungary	0.6–0.9 kg
6	UK	0.4 kg
7	China	100 g per year
8	Russia	500 g per year
9	Serbia, Ukraine	600 g per year
10	USA	800–1000 g per year
11	Japan	300 g per year
12	Poland	400 g per year
13	Switzerland	2.0 kg
14	Nepal	3 g per year
15	Turkey	850 g
16	Croatia	400 g
17	Netherlands	300–400 g
18	Indonesia	300 g
19	Bulgaria	400–500 g
20	Australia	1.6 kg

the USA. The data in Table 22.6 and Fig. 22.2 show that China is the largest exporter of honey in the world accounting for 11.8 % of the world share as compared to India which accounts for 3.7 % only. Argentina is the largest importer of honey with 18.5 % share of world honey imports (Table 22.7). The honey industry in India is still far behind to achieve its goal as India has also to import 15.8 % of the honey from other countries.

In India major honey-producing states include Punjab, Haryana, Uttar Pradesh, Bihar, and West Bengal. The foreign exchange earned amounts to Rs 200 crore (2002–2003).

Furthermore in India, the sale price of honey is very less from Rs 25 to Rs 45 per kg compared to Rs 55 to Rs 80 a kg in the USA, Argentina, and Brazil. Organized collection of rock bee and other forest honey and beeswax using improved methods can result in an additional production of at least 50,000 tonnes of honey and 5000 tonnes of beeswax. This can generate income to about half a million tribal families.

22.6 Declining Bee Populations

The population of honeybees and, what's more, different species of pollinators that fertilize plants is declining at a disturbing rate which has debilitated the presence of vegetation, and this descending pattern could harm many financially critical

Table 22.6 Top exporters of honey in the world

Top exporters	2009 value	Share (%)
China	$284,064,882	11.80
Germany	$212,519,898	8.90
Mexico	$164,486,793	6.90
Brazil	$134,944,059	5.60
New Zealand	$117,387,647	4.90
Spain	$116,734,881	4.90
Hungary	$114,880,765	4.80
India	$87,560,291	3.70
Canada	$81,491,036	3.40
Vietnam	$74,327,554	3.10
All others	–	42 %

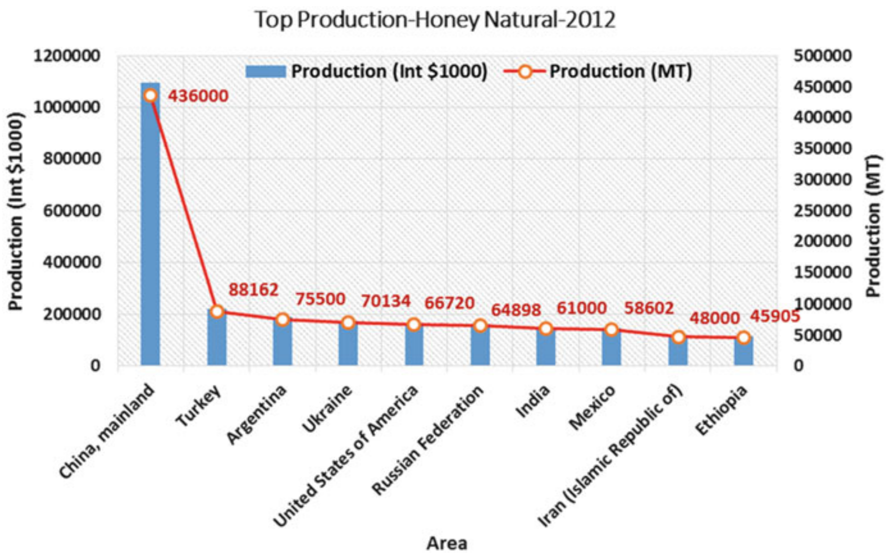

Fig. 22.2 Top production of honey during 2012 (Source: http://www.beekeeping.com)

products. A decrease in pollinator populaces is one type of worldwide change that really can possibly modify the shape and structure of physical and biological communities. The decrease in pollinator populace and differences presents genuine risk to farming generation and protection and upkeep of biodiversity of florea in numerous parts of the world. One pointer of the decrease in common arthropod pollinators is diminishing product yields and quality regardless of essential agronomic inputs. Insect pollination is essential for production of good-quality marketable fruits. Though a number of species of bees are managed for pollination (Strickler and Cane 2003), the honeybees (*Apis mellifera* L.) are the most important

