ECONOMIC IMPORTANCE OF INSECTS

The estimated annual value of the ecological services provided by insects in the United States alone is at least $57 billion, an amount that justifies greater investment in the conservation of these services. Without the activities of insects, human life on earth would eventually be extinguished. Over one lakh currently living species of insects have been identified, but the true number is surely much larger, about a million.

BENEFICIAL INSECTS

Pollinators of crops (Bees, wasps, butterflies, moths, hoverflies, beetles)

Many plants depend on insects to transfer pollen as they forage. Plants attract insects in various ways, by offering pollen or nectar meals and by guiding them to the flower using scent and visual cues. This has resulted in strong relationships between plants and insects. Value of crop production from pollination by native insects is estimated to be about $3 billion in US alone. When we talk about pollinators the ones that come to mind are honey bees and butterflies, but there are also many other insects that perform this job for flowering plants, as well. There are flies, wasps, beetles and even some other insects that most people know nothing about, such as Hemiptera and thrips.There are many important pollinating insect species in the orders: Hymenoptera (bees, wasps, and ants), Lepidoptera (butterflies and moths), Diptera (flies) and Coleoptera (beetles).

As adults these insects feed on pollen and nectar from flowers. They forage from plant to plant and may initiate pollination by transferring pollen from an anther to a stigma. Female bees and pollen wasps provision their nests with pollen and nectar that they actively collect onto their bodies. Their larvae then feed on the collected pollen and nectar. Yucca moth larvae do not feed on pollen or nectar but on the seeds of yucca plants. The adults pollinate the yucca plant by actively collecting pollen onto their palps and then placing the collected pollen on a receptive stigma to ensure proper seed set for their offspring.

Economic value of insect pollination worldwide is estimated at U.S. $217 billion

(Science Daily, Sept. 15, 2008). German scientist found that the worldwide economic value of the pollination service provided by insect pollinators, bees mainly was dollar153 billion in 2005 for the main crops that feed the world. This figure amounted to 9.5% of the total value of the world agricultural food production. The study also determined that pollinator disappearance would translate into a consumer loss of food estimated between dollar 190 to 310 billion.

Predators of pests (Dragonflies, beetles, bugs, lacewings, wasps)

The arthropod predators of insects and mites include beetles, true bugs, lacewings, flies, midges, spiders, wasps, and predatory mites. Insect predators can be found throughout plants, including the parts below ground, as well as in nearby shrubs and trees. Some predators are specialized in their choice of prey, others are generalists. Some are extremely useful natural enemies of insect pests. Unfortunately, some prey on other beneficial insects as well as pests.

Major characteristics of arthropod predators:

- Adults and immature stages are often generalists rather than specialists.
- They generally are larger than their prey.
- They kill or consume many preys.
- Males, females, immature stages and adults may be predatory.
- They attack immature and adult prey.

Important insect predators include lady beetles, ground beetles, rove beetles, flower bugs and other predatory true bugs, lacewings and hover flies. Spiders and some families of mites are also predators of insects and mite pests. Natural enemies play an important role in limiting potential pest populations. We have seen what happens when pesticides devastate the natural enemies of potential pests. Surveys of agricultural systems give an indication of the potential number and diversity of predators in a crop. For example, over 600 species of predators in 45 families of insects and 23 families of spiders and mites have been recorded in cotton. Eighteen species of predatory insects (not including spiders and mites) have been found in potatoes in the northeastern United States.

Parasites of pests (Hymenoptera and Diptera)

Parasitoids are insects with an immature stage that develops on or in an insect host, and ultimately kills the host. Adults are typically free-living, and may be predators. They may also feed on other resources, such as honeydew, plant nectar or pollen. Because parasitoids must be adapted to the life cycle, physiology and defenses of their hosts, many are limited to one or a few closely related host species. Crop losses averted by beneficial insects from predators or parasites of agricultural pests are estimated to be $4.5 billion. The most valuable insect parasites belong to the following groups:

- Tachinid Flies (Diptera)
- Ichneumonid Wasps (Hymenoptera)
- Braconid Wasps (Hymenoptera)
- Chalcid Wasps (Hymenoptera)

These parasites live in or on one host insect pest which is killed after the parasite completes its development. Parasite (also called parasitoid) adults are free-living; the immature stage lives on or inside a host and kills the host before the host completes its development. Parasites lay one or more eggs on the outside of the host body or they insert the eggs inside their host. The immature parasite feeds on the host and requires only a single individual prey to complete its development. Free-living adults may feed on nectar from flowering plants or obtain nutrients by piercing the body of host insects and withdrawing fluids (host-feeding). Parasites are often considered more effective natural enemies than predators because many have a narrower host range, require only one host to complete development, have an excellent ability to locate and kill their host and can respond rapidly to increases in host populations.

