BRITISH COLUMBIA

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Factsheet #111

BEE BEHAVIOUR DURING FORAGING

Insect pollinators, including honeybees, evolved together with flowering plants for millions of years. Plants developed floral parts with increasingly specialized features to attract visiting insects who, in turn, would distribute pollen grains and optimize the plant's reproductive capabilities. Simultaneously, these wasp-like insects underwent physiological adaptations to take advantage of the nutritional benefits offered by flowering plants. Physical adaptations were augmented by changes in foraging and nesting behaviour that proved mutually beneficial to flora and fauna. Some of the physical adaptations of the honeybee include:

SENSE ORGANS

- **Vision**
  Each compound eye is spherical in shape and comprised of some 6,300 cone-shaped facets or eyes. Bees can easily distinguish high contrast shapes and patterns. The visual spectrum of the honeybee has shifted towards shorter wavelengths, enabling it to detect ultra-violet, while red, with its longer wavelength, appears as a dull grey. Bees are particularly sensitive to blue, yellow and blue-green colours even though bees can detect light intensity only 1/20 as well as humans.

  The sensitivity to ultra-violet and polarized light enables the honeybee to observe the sun under cloudy conditions. Its spherical-shaped eyes allow the honeybee to measure angles accurately between the relative positions of the sun, the food source and the nest. These field observations are then interpreted and communicated to other bees inside the hive through a 'dance'. Scout bees can direct their fellow worker bees to the location of a food source, negating the need for each individual to search. Unlike most other insect pollinators, the adaptation of communication has enabled honeybees to utilize floral resources of a large area. As a result, honeybee colonies can attain a biomass at the height of the season far greater than any other pollinating insect. Bumble bees and all solitary bees do not communicate and hence, each individual relies on its own foraging success. The foraging range of these pollinators is limited to a comparatively small area.

- **Odour**
  The honeybee's olfactory sense is estimated to be 40 times better than man's and plays a critical role in locating food sources and communication in and outside the nest. Some 5,000 - 6,000 olfactory detectors are on each antenna.

- **Taste**
  Taste is detected through the mouthparts and forelegs. Bees have a limited range of taste and many substances detected by humans are tasteless to bees. Within the narrow range of substances they can taste, bees display high sensitivity. Sugar solutions as low as 2% can be detected although for foraging purposes, bees are not interested unless the sugar concentration is 30% or higher.

- **Sense of Time**
  Bees are known to be time sensitive. Communication inside the nest expressing the location of a site relative to the sun has been observed over time, even when the sun's position progressed below the horizon. Awareness of time is important in determining the time of nectar secretion and the commencement of foraging.

FORAGING

- **Economics of Foraging**
  Foraging requires energy and the honeybee's evaluation as to where, what and how long to forage is all related to the economics of energy consumption and the net gain of food to the colony. For example, foraging bees may not access a high quality food source because its distance requires energy expenditure exceeding the energy value of the food source. Generally bees fly only as far as necessary to secure an acceptable food source from which there is a net-gain. Factors that influence foraging behaviour and determine profitability:
  - weather e.g. wind, temperature, and sunlight,
  - distance of the food source from the hive (including differences in elevation),
  - food quality (concentration of sugar, protein content of the pollen),
  - quantity of nectar or pollen.

- **Foraging Range**
  Bees are known to fly as far as 12 km (8 miles), but usually foraging is limited to food sources within 3 km. Approximately 75% of the bees from a colony forage within one kilometre while young field bees only fly within the first few hundred metres.

- **Constancy to Species**
  Foraging bees tend to limit their visits to a single species of plant during each trip. This behavioural adaptation is critically important for plants since it assures the transfer of pollen from one plant to another plant of the same species. In commercial crops, foraging constancy is essential for optimizing seed set and fruit development.

  Individual foragers will acquire a sample through scouting in the morning and tend to fly to the same source as long as it remains profitable. Bees will shift to another plant species if the nectar or pollen fails. Even then, memory will cause these foragers to return several times and re-check. In areas with great floral diversity and small plantings, a higher percentage of foraging bees will visit different kinds of plants during the same trip. This would account for the mixed pollen loads of returning bees.

- **Speed of Work**
  Bees visit up to about 40 flowers per minute depending on floral type, nectar availability and weather conditions. Floral visitation rate by honeybees of some important crops:
  - apricots 10 sec
  - apples 68 sec
  - cherries 82 sec
  - raspberry 116 sec
  - black currant 134 sec

  The longer the time period, the greater the nectar availability. It takes twice as much time to collect a load of nectar compared with a load of pollen.

  Honeybees are foraging generalists and capable of utilizing a wide range of floral sources. On the other hand, many insect pollinators are specialists and only visit certain floral sources. Foraging specialization by the insect coincides with higher efficiency of utilizing the food source which means improved pollination for the plant. For example, bumblebees evolved in bog environments of temperate zones, where the principal nectar and pollen sources bloom during cool and wet spring conditions and are characterized by long colliery floral tubes. Furthermore, pollens of these sources are generally moist and sticky. Bumble bees have developed a long proboscis (tongue), are highly pubescent (hairy) to forage under inclement weather, and are capable of "buzzing" while on the flower to cause the release of pollens. As such, bumblebees have proven highly efficient in crops such as blueberry, cranberry and blackberry.