Table 22.7 Major importers of honey in the world

Imports from country	2010 value	Share (%)
Argentina	$54,227,583	18.50
Vietnam	$46,946,545	16.00
India	$46,356,898	15.80
Canada	$39,729,080	13.60
Brazil	$28,958,207	9.90
Malaysia	$24,915,368	8.50
Indonesia	$13,653,764	4.70
Mexico	$10,012,673	3.40
New Zealand	$4,185,579	1.40
Thailand	$3,866,587	1.30
All others	–	6.90

pollinators (Free 1993; Klein et al. 2007). However, managed honeybee colony numbers are declining in some regions; the Food and Agriculture Organization (FAO) of the United Nations reported a decrease of >40 % in the past 10 years in Western Europe (FAO Prod STAT 1997–2007; http://faostat.fao.org/). In 2006, colony collapse disorder spread rapidly across the USA and Canada, sometimes killing 50–90 % of hives of commercial beekeepers (Oldroyd 2007).

The honeybee (*Apis mellifera*) is the principal species used for crop pollination worldwide (Free 1993); the pollination services honeybees provided to US crops were worth $14.6 billion in 2000 (Morse and Calderone 2000). Although honeybees pollinate a wide variety of crops, they are often relatively ineffective pollinators on a per-visit basis (Westerkamp 1991; Parker 1981; Kevan 2001; Batra 1995). Farmers obtain adequate pollination services by bringing large numbers of honeybees to crop fields. However, supplies of honeybees have declined, in part because of problems caused by parasitic mites (Thompson et al. 2003; Underwood and van Engelsdorp 2007) and pesticide misuse. Since the 1970s the number of managed honeybee colonies in the USA decreased from >4 million to 2.41 million; declines were also reported in Europe (Kevan 2001; Williams 2002). Several documented examples show that reductions in bee abundance can cause reduced crop yields (Kevan 1977; Ricketts et al. 2004).

22.6.1 Pollinator Decline

In India, 50 million hectares is under entomophilous crops, cross-pollinated by different abiotic and biotic agents. Considering the fact that there are indications of differing pollinator decline impacts between developing and developed world, the same requires closer scrutiny for developing countries like India, Bangladesh, Sri Lanka, the Philippines, Vietnam, and others which have undergone over four decades of pesticide-dependent agriculture and are undergoing changes in land use due to urbanization and industrialization. Evidently, the deliberate misuse of pesticides has posed a major threat to pollinators and pesticide-induced declines in bee abundance in many countries of the world (Johansen 1977). The decline in pollinator population and diversity presents a serious threat to agricultural production and conservation and maintenance of biodiversity in several parts of the world (Buchmann and Nabhan 1996; Johansen and Mayer 1990). One indicator of the decline in natural insect pollinators is decreasing crop yields and quality despite necessary agronomic inputs. Examples can be found in Himachal Pradesh in northwest India, where despite all agronomic inputs, production and quality of fruit crops such as apples, almonds, cherries, and pears is declining. Another example is the declining rice yields in the Philippines, Vietnam, Indonesia, and other Southeast Asian countries. Extreme negative impact of declining pollinator populations can be seen in other areas, for example, several farmers in Jammu and Kashmir were disappointed with lower yields and quality of apples as a result of poor pollination of apple trees (Partap 2003).