Productive insects (Silkworm, Honey bees, Lac insects)

Sericulture is an agro-based industry. It involves rearing of silkworms for the production of raw silk, which is the yarn obtained out of cocoons spun by certain species of insects. The major activities of sericulture comprises of food-plant cultivation to feed the silkworms which spin silk cocoons and reeling the cocoons for unwinding the silk filament for value added benefits such as processing and weaving. Five varieties of silk worms are reared in India for producing this natural fibre. *Bombyx mori,* the silk worm, feeds on the leaves of mulbery to produce the best quality of fibre among the different varieties of silk produced in the country. *Antherea assama* is confined to only Brahmaputra Valley of India in the world. It produces the famous muga silk. Tasar silk is a product of *Antherea mylitta,* which feeds on *Terminalia tomentosa* grown in the thick jungles of Bihar, Madhya Pradesh and Orissa. The recent introduction of *Antherea royeli* and *Antherea perniyi* has enabled the country to produce the oak tasar silk, *Phylosamia ricini,* the eri silkworm, which feeds on *Ricinus communis,* is raised in Assam and Orissa commercially. Of the total production of 2,969 tonnes of silk in India, as much as 2,445 tonnes is produced by the mulberry silkworms, *Bombyx mori.*

Lac Insect any of the species of *Metatachardia, Laccifer, Tachordiella,Austrotacharidia, Afrotachardina,* and *Tachardina* of the superfamly Coccoidea, order Homoptera that are noted for resinous exudation from the bodies of females. Members of two of the families viz. Lacciferidae and Tachardinidae appear to be more concerned with lac secretion. There are several lac insects, some of which secrete highly pigmented wax. The Indian lac insect *Laccifer lacca* is important commercially. It is found in tropical or subtropical regions on banyan and other plants. The females are globular in form and live on twigs in cells of resin created by exudations of lac. Of the many species of lac insect,*Laccifer lacca, (=Tachardia lacca)* is the commercially cultured lac insect. It is mainly cultured in India and Bangladesh on the host plant, *Zizyphus mauritiana*and *Z. jujuba.* The insect starts its life as a larva or nymph which is about 0.6 mm long and 0.25 mm wide across the thorax. The young settles down on a suitable place of the host plant gregariously. On the average some 150 of such larvae may be present per square inch of the twig.

Apiculture or beekeeping is the maintenance of honey bee colonies, commonly in hives by a beekeeper in apiary in order to collect honey and beeswax, and for the purpose of pollinating crops. The genus *Apis* is comprised of a comparatively small number of species

including the western honeybee *Apis mellifera,* the eastern honeybee *Apis cerana,* the giant *bee Apis dorsata,* and the small honeybee *Apis florea.*

Nectar is a sugar solution produced by flowers containing about 80% water and 20% sugars. Foraging bees store the nectar in the 'honey sac' where the enzyme invertase will change complex sugars into simple sugars called mono-saccharides. Upon return to the hive, the foraging bee will disgorge the partially converted nectar solution and offer it to other bees. Housekeeping bees will complete the enzymatic conversion, further removing water until the honey solution contains between 14 – 20% water.

Human food value

There are 1,462 recorded species of edible insects. Doubtless there are thousands more that simply have not been tasted yet. 100 grams of cricket contains: 121 calories, 12.9 grams of protein, 5.5 g of fat, 5.1 g of carbohydrates, 75.8 mg calcium, 185.3 mg of phosphorous, 9.5 mg of iron, 0.36 mg of thiamin, 1.09 mg of riboflavin, and 3.10 mg of niacin. Compare this with ground beef, which, although it contains more protein (23.5 g.), also has 288.2 calories and a whooping 21.2 grams of fat. Usually crickets, grasshoppers, beetle and moth larvae and termites are eaten. Australian aborigines regularly ate honey pot ants, adult bogong moths and the larvae of wood moths. Being rich source of protein, grasshoppers have been eaten in nearly all regions of the world. They are a common food in parts of Asia and Africa—fried, roasted or ground to be mixed with flour. The grasshoppers eat green plants, however, by far outweighs their value as food. Insects are an important food for many vertebrates, including birds, amphibians, reptiles, fish and mammals. These "insectivorous" vertebrates usually feed on many insect species, and rarely focus on specific pests, unless they are very abundant.

