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COLONY ORGANIZATION AND SOCIAL BEHAVIOR OF HONEY BEES

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Honey bees are social insects and live in colonies consisting of different developmental stages such as eggs, larvae and pupae which are collectively known as brood. Among various insect orders, only 8 have been acknowledged by insect taxonomists for displaying communal life. Out of these 8 orders only Isoptera and Hymenoptera exhibit well developed social organization (Kalpana *et al*., 2017). In the Hymenoptera order, specifically in the superfamily Apoidea, only two families, namely Halictidae and Apidae, contain fully social species. The majority of other bee species live solitary life (Mulatu and Gebissa, 2021).

The earliest evidence of this association is evident in rock paintings created by primitive humans. Thousands of years ago, Egyptians were well acquainted in bee keeping before the Christian Era. References to bees and honey are found in the Rigveda. The commercialization of beekeeping gained prominence during the 19th century as a result of scientific research (Grimaldi and Engel, 2005). Apiculture is now a flourishing industry in many advanced countries like USA, Australia, Germany and Canada.

Colonization of Honey Bee

A normal colony, during active season is composed of 3 kinds of individuals which may vary in size (Fig. 1).

Castes and Their Activities

1. Queen - only one; functional female
2. Workers - 20000-30000, sterile females
3. Drones - few only, functional males (prior to swarming).

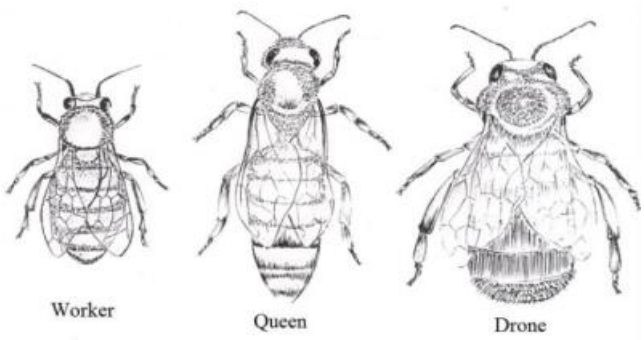

Fig.1: Different castes of honey bee
(Image source: J.K. Gupta; Apiculture, Agrimoon.com)

1. Queen Bee

- The queen bee is the only fully developed female with well developed ovaries and other organs of the female reproductive system.
- It is the largest in size.
- Wings are smaller and shriveled.
- Mouth part for sucking food is shorter compared to workers.
- The queen has no wax glands.
- She lives for about 3-4 years, laying eggs at the rate of 800-1500 per day.

Events in the life of queen bee:

Usually, around the age of 7-10 days within her parent hive, after the old queen along with some workers have departed to initiate another hive, the new virgin queen goes out for nuptial (marriage) flights. The drones from the same hive chase her during these flights. This swarm may also attract drones (male bees) from other hives. Mating occurs while flying, on an average, the queen mates with about six drones before returning to the hive. The sperms she acquires during these flights are sufficient for her entire reproductive life, and she never mates again. The queen has a control mechanism for releasing sperms from the spermatheca (sperm store). She can lay two types of eggs, fertilized and unfertilized.

2. Worker Bee

- Worker bees are imperfectly developed females and smaller than the queen.
- These have strong wings to fly for pollen and nectar collection.
- Workers have a large and efficient proboscis (mouth parts packed together like a thin tube) for sucking nectar.
- A well developed sting is present in abdomen.

- Pollen basket is present on hind legs for collecting pollen.
- Life span of worker is about 35 days.

Table 1: Different duties which they perform age wise are as follows:

S.No.	Age of Worker Bee	Duties performed
1.	Till 3rd day of emergence	Maintain wax cells in sanitary state, cleaning their floors and walls after the emergence of young bees.
2.	From 4th -6 th day of emergence	Feed older larvae with mixture of honey and pollen and flies around the hive for getting layout of the hive, (orientation flights)?
3.	From 7th -11th day of emergence	Hypopharyngeal glands (food glands) get developed and start secreting royal jelly and feed younger larvae.
4.	From 12th to 18th day	The bees develop wax glands and work on building of comb, construction of cells etc., Receive the nectar, pollen, water, propolis etc., from field gatherers, deposit in the comb cells and help in keeping the brood warm.
5.	From 18th to 20thday	Perform guard duty
6.	From 20th day onwards	The worker bees take the duty of field i.e. foraging for nectar and pollen, collecting propolis and water.

Foraging behavior of worker:

For foraging, some scout bees venture out in the morning. Upon finding good sources of nectar (i.e., flowers), they return to their hive and perform characteristic movements (bee dances) on the comb. These dances convey the distance and direction of the food source to other worker bees, leading to the deployment of more workers in food gathering. The workers visit flower to flower, collect nectar and pollen, and return to their nest, guided by the position of the sun as well as by certain amount of memory and the smell of their specific hive (Fig. 3).