In spite of its monetary value, biodiversity, the Asian hive honeybee, *A. cerana* is enduring sharp decrease and is undermined with elimination in its whole local environment. For instance, in Japan, beekeeping with this local honeybee species has been totally supplanted by European bumble bee, *A. mellifera*, and just a couple of beekeepers and exploration establishments are raising *A. cerana* (Sakai 1992). In China, out of more than 8.5 million settlements of honeybees kept in current hives, 70 % are intriguing to *A. mellifera* (Zhen-Ming et al. 1992). Additionally, in South Korea, just 16 % beekeeping is with local *A. cerana*, and the remaining has been supplanted by extraordinary *A. mellifera* (Choi 1984). This pollinator emergency appears to be more intense in scenes ruled by yearly products (e.g., grains and oil seeds) as these seriously oversaw and most exceptionally bothered monocultures don't give natural chances to useful arthropods. Large amounts of unsettling hamper the foundation of pollinator populaces, and this could diminish harvests, for example, of canola, flax, safflower, sunflower, tomatoes, peppers, strawberries, and cucurbits. Some cole crops require bug fertilization for seed generation. Steps required to defeat the issue of pollinator decay are:

(a) Teach the general population on the significance of pollinators.
(b) Bring issues to light of the fertilization emergency.
(c) Prepare the up-and-coming era of specialists and taxonomists.
(d) Bolster national arrangements for the preservation of honeybees and expansion of the consciousness of governments, industry, and people in general.
(e) Embrace research on option pollinator.
(f) Agriculturists have uncovered that more than 90 % of the ranchers had no information of fertilization.
(g) There is a requirement for national approach on pollinators. Fertilization has not just been underplayed by the organizers, government powers, and the agriculturists who have overlooked through and through.
(h) There is requirement for zonation for European and Indian hive honeybees.
(i) There is a requirement for protection of pollinators (Allsopp et al. 2008) by giving settling destinations, great rummage, and toxic substance-free environment.

Similarly, managing flowering weeds at desirable levels to provide alternative forage to pollinators within crop fields has been a totally neglected habitat management tactic for encouraging pollinators. Many advances, however, have been achieved in biological control where entomologists and agroecologists continually manipulate weeds and other floral diversity to enhance predators and parasitoids of pests (Altieri and Nicholls 2004). The same principles that apply in conservation biological control can be applied to enhance pollinator services, thus simultaneously achieving plant protection and pollination.

22.6.2 Pesticides

Pesticides are also responsible for pollinator population decline. Neonicotinoids are highly likely to be responsible for triggering "colony collapse disorder" in honeybee hives that were healthy prior to the arrival of winter. The loss of honeybees in many countries in the last decade has caused widespread concern because about three-quarters of the world's food crops require pollination. In December 2013, the EU banned the use of three neonicotinoids for 2 years. Many believe that the increasing use of chemical pesticides and herbicides, which honeybees ingest during their daily pollination rounds, is largely to blame. Commercial beehives are also subjected to direct chemical fumigation at regular intervals to ward off destructive mites. Another leading suspect is genetically modified crops, which may generate pollen with compromised nutritional value.

It may be that the buildup of both synthetic chemicals and genetically modified crop pollen has reached a "tipping point," stressing bee populations to the point of collapse.

22.6.3 Radiation

Bee populations seem to be vulnerable to many other factors, such as the recent increase in atmospheric electromagnetic radiation as a result of increased use of cell phones and wireless communication towers. The nonionizing radiation given off by such devices may interfere with bees' ability to navigate. A small study at Germany's Landau University found that bees would not return to their hives when mobile phones were placed nearby. Further research is currently underway in the USA to determine the extent of such radiation-related phenomena on bees and other insect populations.

22.6.4 Global Warming

Biologists also wonder if global warming may be exaggerating the growth rates of pathogens such as the mites, viruses, and fungi that are known to take their toll on bee colonies. The unusual hot-and-cold winter weather fluctuations in recent years, also blamed on global warming, may also be wreaking havoc on bee populations accustomed to more consistent seasonal weather patterns.