Scavangers

Ants, beetles, apterygotes, cockroaches, crickets and a large number of other insects thrive on dead carcasses, left over organic matter or excreta and in the process clean the environment. Economic losses avoided every year by the burial of livestock waste by dung beetles only are estimated to be over $3.8 billion.

NEUTRAL INSECTS

Majority of insects, almost 98% of all insect species, live in low populations in different ecosystems, without causing appreciable damage. But they form an important component of the food web and work unnoticed. Conservation of such fauna is important since we do not know the interactions of such insects with the animal and plant species.

INJURIOUS INSECTS

Less than 1% of insects are regarded as pests. They can be classified into the following categories.

Pests of agriculture and forestry (Locusts, caterpillars, bugs, hoppers, aphids etc.)

Locusts are among the most destructive of all insect pests. Swarms of desert locusts were among the plagues of the Biblical Egyptians, and they still plague farmers throughout Asia and Africa. Their threat is so great that regional and international organizations monitor desert locust populations and launch control measures when necessary.

Locusts are particularly destructive in hot, dry regions when a sudden increase in their numbers, combined with food shortage, forces them to migrate. They migrate in huge swarms, devouring virtually every green plant in their path.

Pests of stored grains

The most common insect pests of stored cereal grains are:

Rice Weevil *(Sitophilus oryzae);* Lesser Grain Borer *(Rhyzopertha dominica);*

Rust Red Flour Beetle: *(Tribolium* spp.); Sawtooth Grain Beetle: *(Oryzaephilussurinamensis);* Flat Grain Beetle: *(Cryptolestes* spp.); Indian Meal Moth *(Plodiainterpunctella);* Angoumois Grain Moth *(Sitotroga cerealella);* Khapra beetle*(Trogoderma granarium);* Rice moth *(Corcyra cephalonica).*

Insect management for stored grain depends upon good sanitation and grain storage practices. Clean storage areas to reduce the potential for insect migration into the new grain. Once the grain is dried to 13 percent moisture or less, cool it as soon as possible by running aeration fans. Reducing the grain temperature to less than 60ºF stops insect reproduction, and lowering it to less than 50ºF stops insect feeding activity. Infested grains should be fumigated by Aluminum phosphide (Phostoxin, Fumitoxin), which is best in most circumstances. Methyl bromide may also be used.

Household pests (carpet beetles, furniture beetles, cloth moth, termites and silverfish)

Common household pests include ants, termites, bed bugs, carpet beetles, furniture beetles, book lice, house flies, fleas, cockroaches, silver fish, clothes moths and spiders - the list seems almost endless. Common household pests enter our homes for shelter and food, and also to nest and breed. Common household pests can cause damage to our homes especially clothes, eatables and furniture. Household pests can also be a threat to health of our families by spreading bacteria, diseases or allergens in our homes. Household pests can be irritating, annoying or irritating and annoying. They can be controlled by spraying insecticides or by fumigants and by maintaining hygiene.

Insects of medical and veterinary importance (Mosquitos, flea, beetles, flies)

Mosquitoes can spread diseases such as malaria, yellow fever, dengue fever. Tsetse flies spread sleeping sickness. Lice suck human blood and can cause sores, which if left untreated can become infected which may lead to blood poisoning.

Screw worm flies lay their eggs in the wounds of farm animals and pets. Horseflies and black flies suck blood and have painful bites, which can become infected. Houseflies spread germs and spoil meat by laying eggs in it. Bubonic Plague (or Black Death) was the worst disease epidemic in human history. It took 14 million lives–nearly 1 out of 4 people–in 14th-century Europe. The plague is passed to humans by the bite of the Oriental rat flea (Xenopsylla cheopis), which picks up the disease-causing bacteria from rats.