- **Temperature Conditions**

Below 8 C	- no foraging
8 C - 16 C	- some activity
16 C - 32 C	- optimal conditions
Above 32 C	- reduction in foraging, increase in water collection.

- **Speed of Flight**

Loaded bee	- approx. 25 km/h (15 mph) on average;
Empty bee leaving hive	- 20 km/h (12.5 mph) on average.

  Increased wind reduces foraging activity. At a wind speed of 40 km/h (25 mph) foraging will stop.

- **Number of Trips per Day**
  The number of trips will depend on various conditions including weather, forage availability, strength of colony, etc. In general, 5-15 trips are made, while a water collector may make as many as 100 trips per day.

NECTAR FLOW

The nectar flow is the period when bees forage and collect nectar to sustain the colony. The nectar flow is the period when there is such an abundance in nectar production that the bees gather a surplus beyond the immediate needs of the colony, which is converted to honey and stored in the combs. To optimize the nectar resource of an area, the beekeeper must be thoroughly familiar with the vegetation, its condition and blooming time.

LOCATING THE NECTAR

Nectar and pollen sources are located by any foraging bee and not limited to scout bees. After finding a valuable food source, the bee will return to the colony and communicate its finding to other bees through a ‘bee dance’. Carl von Frisch first described this form of communication, expressing direction, distance and food quality.

GATHERING NECTAR

The bee's specialized tongue, called the proboscis, is a suction pump. The nectar passes through the esophagus into the nectar sac where a valve prevents the nectar from passing into the digestive stomach or ventriculus. The nectar sac is essentially a widening of the esophagus and functions as a collecting chamber of liquid foods during transportation. The weight of a full nectar sac may be as much as 90% of the body weight of the bee.

During the return trip to the hive, saliva is added to the nectar which contains the enzyme invertase. Invertase reduces complex sugars into simple sugars, which is part of the conversion from nectar into honey. Should the bee require more energy for the flight home, the valve between the nectar sac and the ventriculus will open, allowing nectar to pass into the digestive stomach.

A field bee carrying only nectar will fly with the rear legs wide apart.

HANDLING NECTAR ON RETURN TO THE HIVE

After return to the hive, the forager passes the nectar on to 'house' bees. She opens her mandibles with her proboscis retracted, and a drop of liquid appears at the base of the glossa while the house bee extends her proboscis fully, and sucks up the drop. The speed of food transmission and processing is determined by various factors, including temperature, the age of the bees, colony strength, its food reserves and the total colony intake of nectar and pollen.

During a strong nectar flow the partly ripened honey is stored in the cells of the comb immediately, or after only a few transfers from bee to bee. During a moderate or weak flow the food is passed on to and by many bees before it is stored. The greater the number of bees in the chain, the richer the ripe honey will be in their secretions and hence in enzymes.

RIPENING HONEY

Partially processed nectar or raw honey contains too much water. Water is removed through evaporation during the ripening process, which involves two phases.

A bee, actively involved in processing nectar, first pumps out the contents of her nectar sac into a flat drop on the underside of the proboscis which she then draws up again. This back-and-forth action is repeated rapidly for 15-20 minutes. The liquid is thereby exposed to the warm air of the hive, causing evaporation. In this way, the bees produce half-ripened honey containing about 50-60% (maximum 70%) of dry substance.

The second, passive phase of honey ripening involves the deposit of half-ripened honey in small droplets on the cell walls, or in a thin film on the cell floor. As a rule, 1/4 to 1/3 of the cell is filled; but during a strong flow, or if there is lack of space, 1/2 or 3/4 of each cell is filled straight away. Normally, when the honey is nearly ripe, the bees move it again, and the cells are then filled to 3/4 of their capacity. The final ripening takes 1 - 3 days, depending on the water content when the honey is first put into the cells, the level to which the cells are filled, the amount of air movement achieved, and temperature and relative humidity. Under good conditions, the percentage of water in the honey will be reduced to below 20% in about 4 days.

The rate of evaporation from cells 1/4 full is three times that of cells filled 3/4 full. When adequate comb space is available, few cells are more than half full. As moisture is evaporated, bees fill cells, leaving empty cells to receive more green nectar. It is important to have adequate empty comb space during the nectar flow to prevent crowding.

POLLEN COLLECTING AND STORAGE

Pollen is dislodged from the anther of the flower and adheres to the branched hairs of the bee. The tongue and mandibles (jaws) are often used to lick and bite the anther. Pollen becomes stuck to the mouthparts and is moistened. While the bee is resting or hovering in the air, she removes the pollen from her body and transfers it to the corbicula (pollen basket) of her rear legs.

The process involves all of the bee’s three pairs of legs. The wet pollen is removed from the mouthparts, head and antenna by the forelegs. Small amounts of nectar are used to moisten the pollen mixture. The second pair of legs (mid legs) comb pollen from the underside of the thorax and receive it from the forelegs. The inside of the basi-tarsi of the rear legs contain combs which remove the pollen from the brushes of the mid legs. By rapidly rubbing the hind legs, pollen is gradually moved up to the opening between the basi-tarsus and tibia of the rear leg. The rake of the opposite leg will then force the pollen into the corbicula or “pollen basket”. A pollen load contains up to 10% nectar, which is necessary for packing.

In the hive, pollen is removed from the rear legs by a spike on the mid legs and is placed in cells. Often the head is used to pack the pollen in cells. Honey is added to maintain pollen quality. This final product is is called bee bread.