22.7 Future Action Plan

22.7.1 At Industry Level

22.7.1.1 Extension

1. Manufacturing, stocking, and distributing of bee boxes, honey extractors, and other beekeeping equipment
2. Qualitative improvement in worked out areas
3. Survey of new potential areas
4. Establishment of demonstration cum training centers
5. Establishment of bee nursery units
6. Registration of beekeepers

22.7.1.2 Research

1. Standardization of beekeeping equipment.
2. Standardization of bee management methods for different zones of India.
3. Protection of bees from harmful chemicals like insecticides, miticides and fungicides.
4. Maintenance and conservation of all the species of honeybees and assessing their utility as pollinators.
5. Improving the strains of honeybees by selection from local stocks, imbibing in them disease resistance and high honey-yielding qualities.
6. Assessment of crops and other flowering plants for their degree of utility to honeybees.
7. Preparation list of multiple tree species region wise having staggered flowering and useful to honeybees during their flowering.
8. Coordinating with agroforestry, farm forestry, and social forestry department for introduction of multipurpose plant species useful to honeybees.
9. Quarantine organizations may be developed.
10. Standardization and preservation of other bee products may be taken up.

22.7.1.3 Training and Education

1. Syllabi of schools and colleges must include topics on apiculture as graded course.
2. Trainings must be organized for unemployed youths and hobbyists.

22.7.1.4 Marketing

1. Marketing of other bee products like beeswax, propolis, bee-collected pollen, etc., to be encouraged.
2. Quality control of bee products should be assured.
3. Export market for bee products be explored.
4. Marketing organization and marketing channels may be established to avoid excessive stocking of honey in any region.

22.7.1.5 At Pollinator End

1. Biodiversity, characterization and taxonomy, multiplication, conservation, and domiciliation of pollinators (Abrol 1993).
2. Protocol for multiplication of pollen vectors
3. Prepare bee maps in the country with respect to the distribution and availability of different bee species in different crops, i.e., scenario or status of bees in time and space.
4. A database on pollinators, their abundance, behavior, floral rewards, and pollinator-plant interaction needs to be generated.
5. The role of honeybees in crop pollination needs to be given due importance.
6. Non-*Apis* bees, pollinators such as stingless bees, carpenter bees, bumble bees, megachilids, and many other bees need to be promoted for crop pollination.
7. In addition to cross-pollination, the role of insects in self-pollinated crops needs to be worked out.
8. Role of insects in increasing crop yields qualitatively and quantitatively.
9. Use of pollinators for seed/hybrid seed production using CMS lines and its economics.
10. Isolation distances for pure-seed production assume greater significance while using pollinators for seed production to reduce contamination and increase the purity of the seed.
11. Use of pollinators for garden and greenhouse crops.
12. Bee lure, attractants, and repellents to be used to increase the attractiveness to the crop or repel the bees from insecticidal treated crop.
13. Safety of pollinators from pesticides, diseases, parasites, and predators and from adverse climatic conditions.
14. Fast and safe multiplication/domiciliation of pollinators both for greenhouse and open fields.
15. Need to extend technology through demonstration, farmers participatory trials, and human resource development (HRD) by organizing on different aspects of insect pollinators for scientists.
16. Need for development of infrastructural facilities.

