

## REVIEW ARTICLE

# The Bumblebees and Buzz Pollination

R. NISHA

Agricultural Entomology, SRM Institute of Science and Technology,  
Kattankulathur, Chengalpattu  
email: nisharengadoss@gmail.com

A bumblebee is a member of the genus *Bombus*, part of Apidae family, one of the bee families. This genus is the only extant group in the tribe Bombini, though a few extinct related genera (e.g., *Calyptapis*) are known from fossils. Over 250 species of bumblebee are known. They are found primarily in higher altitudes or latitudes in the Northern Hemisphere. The brood parasitic or cuckoo bumblebees have sometimes been classified as a subgenus or genus, *Psithyrus*, but are now usually treated as members of *Bombus*. Bumblebees are large, fuzzy insects with short, stubby wings. They are larger than honeybees, but they don't produce as much honey. However, they are very important pollinators. Without them, food wouldn't grow. Two-thirds of the world's crop species depend on animals to transfer pollen between male and female flower parts. Many bumblebees are listed as endangered, vulnerable or near threatened by the International Union for Conservation of Nature and Natural Resource's Red List of Threatened Species. The variable cuckoo bumblebee is listed as critically endangered by the IUCN and is considered one of the rarest species in North American (Alford, D. V., 1973).

### Bumblebee colonies and pollination

Many bumblebees are social insects that form colonies with a single queen. The colonies are smaller than those of honey bees, growing to as few as 50 individuals in a nest. Female bumblebees can sting repeatedly, but generally ignore humans and other animals. Cuckoo bumblebees do not make nests; their queens aggressively invade the nests of other bumblebee species, kill the resident queens and then lay their own eggs, which are cared for by the resident workers. (Natural History Museum: Bumblebees). While other animals pollinate, bumblebees are particularly good at it. Their wings beat 130 times or more per second, according to the National Wildlife Federation, and the beating combined with their large

bodies vibrates flowers until they release pollen, which is called buzz pollination. Buzz pollination helps plants produce more fruit. Bumblebees are important agricultural pollinators, so their decline in Europe, North America, and Asia is a cause for concern. The decline has been caused by habitat loss, the mechanisation of agriculture, and pesticides (Brian, A. D., 1957).

### Morphology of bumble bee

There are over 255 species of bumblebees, according to the Integrated Taxonomic Information System (ITIS), so bumblebees can be many sizes. The largest is the queen of the *Bombus dahlbomii*, which can grow up to 1.6 inches (4 centimeters) long. This is three to four times longer than the American bumblebee, according to Scientific American. Bumblebees have round bodies covered in soft hair (long branched setae) called *pile*, making them appear and feel fuzzy. They have aposematic (warning) coloration, often consisting of contrasting bands of colour, and different species of bumblebee in a region often resemble each other in mutually protective Müllerian mimicry (Brown, 1984). Harmless insects such as hoverflies often derive protection from resembling bumblebees, in Batesian mimicry, and may be confused with them. Nest-making bumblebees can be distinguished from similarly large, fuzzy cuckoo bees by the form of the female hind leg. In nesting bumblebees, it is modified to form a pollen basket, a bare shiny area surrounded by a fringe of hairs used to transport pollen, whereas in cuckoo bees, the hind leg is hairy all round, and pollen grains are wedged among the hairs for transport (Cockerell, 1922).

### Distribution, habitat and habits

With so many species, it isn't surprising that bumblebees are found all over the world. For example, the largest bumblebee is found in Argentina and Chile and the rusty patched bumblebee is found in the United



Fig. 1. A Bumble Bee

States and Canada. Bumblebees are typically found in temperate climates, and are often found at higher latitudes and altitudes than other bees, although a few lowland tropical species exist. A few species (*B. polaris* and *B. alpinus*) range into very cold climates where other bees might not be found; *B. polaris* occurs in northern Ellesmere Island in the high Arctic, along with another bumblebee *B. hyperboreus*, which parasitises its nest. Bumblebees usually build their nests close to the ground — under piles of wood, dead leaves and compost piles — or even below ground in abandoned rodent tunnels. This is the most northernmost occurrence of any eusocial insect. One reason for their presence in cold places is that bumblebees can regulate their body temperature, via solar radiation, internal mechanisms of “shivering” and radiative cooling from the abdomen (called heterothermy). (Natural History Museum: Bumblebees). Other bees have similar physiology, but the mechanisms seem best developed and have been most studied in bumblebees. They adapt to higher elevations by extending their wing stroke amplitude. Bumblebees have a largely cosmopolitan distribution but are absent from Australia (apart from Tasmania where they have been introduced) and are found in Africa only north of the Sahara. Bumblebees are some of the most social creatures in the animal kingdom. A group of bumblebees is called a colony. Colonies can contain between 50 and 500 individuals,

according to the National Wildlife Federation. A dominant female called the queen rules the colony. The other bees serve her or gather food or care for developing larvae. During the late fall, the entire colony dies, except for the queen. She hibernates during the winter months underground and starts a new colony in the spring (Brown, 1984).