Honey Bee

The Honey Bee

(By Dr. Girish Chandra)

Honey bees are colonial insects that visit flowers, collect nectar and convert it into a golden-yellow aromatic viscous fluid called honey, which is also called the liquid gold of nature. There is nothing comparable to honey, whether natural or manmade. It is a complete food made and stored by honeybees for the whole colony.

Honey contains about 80% sugars, mainly glucose and fructose. Harmful sucrose is only 1-2% in honey. In addition, honey contains all essential vitamins, minerals and proteins. It has antiseptic properties, is a good blood-purifier, removes gastric problems and corrects metabolic imbalances in the body. It gives instant energy to sportspersons.

A bee colony has about 20,000 workers, one queen and about two dozen drones. Queen can lay up to 3000 eggs per day, which is twice the weight of her body but normal fecundity is about 600 eggs per day. Queen can produce male or female offsprings by choice; unfertilized eggs develop into males and fertilized ones into females. Growing larvae can also be developed into queens or workers by choice, both of which are genetically females. Males are called drones, which are darker, robust and hairy and larger than workers. There are about two dozen of them in a hive and chase the queen in air every time she ventures on nuptial flight. One of them manages to mate with her during such flight and dies in the process. Drones are not tolerated in the hive once the queen is fertilized and are generally driven out of hive, where they eventually die of starvation.

A worker has a lifespan of 6 weeks, the first half of which is spent in the hive attending to household chores, secreting wax and building hive, producing a highly nutritious royal-jelly and converting nectar into honey. They become foragers in the latter part of life and tirelessly collect nectar and pollen throughout life. Towards the end they become incapable to collect nectar and therefore become water-carriers. They eventually die in work, an excellent example of selfless service for the society. An amazing phenomenon that has been observed in honeybees is their capacity to reverse their age should a catastrophe struck the colony. In case of a crisis, such as destruction of the hive, the 4-5 week old foragers start reversing their age and become younger to secrete royal jelly and wax, repair their hive, rear a new queen from the larvae and rebuild their colony. Members of a colony are heavily dependent on one another and cannot survive in isolation, even if kept in the best of conditions. They communicate by ultrasound signals, pheromones, dancing and gestures.

Workers possess morphological adaptations to carry out their duties. Their mandiblular glands secrete wax softening substance, pharyngeal glands secrete a gelatinous highly nutritious substance called Royal Jelly and stomach contains several glands that help in converting nectar into honey. There are wax glands on abdominal segments 4-7 which open by several ducts on to the sternites 4-7. Hind legs have tibia and basitarus modified to form a pollen basket and pollen press. Mouth parts are chewing and lapping type. Workers are sterile females and hence their ovipositors are modified to form sting and accessory reproductive glands get modified to form poison glands. A worker in its entire lifespan makes about a spoonful of honey. To make 500 grams of honey, bees have to extract nectar from more than 4 million flowers, for which they have to make about 50,000 trips of the foraging area 5 km away, which would come to roughly 5 times the circumference of earth. Workers of a single bee colony collectively make approximately 2-3 million flower visits in a day.

Days of life	**Worker Bee's Activities**
1 and 2	Cleaning the honeycomb cells and keeping the eggs and the larvae warm.
3 to 6	Feeding the older larvae with beebread.
7 to 11	Feeding the younger larvae with royal jelly.
12 to 17	Making beeswax and building honeycombs; moving food around the hive.

18 to 21	Guarding and ventilation of the entrance to the hive. On defense duty.
22 to 34	Visiting flowers to collect pollen and nectar as scouts and foragers.
35 to 45	Serve as water carriers. End of the life of a worker bee.

Two species of honeybees, namely, *Apis cerina indica* and the American species, *Apis mellifera* are reared in closed wooden hives for commercial production of honey. While the Indian species can give a harvest of about 40 kg of honey in a year, the American species can produce 2-3 times of that quantity. For that reason the latter species has now been introduced in Indian apiaries. Owning apiaries is an excellent business venture, in which honeybees work tirelessly to make and

store honey in the hives and we have to just go and harvest it every 15 days. In the process they also

pollinate out crops and increase production in agriculture. There is no other insect as friendly to man

as the busy bee.

Pollination

Agriculture depends greatly on the honeybee for pollination. Honeybees account for 80% of all insect pollination. Without such pollination, we would see a significant decrease in the yield of fruits and vegetables.