3. Drone

Drones are male bees produced from unfertilized eggs. Their production in the hive synchronizes with the production of new (virgin) queens. At the age of 14-18 days, drones engage in mating flight, chasing the virgin queen in the air. Drones can live for about 60 days, although they are stung and killed after mating. The schematic representation of the formation of various castes of bees is shown in Fig. 2.

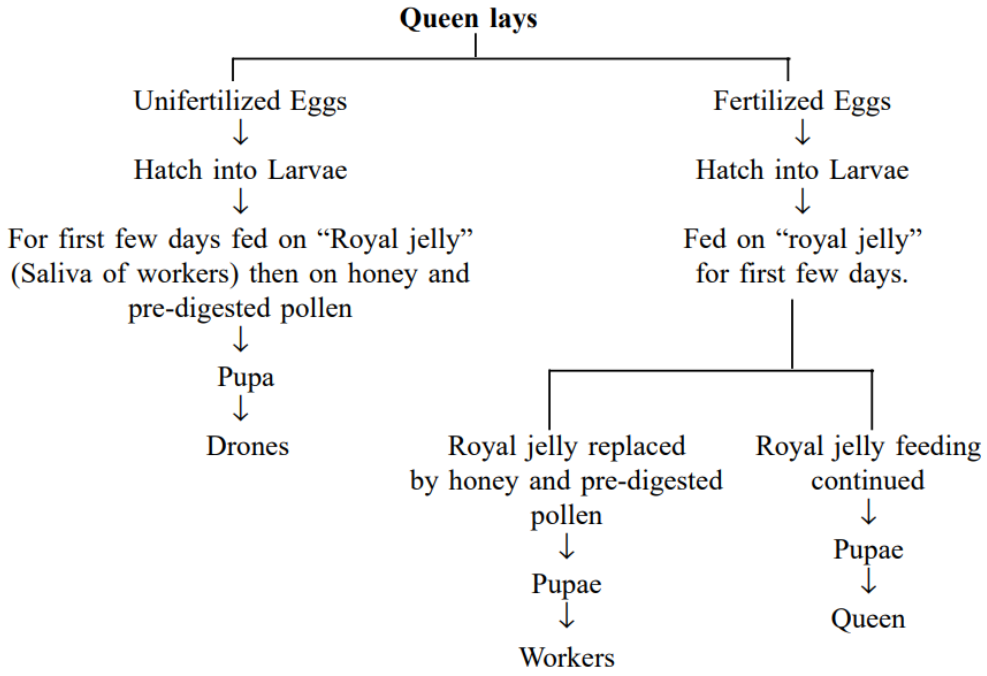

Fig. 2: Schematic representation of the formation of different castes in honeybee

Emergence of new Queen and Swarming of Other One

When the queen gets older, usually in the third year, her body releases a chemical stimulus to the workers to construct a few rearing cells for queens. She places one fertilized egg in each of these brood cells. Larvae are fed royal jelly (saliva of workers) and turn into the pupae and then queens. The first queen emerged from the brood cell, kills the remaining ones. The old queen then takes to swarming along with workers of all ages, leaves the old hive to develop a colony at a new site. The new queen in the old hive engages in a mating flight with the drones and returns to the same hive, as described earlier.

Social Behavior of Honey Bee

Honey bees are fully social insects, having an overlap of many generations within the same nest. The colony functions as a well organized social group with a division of labor, encompassing tasks such as egg laying, nursing, comb building, guarding, food collection with storage. Their communication system is highly developed, involving various types of dances and trophallaxis.

Biological Communication

It can be defined as an action by one organism that modifies the probability pattern of behavior in another organism in an adaptive manner. The term "adaptive" implies that both signaling and response are genetically programmed to some extent through natural selection.

Trophallaxis

This is a form of food transmission or exchange of food which is common between workers and also extends from workers to queen and drones. It serves as a means of communication regarding the availability of food and water, as well as a medium for the transfer of pheromones.

In honey bees, recruit communication is a crucial mode of communication which is defined as a communication that brings nest mates to a specific point in space where work is required. Dances performed by honey bees play a significant role in recruit communication.

Dances of Honey Bee

Father Spitzner, in 1788, was the first to describe bee dances as a method of communication among hive inhabitants, conveying information about the volume of honey flow and the location of nectar sources. These observations gained attention when Frisch (1920) published his findings. Karl von Frisch was awarded the Nobel Prize in 1973 (in Physiology & Medicine, shared with two other animal behaviorists) based on his work published in 1946.

Types of Dances

In honey bees, a portion of the foraging force (5-35%) functions as scout bees or searcher bees, covering considerable distances, with some traveling many kilometers. The average foraging radius of a colony is only a few hundred meters in agricultural areas and approximately 2 km in forested regions. Scouts communicate information about the distance, direction, and quality of flowers using different types of dances, leading to the recruitment of additional workers foraging on the best available sources.