### Biology

#### Diet and Feeding

Bumblebees eat nectar and pollen made by flowers. The sugary nectar provides the bees with energy while the pollen provides them with protein, according to The Bumblebee Conservation Trust. They make honey by chewing the pollen and mixing it with their saliva, according to Animal Diversity Web (ADW). They feed the honey to the queen and the developing brood. The bumblebee tongue (the proboscis) is a long, hairy structure that extends from a sheath-like modified maxilla. The primary action of the tongue is lapping, that is, repeated dipping of the tongue into liquid. The tip of the tongue probably acts as a suction cup and during lapping, nectar may be drawn up the proboscis by capillary action. When at rest or flying, the proboscis is kept folded under the head. The longer the tongue, the deeper the bumblebee can probe into a flower and bees probably learn by experience which flower source is best-suited to their tongue length. Bees with shorter proboscides,

like *Bombus bifarius*, have a more difficult time foraging nectar relative to other bumblebees with longer proboscides; to overcome this disadvantage, *B. bifarius* workers were observed to lick the back of spurs on the nectar duct, which resulted in a small reward (Greene, 1858).

### **Wax production**

The exoskeleton of the abdomen is divided into plates called dorsal tergites and ventral sternites. Wax is secreted from glandson the abdomen and extruded between the sternites where it resembles flakes of dandruff. It is secreted by the queen when she starts a nest and by young workers. It is scraped from the abdomen by the legs, moulded until malleable and used in the construction of honeypots, to cover the eggs, to line empty cocoons for use as storage containers and sometimes to cover the exterior of the nest (Greene, 1858).

### **Temperature control**

Bumblebees are active in conditions when honeybees stay at home, and can readily absorb heat from even weak sunshine. The thick pile created by long setae (bristles) acts as insulation to keep bumblebees warm in cold weather; species from cold climates have longer setae (and thus thicker insulation) than those from the tropics. The temperature of the flight muscles, which occupy much of the thorax, needs to be at least 30 °C (86 °F) before flight can take place. The muscle temperature can be raised by shivering. It takes about five minutes for the muscles to reach this temperature at an air temperature of 13 °C (55 °F) (Greene, 1858).

### **Communication and social learning**

Bumblebees do not have ears, and it is not known whether or how well they can hear. However, they are sensitive to the vibrations made by sound travelling through wood or other materials. Bumblebees do not exhibit the “bee dances” used by honeybees to tell other workers the locations of food sources. Instead, when they return from a successful foraging expedition, they run excitedly around in the nest for several minutes before going out to forage once more. These bees may be offering some form of communication based on the buzzing sounds made by their wings, which may stimulate other bees to start foraging. Another stimulant to foraging activity is the level of

food reserves in the colony. Bees monitor the amount of honey in the honeypots, and when little is left or when high quality food is added, they are more likely to go out to forage (Goulson and Williams 2001).

### **Reproduction and nesting**

Nest size depends on species of bumblebee. Most form colonies of between 50 and 400 individuals, but colonies have been documented as small as ~20 individuals and as large as 1700. These nests are small compared to honeybee hives, which hold about 50,000 bees. Many species nest underground, choosing old rodent burrows or sheltered places, and avoiding places that receive direct sunlight that could result in overheating. Other species make nests above ground, whether in thick grass or in holes in trees. A bumblebee nest is not organised into hexagonal combs like that of a honeybee; the cells are instead clustered together untidily. The workers remove dead bees or larvae from the nest and deposit them outside the nest entrance, helping to prevent disease. Nests in temperate regions last only for a single season and do not survive the winter (Carvell, 2002).