Pollen

Bees collect 66 lbs of pollen per year, per hive. Pollen is the male germ cells produced by all flowering plants for fertilization and plant embryo formation. The Honeybee uses pollen as a food

which is called bee-bread. Pollen is one of the richest and purest natural foods, consisting of up to

35% protein, 10% sugars, carbohydrates, enzymes, minerals, and vitamins A (carotenes), B1 (thiamin), B2 (riboflavin), B3 (nicotinic acid), B5 (pantothenic acid), C (ascorbic acid), H (biotin),

and R (rutine). Pollen is also mixed with nectar while converting it into honey.

Honey

Honey is used by the bees as food all year round. There are many types, colors and flavors of honey, depending upon its nectar source. The bees make honey from the nectar they collect from flowering trees and plants. Honey is an easily digestible, pure food. Honey is hydroscopic and has antibacterial qualities. Eating local honey can fend off allergies. Honey bees swallow nectar and store

it in their crops where secretions of stomach lining, salivary glands and mandibular glands are mixed in

it. It is then regurgitated into the cell and fanned to evaporate excess moisture. This process is repeated many times to ripen the honey. Ripe honey is golden yellow in colour, viscous fluid but transparent and does not ferment. Cells containing ripe honey are sealed with a waxy membrane.

Beeswax

Secreted from the glands on abdominal segments 4-7, beeswax is used by the honey bees to build honey comb. It is secreted on sternal wax plates which are located on the ventral side of abdomen, from where it is removed as flakes and chewed with mandibles, softening it with the secretion of mandibular glands. It is used by humans in drugs, cosmetics, artists' materials, furniture polish and candles.

Propolis

Collected by honeybees from trees, the sticky resin is mixed with wax to make a sticky glue

that makes foundation of the comb strong. The bees use this to seal cracks and repair their hive. It is used by humans as a health aid, and as the basis for fine wood varnishes.

Royal Jelly

The powerful, milky substance that turns an ordinary bee into a Queen Bee. It is made of digested pollen and honey or nectar mixed with a chemical secreted from a gland in a nursing bee's

head. It commands premium prices rivaling imported caviar, and is used by some as a dietary supplement and fertility stimulant. It is loaded with all of the B vitamins. See below for detailed composition.

Bee Venom

Honey bee venom contains at least 18 active substances. Melittin, the most prevalent substance, is one of the most potent anti-inflammatory agents known (100 times more potent than hydrocortisol). Adolapin is another strong anti-inflammatory substance, and inhibits cyclo-oxygenase; it thus has analgesic activity as well. Apamin inhibits complement C3 activity, and blocks calcium-dependent potassium channels, thus enhancing nerve transmission. Other substances, such as Compound X, Hyaluronidase, Phospholipase A2, Histamine, and Mast Cell Degranulating Protein (MSDP), are involved in inflammatory response of venom, with the softening of tissue and the facilitation of flow of the other substances. Finally, there are measurable amounts of the neurotransmitters Dopamine, Norepinephrine and Seratonin.

Bee venom is hemorrhagic, differing from snake (viper) venom, which is a coagulant. As well as containing apamine, melittin, phospholipase, hyaluronidase, which have the opposing action of inhibiting the nervous system, and stimulating the heart and the adrenal glands; the venom also contains the mineral substances, volatile organic acids, formic acid, hydrochloric acid, ortho-phosphoric acid. Also present are some antibiotics, an enzyme – phospholipase A, as well as two amino acids rich in sulphur methionine and cystine. Sulphur is the main element in inducing the release of cortisol from the adrenal glands, and in protecting the body against infections.

Composition of honey

Carbohydrates

Unsurprisingly, these comprise the major portion of honey - about 82%. The carbohydrates present are the monosaccharides fructose (38.2%) and glucose (31%); and disaccharides (~9%) sucrose, maltose, isomaltose, maltulose, turanose and kojibiose. There are also some oligosaccharides present (4.2%), including erlose, theanderose and panose, formed from incomplete breakdown of the higher saccharides present in nectar and honeydew.