Scout bees engage in two types of dances:

(1) Round dance

(2) Wag-tail dance

1. Round Dance:

This dance is executed when the food source is nearby (within 100 meters in the case of *Apis mellifera* and 10 meters in *Apis cerana*). The performing bee takes quick, short steps and moves around in narrow circles on the comb, alternating between right and left for several seconds. The dance excites the bees, prompting them to touch the performer with

their antennae before leaving the hive to search for the food source. There is no indication of the food direction in this dance, and foragers explore within 100 meters in all directions, guided by the floral odor clinging to the hairy body of the scout bee and the sips of nectar they receive during the dance.

2. Wag-tail Dance:

This dance is performed when the food source is more than 100 meters away from the hive. The bee starts dancing on the comb, creating a half circle to one side, takes a sharp turn, and runs in a straight line to the starting point. It then completes another half circle in the opposite direction to form a full circle. The bee runs in a straight line to the starting point, making wiggling motions with her body during the straight run, hence the name "wag-tail dance". The location of the food is indicated by the direction of the straight run in relation to the line of gravity. If the food aligns with the sun, the bee wags its tail upwards, and if it is away from the sun, it performs downwards. When the food source is to the left of the sun, the bees dance at an angle counter clockwise to the line of gravity, whereas if it is to the right of the sun, the bees dance to the right of the line of gravity (Figure 3).

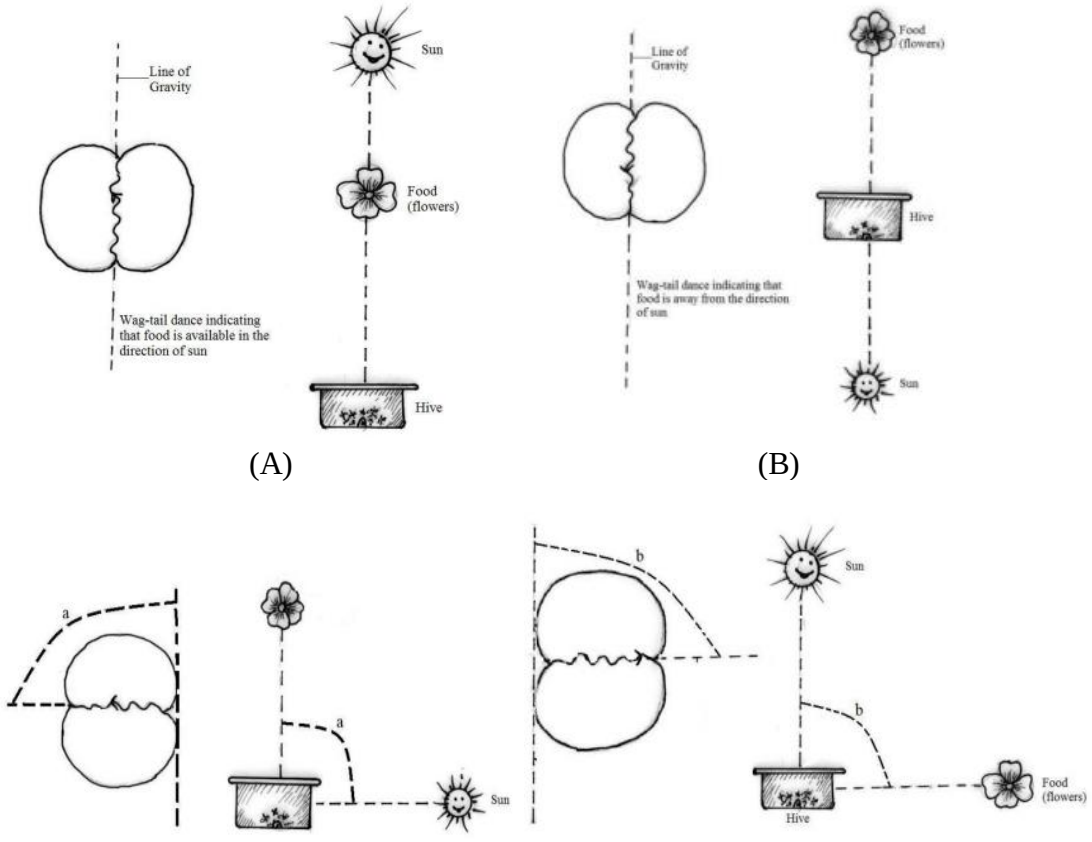

Fig. 3: Wag-tail dance in relation to direction of sun

(A). Direction indication in wag-tail dance when food is in the direction of sun

(B) Dance when food is away from direction of sun

(C). If food is to the left of the sun, bee dances at an angle counterclockwise to the line of gravity

(D). If food is to the right of the sun, bee dances to the right of the line of gravity

(Image source: J.K. Gupta; Apiculture, Agrimoon.com)

The distance is identified by the number of straight runs per 15 seconds as given below:

S. No.	Distance of food from hive (m)	No. of straight runs/15 sec.
1.	100	9-10
2.	600	7
3.	1000	4
4.	6000	2

Conclusion

Honeybee colonies remain active year-round and can be trained to pollinate specific crops. This training involves feeding the bees extracts of flowers from the target crop mixed with sugar syrup. As the bees become accustomed to the aroma of the crop, they visit the flowers, thus facilitating pollination.

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