In the early spring, the queen comes out of diapause and finds a suitable place to create her colony. Then she builds wax cells in which to lay her eggs which were fertilised the previous year. The eggs that hatch develop into female workers, and in time, the queen populates the colony, with workers feeding the young and performing other duties similar to honeybee workers. In temperate zones, young queens (gynes) leave the nest in the autumn and mate, often more than once, with males (drones) that are forcibly driven out of the colony. The drones and workers die as the weather turns colder; the young queens feed intensively to build up stores of fat for the winter. They survive in a resting state (diapause), generally below ground, until the weather warms up in the spring with the early bumblebee being the species that is among the first to emerge. Many species of bumblebee follow this general trend within the year. *Bombus pensylvanicus* is a species that follows this type of colony cycle. For this species the cycle begins in February, reproduction starts in July or August, and ends in the winter months. The queen remains in hibernation until spring of the following year in order to optimize conditions to search for a nest (Buchmann *et al.*, 2008).

In fertilised queens, the ovaries only become active when the queen starts to lay. An egg passes along the oviduct to the vagina where there is a chamber called the spermatheca, in which the sperm from the mating is stored. Depending on need, she may allow her egg to be fertilised. Unfertilised eggs become haploid males; fertilised eggs grow into diploid females and queens. The hormones that stimulate the development of the ovaries are suppressed in female worker bees, while the queen remains dominant (Carvell, 2002).

To develop, the larvae must be fed both nectar for carbohydrates and pollen for protein. Bumblebees feed nectar to the larvae by chewing a small hole in the brood cell into which they regurgitate nectar. Larvae are fed pollen in one of two ways, depending on the bumblebee species. Pocket-making bumblebees create pockets of pollen at the base of the brood-cell clump from which the larvae feed themselves. Pollen-storing bumblebees keep pollen in separate wax pots and feed it to the larvae (De Meulemeester, *et al.*, 2010).

After the emergence of the first or second group of offspring, workers take over the task of foraging and the queen spends most of her time laying eggs and caring for larvae. The colony grows progressively larger and eventually begins to produce males and new queens. Unlike the workers of more advanced social insects such as honeybees, bumblebee workers are fertile, and can lay unfertilized haploid eggs (with only a single set of chromosomes) that develop into viable male bumblebees. Only fertilized queens can lay diploid eggs (one set of chromosomes from a drone, one from the queen) that mature into workers and new queens.

In a young colony, the queen minimizes reproductive competition from workers by suppressing their egg-laying through physical aggression and pheromones. Worker policing leads to nearly all eggs laid by workers being eaten. Thus, the queen is usually the mother of all of the first males laid. Workers eventually begin to lay male eggs later in the season when the queen's ability to suppress their reproduction diminishes. Because of their reproductive competition between workers and the queen, bumblebees are considered "primitively eusocial".

Although a large majority of bumblebees follow such monogynous colony cycles that only involve one queen, some select *Bombus* species (such as *Bombus*

*atratus*) will spend part of their life cycle in a polygynous phase (have multiple queens in one nest during these periods of polygyny). The queen is the mother of all the bees in a colony. After waking from hibernation, the queen finds food and looks for a good location for a nest. Once the nest is found, she lays her eggs and stores up food for herself and the babies. The queen sits on the eggs for about two weeks to keep them warm. When the eggs hatch, the queen feeds pollen to the baby bees, called larvae. At two weeks old, the larvae spin cocoons around themselves and stay there until they develop into adult bees. The queen only takes care of the first batch of babies. The first batch grows into worker bees that will clean and guard the nest, find food and take care of the next batch of baby bees. The queen is left to do nothing but lay and hatch new eggs (Fabricius, J. C., 1775, 1777, 1781, 1798).

Bees born in late summer are male bees, called drones, and future queen bees. Both leave the nest as soon as they are mature. The males from other nests mate with future queens and then die. After mating, the future queens fatten themselves up and hibernate throughout the winter.

### Foraging behaviour

Bumblebees generally visit flowers that exhibit the bee pollination syndrome and these patches of flowers may be up to 1–2 km from their colony. They tend to visit the same patches of flowers every day, as long as they continue to find nectar and pollen there, a habit known as pollinator or flower constancy. While foraging, bumblebees can reach ground speeds of up to 15 metres per second (54 km/h).

Bumblebees use a combination of colour and spatial relationships to learn which flowers to forage from. They can also detect both the presence and the pattern of electric fields on flowers, which occur due to atmospheric electricity, and take a while to leak away into the ground. They use this information to find out if a flower has been recently visited by another bee. Bumblebees can detect the temperature of flowers as well as which parts of the flower are hotter or cooler and use this information to recognize flowers. After arriving at a flower, they extract nectar using their long tongues ("glossae") and store it in their crops. Many species of bumblebees also exhibit "nectar robbing": instead of inserting the mouthparts into the flower in the normal way, these bees bite

directly through the base of the corolla to extract nectar, avoiding pollen transfer (Harder, 1983).

