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Effects of seasonal variations on the development of different castes of honeybees (*Apis mellifera*)

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Abstract
Apis mellifera is a bee species with three types of adults: a queen, hundreds of drones (males), and thousands of workers (sterile females). Both queens and workers are developed from fertilized eggs. The developmental stages of A. mellifera are divided into four phases: egg, larva, pupa, and adult. Queens are larger while drones are intermediate between queen and worker. The study examined the development of worker, drone, and queen bees, A. mellifera, at a local farmer apiary in Muzaffarpur, Bihar. Six colonies were installed and observed during the breeding season (November-January) and dearth period (July-September) between 2021-2022. The colonies were dequeened, inspected for eggs, and introduced to new queens. The queen's development was observed during the breeding season, with worker bees rearing new queens. The egg periods, larva periods, and pupal stages for workers, drones, and queens were 2.90±0.20, 3.06±0.07, 6.82±0.33, and 5.32±0.39, respectively during breeding season. Egg periods, larvae, and pupal stages were 3.09±0.05 days, 6.64±0.32 days, and 13.87±0.20 days, respectively, resulting in total developmental periods of 21.29±0.26 and 24.27±0.43 days during dearth period.

Keywords: *Apis mellifera*, larva, pupa, developmental period, breeding season, dearth season

Introduction
The developmental stages of different castes of *A. mellifera* are interesting examples of how environmental factors can influence the expression of genes and the emergence of phenotypes. *A. mellifera* is a highly eusocial species of bee that has three types of adults: a single queen, hundreds of drones (males), and thousands of workers (sterile females). The queen and the workers both are developed from fertilized eggs, but they differ greatly in morphology, physiology, and behaviour (Nelson, 1915; Winston, 1987) [11, 8]. The main factor that determines whether a female larva will become a queen or a worker is the type and amount of food that she receives from the nurse bees. Queen larvae are fed exclusively with royal jelly (RJ), a protein-rich secretion from the glands in the head of the nurse bees, while worker larvae are fed with worker jelly (WJ), a similar but less nutritious secretion, and later with honey and pollen. The RJ contains several components that can affect the development of the larvae, such as sugars, amino acids, vitamins, minerals, and hormones.
The developmental stages of *A. mellifera* are divided into four phases: egg, larva, pupa, and adult (Nelson, 1915; Schnetter, 1934; Fleig and Sander, 1986; Winston, 1987) [11, 5, 2, 8]. The egg stage lasts for about three days for both castes. The larval stage lasts for about five and a half days for queens and six days for workers. During this stage, the larvae undergo five moults and increase their weight by more than 1000 times. The pupal stage lasts for about seven and a half days for queens and 12 days for workers. During this stage, the larvae undergo metamorphosis and develop their adult structures, such as wings, legs, eyes, antennae, and reproductive organs.
The different developmental stages of *A. mellifera* result in significant differences between the castes in terms of anatomy and physiology. For example, queens are larger than workers, have longer abdomens, shorter wings, bigger ovaries, smaller brains, longer lifespans, and can produce pheromones that regulate the behaviour of the colony. Longer wing, shorter abdomen, shorter life span. Workers perform various indoor and outdoor tasks such as cleaning, nursing, building, guarding, communicating, and foraging. Drones are haploid males that develop from unfertilized eggs. They are intermediate between queen and worker, having bigger eyes and longer antennae than females (Seidl. 1980) [6]. Drones lack stingers and pollen baskets.

Present investigation was carried out to understand the development of A, mellifera in (i) the breeding season and (ii) the dearth period in changing climatic condition.

Materials and Methods

For the study of the development of *A. mellifera* (worker, drone, and queen bees), six langstroth colonies of equal (9 frames) strength were installed. Observations were conducted at a local farmer apiary in Muzaffarpur, Bihar. To understand the seasonal effect on the development of *A. mellifera*, observations were conducted in two periods: (i) the breeding season (November-January) and (ii) the dearth period (July-September) during 2021-2022.

First, the experimental colonies were dequeened, and after that, these colonies were inspected for 5 days to know about the development of eggs laid by the previous queen. After 5 days, fresh queens from other colonies were introduced to the experimental colonies. The colonies were then inspected daily until the queen laid eggs in a marked area (6*6 for workers, 8*8 for drones)**.**

The marked area for workers contained approximately 100 cells, and for drones, 81 cells. Five individuals from each marked area were observed daily. The development of the queen was observed during the breeding season only. As the colonies were dequeened, the worker bees started rearing new queens. When the queens were about to emerge**,** the mature queen cell had to be covered with a queen cell protector to prevent the other queen cells from being destroyed by the newly emerged queen.