22.7.1.6 Biotechnological Interventions

1. Biotechnology-related research with honeybees is being conducted at US Department of Agriculture (USDA), USA. The goal of this research is to develop the technology to locate, manipulate, and transfer genes in honeybees. The first gene to transfer will be the one which can be identified easily so that verification of a successful transfer is simplified. Once a reliable transfer method is developed, other genes that will result in an improved stock can be transformed.
2. One class of genes that is being evaluated as the most promising for honeybees is the genes coding for proteins known as cecropins. These genes are from insects and produce proteins that have very strong bactericidal and fungicidal effects, even at low concentrations. Thus, by transferring a single gene into

honeybees, resistance to American foulbrood (AFB), European foulbrood (EFB), and chalkbrood might all be obtained simultaneously. It is possible that honeybees contain cecropins, but in some cases, they are either induced or turned on late when the larva is already infected and fails to provide acceptable level of resistance. Therefore, by examining honeybee DNA to determine the sequence of cecropin proteins, it might be possible to modify the expression of this gene in honeybee larvae so that the cecropin protein is present to respond to the challenge of various diseases equally in *Apis mellifera* and *Apis cerana*.

3. Another area of biotechnology-related research emerging is that of resistance to mites. *A. cerana* is the natural host of *Varroa jacobsoni*, but in some ways, it is resistant to the effects of this mite to keep the levels very low. As an alternative to chemical control methods, it would be desirable to have the same résistance in *A. mellifera* as is present in *A. cerana*. Since these two species do not hybridize, the use of recombinant DNA methods is the only solution to transfer this resistance.
4. The genetic diversity of *A. mellifera* is well established. In *A. cerana*, only three species have been recognized from India. All these subspecies seem to have different geographical populations/subgroups or ecotypes (Verma 1992; Abrol and Khan 2002) which can be used for improvement through selective breeding.
5. Similarly, in *Apis cerana*, the transformation for the cecropin gene is an obvious choice. An important problem for *A. cerana* is a virus disease, Thai sacbrood. A disease caused by virus would not be affected by the cecropin protein. Identification of a gene in *A. mellifera* which conferred resistance to this sacbrood virus would provide a gene which would be important to *A. cerana* and would only be available through recombinant DNA technology.

22.7.1.7 Future Prospects

Honey industry in the country can well become a major foreign exchange earner if international standards are met. Beekeeping is an age-old tradition in India but it is considered a no-investment profit giving venture in most areas. Of late it has been recognized that it has the potential to develop as a prime agri-horticultural- and forest-based industry. Honey production is a lucrative business and it generates employment. The informal sector is providing up to 70 % of the honey and beeswax market in India. Indian honey has a good export market. With the use of modern collection, storage, beekeeping equipment, honey-processing plants, and bottling technologies, the potential export market can be tapped. One problem is the quality of honey production. From a buyer's point of view, quality honey is essential. But India is lacking on that front. There is a need to look specifically at how to promote quality production and develop an export market. For tapping its potential, there is a need to chalk out suitable export strategy. Some of the points which merit attention of the policy makers in this respect include:

Application of advanced technology for collection, and processing of honey, adhering strictly to the quality standards including health regulations, laid down by markets such as the EU, Japan, and the USA.

- Recognition of beekeeping as agro-industry
- Priority allocation and concessions to be made applicable for material needed for beekeeping, like wood for bee boxes, sugar for supplementing feeds to bees, and medicines for bees' diseases
- Campaigning abroad about the quality of our honey
- Developing an efficient export marketing network to optimize the production and exports
- Creating an Indian logo as a joint effort of exporters, APEDA, and the Ministry of Commerce and Industry, government of India. The brand equity thus created can be better marketed for higher sales realization. Timely implementation of the above steps is likely to pave the way for a quantum jump in the export of honey from the country in the coming years.

22.7.1.8 Need for Certification

- Certification is an indicator that the honey-manufacturing company is competent and this has been established through a third-party analysis, done professionally, using the most recent and up-to-date technologies, procedures, and equipments.
- India is becoming an increasingly important supplier of high-quality, mild honey with versatility for the North American market. India has been identified as a potential point of transhipment for Chinese honey en route to the USA.
- Certification will help identify and certify honey that has met the expectations of government, industry, and consumers: Fully traceable, high-quality honey of pure Indian origin.
- Certification would help to preserve the image of Indian honey and that of legitimate Indian exporters and validate the livelihood of approximately 250,000 beekeepers.

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