Pollen is removed from flowers deliberately or incidentally by bumblebees. Incidental removal occurs when bumblebees come in contact with the anthers of a flower while collecting nectar. When it enters a flower, the bumblebee's body hairs receive a dusting of pollen from the anthers. In queens and workers this is then groomed into the corbiculae (pollen baskets) on the hind legs where it can be seen as bulging masses that may contain as many as a million pollen grains. Male bumblebees do not have corbiculae and do not purposively collect pollen. Bumblebees are also capable of buzz pollination, in which they dislodge pollen from the anthers by creating a resonant vibration with their flight muscles (Cameron *et al.*, 2007).

In at least some species, once a bumblebee has visited a flower, it leaves a scent mark on it. This scent mark deters bumblebees from visiting that flower until the scent degrades. This scent mark is a general chemical bouquet that bumblebees leave behind in different locations (e.g. nest, neutral, and food sites), and they learn to use this bouquet to identify both rewarding and unrewarding flowers, and may be able to identify who else has visited a flower. Bumblebees rely on this chemical bouquet more when the flower has a high handling time, that is, where it takes a longer time for the bee to find the nectar once inside the flower (Hanski, 1982).

Once they have collected nectar and pollen, female workers return to the nest and deposit the



Fig. 2. A rusty patched bumblebee collects pollen and nectar from a flower.

harvest into brood cells, or into wax cells for storage. Unlike honeybees, bumblebees only store a few days' worth of food, so are much more vulnerable to food shortages. Male bumblebees collect only nectar and do so to feed themselves. They may visit quite different flowers from the workers because of their different nutritional needs (Cardale, 1993).

#### Other facts of bumblebees

- Bumblebees are larger than honey bees and generate more heat. This allows them to work during cooler weather.
- Bumblebees don't die when they sting. This is trait found in honey bees- That's just a thing in honeybees. A bumblebee can sting you twice. However, male bumblebees don't have a stinger at all, and female bumblebees aren't very aggressive, so unless you go barging into their nest, you're likely safe.
- Bees are covered in an oil that makes them waterproof.
- Queens shiver to warm up and keep eggs toasty (U.S. Fish and Wildlife Service: Rusty Patched Bumble Bee Fact Sheet).
- Unlike most native bees, but like honey bees, bumble bees are social insects that live in colonies.
- Bees have to eat a ton- Bumblebees have extremely fast metabolisms, so they have to eat almost continuously. "A bumblebee with a full stomach is only ever about 40 minutes from starvation,"
- Bumblebee eggs are shaped like tiny sausages
- Bumblebee nests are much smaller than those of other species- They have a maximum of 300 to 400 worker bees, compared to the tens of thousands found in a honeybee or wasp nest. For context, there are around 25,000 known species of bee, though there are likely more that have yet to be discovered.
- Bee sperm lives for months inside the queen bee- Only the fat queen bee survives winter hibernation, and she's left to create a colony by herself. Sperm stored up from mating the previous summer survives in her ovaries, ready to fertilize her eggs once she finally finds a nesting place. By the end of the summer, when

she's a little over a year old, the queen and all her worker bees die, to be replaced by her daughters.

- Queen bees control the genetics of their offspring- Male bumblebees have only one chromosome, and no father. To produce a son, a queen bee merely has to lay an unfertilized egg. To have daughters—who make up the entirety of a bee workforce—a queen bee fertilizes her eggs with sperm she's been storing since the previous summer.
- Except for new queens, which hibernate during winter, bumble bee colonies die in late fall.
- Bumble bees do not produce honey, but pollination services they provide are worth more than that product would yield.
- Bumble bees' wings beat 130 or more times per second.
- Bumblebees air condition their nests with their own wings- If the nest gets too hot, worker bees post themselves near the entrance and fan the hot air out, like tiny flapping A/C units.
- *Hordes of male bumblebees congregate on hilltops (Goulson et al., 2005).*

### **Cautions to protect bumble bees**

#### **Provide pollen and nectar for food.**

Active from early spring through late fall, bumble bees need access to a variety of nectar- and pollen-producing flowers so food will be available throughout all stages of the insects' life cycle. Native plants are best because they have coevolved with indigenous bumble bees.

#### **Ensure bumble bees have nesting sites.**

Most bumble bees nest underground in holes made by larger animals, while others nest aboveground in abandoned bird nests, grass tussocks or cavities such as hollow logs or spaces beneath rocks. In gardens, they may also use compost piles or unoccupied birdhouses.

