Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2018; 6(2): 352-355

Received: 25-01-2018
Accepted: 28-02-2018

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Pollen collecting activity of *Apis mellifera*

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Abstract
Present study revealed that a limited number of strong colonies of *Apis mellifera* when kept in any apiary with abundant bee flora in vicinity collected more amount of pollen and if the number of hives in apiaries were increased then pollen became a limiting factor. Surplus pollen stores in hives affected pollen gathering activity negatively, while pollen shortage in colonies gave a positive response. When sugar syrup was provided to pollen deficient colonies in pollen flow season then pollen collection increased significantly up to certain limits. There was a positive relationship between the amount of larvae and pollen collection. Empty raised sheets in hives, when present adjacent to frames having open brood stimulated pollen gathering. Moderate nectar flow stimulated pollen gathering up to a certain limit after that pollen and nectar collecting activity became independent from one another. Hives fitted with pollen traps and colonies with functional (right) queen helped to collect more pollen. Pollen collection stopped at 40 ^{O}C. Study also showed that pollen collecting behaviour might also be effected by genetic factors.

Keywords: Pollen foraging, stimulating feed, open brood, pollen trap, pollen stores

1. Introduction
Pollen is source of protein, fat, vitamins as well as minerals and is essential food for adult honeybees and larvae. Worker bees require a sufficient quantity of pollen to secrete royal jelly. Pollen mixed with honey is the food of drones. Ten amino acids are essential for the development of honeybees, brood rearing and reproduction [27]. Amino acid content in nectar is negligible, so pollen is the sole source of these amino acids. Observations showed that colonies lacking pollen had high worker mortality, no interest in queen-caring and remained weak [21, 22]. In natural setting, honeybees can obtain all the nutrients naturally. Unfortunately, modern agriculture has necessitated large scale mono-cropping which can be harmful for honeybees and other insect fauna. Amount of brood rearing is largely determined by pollen availability and one comb cell of pollen is required to rear one larva. Pollen is stored in small quantities as compared to honey. *A mellifera* workers adjust their pollen foraging activity according to requirements within the colony. It is a well-known fact that colony environment affects the colony level and individual foraging activity [13]. The quantity and quality of pollen stored in the colony is considered an important parameter to effect pollen collecting activity and addition or removal of the pollen stores, altered pollen foraging significantly [37] Mechanism of pollen foraging regulation in honey bees is complicated and remains controversial. The present study is an attempt to know various factors which are responsible for the pollen gathering activity so that extra pollen collected may be preserved for dearth periods. As pollen forager bees are good pollinators, so such type of study may help to increase crop yield and hybrid seed production as well as to flourish apiculture.

2. Materials and methods
Experiments were conducted in already running apiaries of *Apis mellifera* under Punjab conditions during 2016-17. Area under pollen stores and open brood in hives was measured with wire grid made on a frame. Selected colonies were provided with 50 per cent sugar syrup (stimulating feed) when pollen providing crops were available in the vicinity of apiaries. Effect of amount of larvae, empty raised frames, pollen deficiency and surplus pollen in colonies on pollen collection was noticed. Pollen gatherers were noted by closing the hive entrance (fig.1) for five minutes at various hours of day.

Fig 1: Hive entrance closed to count pollen foragers

Pollen foraging activity of *A mellifera* on *Brassica napus* (in Feb.) as well as on weeds like *Cyperus rotundus* L., *Trianthema portulacastrum, Parthenium hysterophorus* and *Cannabis sativa* in dearth period (May and June) at various hours of day was recorded. Thus effect of temperature on pollen foraging was observed. Temperature was measured with dial thermometer. The bees coming with pollen pellets were captured with forceps at hive entrances, their pollen loads were removed with camel hair brush in watch glass and weighted with the help of electronic balance. Queen-less and queen-right colonies were also compared for pollen collection. The colonies which were similar in almost all respects, present in the same apiary in the same agro-ecosystem were compared for stocked pollen to study the effect of genetic variations on pollen gathering behaviour. Effect of colony strength, number of colonies in different apiaries, empty comb space, pollen trap, direct access of bees to pollen stores and the larvae was observed. The data collected was consolidated, analyzed statistically and results were calculated.