Proteins and Amino Acids

Honey contains a number of enzymes, including invertase, which converts sucrose to glucose and fructose; amylase, which breaks starch down into smaller units; glucose oxidase, which converts glucose to gluconolactone, which in turn yields gluconic acid and hydrogen peroxide; catalase, which breaks down the peroxide formed by glucose oxidase to water and oxygen; and acid phosphorylase, which removes inorganic phosphate from organic phosphates.
Honey also contains eighteen free amino acids, of which the most abundant is

Vitamins, Minerals and Antioxidants

Honey contains trace amounts of the B vitamins riboflavin, niacin, folic acid, pantothenic acid and vitamin B6. It also contains ascorbic acid (vitamin C), and the minerals calcium, iron, zinc, potassium, phosphorous, magnesium, selenium, chromium and manganese.
The main group of antioxidants in honey are the

Other compounds

Honey also contains organic acids such as acetic, butanoic, formic, citric, succinic, lactic, malic, pyroglutamic and gluconic acids, and a number of aromatic acids. The main acid present is gluconic acid, formed in the breakdown of glucose by glucose oxidase. Honey also contains hydroxymethylfurfural, a natural product of the breakdown of simple sugars below pH 5.

flavonoids, of which one, pinocembrin, is unique to honey and bee propolis. Ascorbic acid, catalase and selenium are also antioxidants. Generally speaking, the darker the honey, the greater its antioxidising properties.proline.

Chemical composition of honey

Moisture(%)	17.2
Levulose(%)	38.19
Dextrose(%)	31.28
Sucrose(%)	1.31
Maltose(%)	7.31
Higher sugars(%)	1.50
Undetermined(%)	3.1
pH	3.91
Free Acidity	22.03
Lactone	7.11
total Acidity	29.12
Lactone/Free Acid	0.335
Ash(%)	0.169
Nitrogen(%)	0.041
Diastase	20.8

Components of Royal Jelly

Most of the components of royal jelly seem to be designed to provide a balance of nutrients for the larvae. However, the lipids present are unusual, in that they are unlike the lipids of typical insect fats, which consist of 14-20 carbon fatty acids. Royal jelly lipids are composed mainly of 8-10 carbon acids, hydroxy acids and diacids, which may be saturated, unsaturated, linear or branched. They include hexanoic acid, octanoic acid, (E)-oct-2-enoic acid, 8-hydroxyoctanoic acid, 3- and 10-hydroxydecanoic acid, and 3,10-dihydroxyoctanoic acid. 10-hydroxydecanoic acid levels rise dramatically in summer. Royal jelly also contains

-9 sterols, 4 phospholipids, 5 glycolipids, and a variety of 16-33 carbon hydrocarbons.

The unusual lipids of royal jelly make it highly acidic, and give it good antimicrobial properties. This seems to be the main role of the lipids. However, these properties disappear above pH 6, so while royal jelly may be used as an effective skin-care product, its antimicrobial properties are negligible within the body, where the pH is maintained at about 7.4 by buffering systems. Because of this, there does not seem to be any pharmaceutical use for royal jelly. However, its good balance of nutrients and high nutrient levels mean that it has become a highly touted specialized health food.

Composition of Bee Pollen or Bee Bread (per 100 parts)

Amino Acids

arginine	4.7 parts
histidine	1.5 parts
isoleucine	4.7 parts
leucine	5.6 parts
methionine	1.7 parts
phenylaline	3.5 parts
threonine	4.6 parts
tryptophan	1.6 parts
valine	6.0 parts
glutamic acid	9.1 parts

Vitamins (per 1,000 milligrams of Bee Pollen)

Thiamine (vitamin B-1)	9.2mg
Riboflavin (vitamin B-3)	18.50mg
Niacinamide (vitamin B-3)	200mg

Pyridoxine (vitamin B-6)	5mg
Pantothenic acid (vitamin B-5)	30-5-mg
Folic acid	3.64-6.8mg
Lactoflavin	
Vitamin A (carotenoids)	.5-.9mg
Vitamin C	7-15mg
Vitamin E	Trace

Minerals (per 1,000 milligrams of Bee Pollen)

Potassium 600 mg

Other Minerals in Bee Pollen

magnesium	1%-12%
calcium	1%-15%
copper	.05%-.08%
iron	.01%-.30%
silica	2%-10%
phosphorus	1%-20%
sulfur	1%
chlorine	1%
manganese	1.4%