Result and Discussion

The development of different castes (workers, drones, and queen bees) during the 2021–2022 breading season is presented in Table 1. The egg periods of workers, drones, and queens were 2.90±0.20, 3.003±0.08, and 3.06±0.07, respectively. Larval periods of workers, drones, and queens were 6.00±0.21, 6.82±0.33, and 5.32±0.39, respectively. The pupal stage comprises 11.17±0.06, 13.80±0.12, and 7.79±0.12 days in the case of worker bees, drones, and queens, respectively. Hence, the total developmental periods in the cases of workers, drones, and queens were 20.07±0.09, 23.64±0.38, and 16.17±0.43, respectively.

Table 1: Developmental stages of different castes of *A. mellifera* during breeding season

Breeding season					
Caste of *A. mellifera*		**Egg**	**Larva**	**Pupa**	**Total developmental period**
Worker	Mean	2.90	6.00	11.17	20.07
	SD (±)	0.20	0.21	0.06	0.09
Drone	Mean	3.03	6.82	13.80	23.64
	SD (±)	0.08	0.33	0.12	0.38
Queen	Mean	3.06	5.32	7.79	16.17
	SD (±)	0.07	0.39	0.12	0.43

The developmental stages of workers and drones during the 2021-2022 dearth season are presented in table 2. The egg periods of workers and drones were 3.09±0.05 and 3.05±0.05 days, respectively. Larval periods for workers and drones were 6.64±0.32 and 7.35±0.36 days, respectively. Pupal stages comprise 11.55±0.254 and 13.87±0.20 days in the case of worker bees and drones, respectively. Hence, the total developmental periods in the cases of workers, drones, and queens were 21.29±0.26 and 24.27±0.43, respectively.

Table 2: Developmental stages of different castes of *A. mellifera* during breeding season

Death season					
Caste of *A. mellifera*		**Egg**	**Larva**	**Pupa**	**Total developmental period**
Worker	Mean	3.09	6.64	11.55	21.29
	SD (±)	0.05	0.32	0.24	0.56
Drone	Mean	3.05	7.35	13.87	24.27
	SD (±)	0.04	0.36	0.20	0.43

It has been observed that the development periods significantly differ in breeding and dearth periods. It was longer during the dearth season (21.06±0.0.50 days) than during the breeding season (20.41±0.42 days) in the case of the development of workers. A similar trend of development was recorded in the case of drones. During the dearth and breeding seasons, it was 23.93±0.34 and 23.72±0.38 days, respectively. The developmental periods of queens of *A. mellifera* were 15.85±0.18 during the breeding season.

Hameed and Adlakha (1973) [3] found that *Apis mellifera* L. colonies had much higher egg-laying capacity and brood-raising capacity than *A.c. indica* colonies. Woyke (1976) [9] discovered that nectar and pollen flows had a direct effect on brood raising. Verma *et al*. (1988) [7] stated significant differences in different colonies in terms of honey yield/colony, pollen stores in square centimeters, areas under eggs, larvae, and sealed brood, total brood area in square centimeters, prolificacy (egg/day), and foraging behaviour (pollen loads/min.) in the Himachal Pradesh bee population. The queen bee took daytime flights (Woyke, 1975a) [10]. It took one or more orientation flights before mating at the age of 3–5 days. According to Woyke's research, the number of eggs deposited resulted in more larvae than the bees could rear. While the major nectar flow brought 95% of the larvae to the sealed brood stage, a moderate flow of pollen and nectar elevated just 50% of the larvae to the sealed brood stage. During a floral shortage, the queens continued to lay, but the larvae were all worker bees; thus, no brood was produced, and absconding colonies left viable eggs in the combs.

According to Chand *et al*. (2002) [1], the entire developmental period of *Apis cerana indica* F and *Apis mellifera* L workers and drones varies dramatically between breeding and dearth seasons. The worker's developmental time was 20.002 and 20.964 days, while the drone's developmental period was 23.53 and 24.016 days. The

overall developmental period in the breeding season for an *A. mellifera* queen was 15.912 days. In the breeding season, the developmental periods of *A.c. indica* were 19.110 and 19.922 days for the worker, 22.690 and 23.611 days for the drone, and 15.134 days for the queen.

Conclusion

Thus, it may be concluded that in the breeding season, the developmental period of both workers and drones takes less time than the dearth period. This may be due to the abundance of floral sources around the hive during the breeding period.

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