#### **Protect hibernation habitat**

Because most queens overwinter in small holes on or just below the ground's surface, avoid raking, tilling or mowing your yard until April or May. If you do need to mow, do so with the mower blade set at the highest safe level.

### **Eliminate pesticides**

Both insecticides and herbicides should be avoided. In particular, steer clear of systemic pesticides such as neonicotinoids, which are taken up by the vascular systems of plants. This means bees and other pollinators are exposed to the poison long after a product has been applied when they feed on the plants' nectar and pollen (The New York Times: A Bumblebee Gets New Protection on Obama's Way Out).

### **CONCLUSION**

Many bumblebees are listed as endangered, vulnerable or near threatened by the International Union for Conservation of Nature and Natural Resource's Red List of Threatened Species. The variable cuckoo bumblebee is listed as critically endangered by the IUCN and is considered one of the rarest species in North American. The rusty patched bumblebee is also listed as critically endangered, and in early 2017 it became the first wild bee in the continental United States to get federal protection under the Endangered Species Act, according to Scientific American. There is a lot of discussion as to why the overall be population is declining. Some scientists think that there may be a sickness killing off the bees. Others think pollution, global warming or lack of native flowers may be to blame (Livesciences).

### **LITERATURE CITED**

- Alford, D. V. 1973. *Bumblebees in Britain*. Central Association of Bee-Keeper, Ilford.- 1975. *Bumblebees*. xii+352 pp. London.
- Brian, A. D. 1957. Differences in the flowers visited by four species of bumble-bees and their causes. *Journal of Animal Ecology* **26**: 71-98.
- Brown, J. H. 1984. On the relationship between abundance and distribution of species. *American Naturalist* **124**: 255-279.
- Buchmann, S., Kevan, P. G., Adams, L. & Dalsimer, A. 2008. Birds, bees, and bases: how military natural resource managers can help local pollinators and why they should care. *Natural Selections* **4**: 5-6.
- Cameron, S. A., Hines, H. M. & Williams, P. H. 2007. A comprehensive phylogeny of the bumble bees (*Bombus*). *Biological Journal of the Linnean Society* **91**: 161-188.
- Cardale, J. C. 1993. Zoological catalogue of Australia, volume 10. Hymenoptera: Apoidea. ix+406 pp. Canberra.
- Carvell, C. 2002. Habitat use and conservation of bumblebees (*Bombus* spp.) under different grassland management regimes. *Biological Conservation* **103**: 33-49.
- Cockerell, T. D. A. 1922. Bees in the collection of the U.S. National Museum. *Proceedings of the United States National Museum* **60**: 20 pp.

- De Meulemeester, T., Aytakin, A. M., Cameron, S. & Rasmont, P. 2010. Nest architecture and species status of the bumble bee *Bombus* (*Mendacibombus*) *shaposhnikovi* (Hymenoptera: Apidae: Bombini). *Apidologie* 42: 301-306.
- Fabricius, J. C. 1775. *Systema entomologiae, sistens insectorum classes, ordines, genera, species, adiectis synonymis, locis, descriptionibus, observationibus*. 32+832 pp. Flensburgi & Lipsiae.
- 1777. *Genera insectorum eorumque characteres naturales secundum numerum, figuram, situm et proportionem omnium partium oris adiecta mantissa specierum nuper detectarum*. xvi+310 pp. Chilonii.
  - 1781. *Species insectorum exhibentes eorum differentias specificas, synonyma auctorum, loca natalia, metamorphosin adiectis observationibus, descriptionibus*. 1: viii+552 pp. Hamburg.
  - 1798. *Supplementum entomologiae systematicae*. [2]+572 pp. Hafniae.
- Goulson, D., Hanley, M. E., Darvill, B., Ellis, J. S. & Knight, M. E. 2005. Causes of rarity in bumblebees. *Biological Conservation* 122: 1-8.
- Goulson, D. & Williams, P. 2001. *Bombus hypnorum* (Hymenoptera: Apidae), a new British bumblebee? *British Journal of Entomology and Natural History* 14: 129-131. [Article]
- Greene, J. W. 1858. II. Descriptions of several new Hymenopterous insects from the north west coast of America. *Annals of the Lyceum of Natural History of New York* 7: 11-12.
- Hanski, I. 1982. Dynamics of regional distribution: the core and satellite species hypothesis. *Oikos* 38: 210-221.
- Harder, L. D. 1983. Flower handling efficiency of bumble bees: morphological aspects of probing time. *Oecologia* 57: 274-280.

*Received on 27-03-2020      Accepted on 21-04-2020*