3. Results and Discussion

Observations revealed that the apiaries with 150 or more colonies, pollen collection was lesser and area under pollen store was only 700 (Standard Error 100.5) cm^2/colony, while small apiaries having up to 50 hives, pollen storage (Fig.2) was significantly higher [1600 (SR 204.5) cm^2/colony].

Fig 2: Comb packed with pollen

Actually the stocking rate of pollen in hives under similar floral conditions depended upon the amount of food (pollen and nectar) available to each colony. The greater the number of hives in the apiary more were the chances of pollen being limited, while smaller apiaries hardly suffer pollen shortage under similar conditions. The relationship between the pollen collection and the availability of floral resources has also been reported earlier [15]. The findings are very much similar to those of other workers [28, 30]. If pollen stores were surplus or made surplus [on average 2000 (SR 204.5) cm^2] by the addition of pollen filled frames, then the number of foragers decreased [average 6 (SR 1.3) bees/5 min.] considerably as compared to control [9 (SR 1.50) foragers/5 min.]. Such activity increased [13 (SR 2.01) bees/min], when pollen stores were removed from the colonies under experiment. A decrease in pollen gathering activity in response to the addition of pollen in colonies and vice versa had been observed in many experiments in past [17]. Similar type of observations were also confirmed by many other workers [13, 15, 18, 32]. But present observations are in contrary to that of some other researchers, who noted an increase in pollen collection activity with increasing pollen stores in bee hives [29].

When the sugar syrup (simulative feed) was given to experimental colonies and pollen providing flora was abundant in the vicinity then amount of pollen collection [1160 (SR 103.2) cm^2/colony] increased considerably as compared to control [900 (SR 21.5) cm^2]while reverse was true when a pollen substitute was given to experimental colonies. Since the energy intake is important, it may affect pollen collection to some extent, as also been concluded by some workers [43]. But the observations are in contrary to those of another author who concluded that giving carbohydrate to colonies did not influence pollen foraging [17]. There was a direct relationship between area under the larvae (Fig. 3)

Fig 3: Comb having larvae and.

and pollen stored in the colony. When the more amount of larvae (frames with open brood) were added to experimental hives then collection of pollen [2200 (SR 203.03) cm^2/colony], number of pollen foragers [10 (SR 0.32) bees/5 min.] and the amount of pollen load/bee[9.50 (SR 0.53) mg] also increased significantly in such colonies while these values were 900 (SR 21.5) cm^2, 9 (SR 1.5) foragers/5 min. and 7.5 (SR 0.15) mg/bee respectively in colonies under control,during blooming season of *Brassica napus*. So the presence of larvae acted as a positive stimulus and increasing quantity of larvae stimulated more pollen foraging activity. It might be due to the fact that larval pheromones excited bees to collect more amount of the pollen and the foraging activity of individual foragers was increased. Similar type of conclusions were drawn by many workers [33-35]. Availability of empty comb area, amount of pollen and open brood (larvae) interacted with each other for pollen collection activity. When frames with raised and empty sheets were

placed adjacent to open brood, then pollen was collected and stored more rapidly which was almost double as compared to that of normal. This means direct access to pollen stores or larvae was necessary to collect more pollen in a colony. Moderate nectar flow effected pollen collection positively up to some extent but further increase in nectar or honey in a hive had no effect on pollen collection. Above mentioned activities (pollen and nectar foraging) became independent from one another provided; sufficient storing space was present in hives. These findings are in line with observations of some other authors [4, 5, 16, 23, 43].

Experiments also showed that pollen foraging also increased in hives fitted with pollen traps (Fig.4).

Fig 4: Pollen trap fixed at hive entrance.

The reason being that pollen got collected in pollen traps while its requirement inside the hives got increased. To fulfill the colony needs urge for pollen collection got enhanced. It was also recorded that pollen collection stopped at 40^{O}C. Observations were taken during dearth period (May and June) on pollen foraging activity of *A. mellifera* on *Cyperus rotundus* L., *Trianthema portulacastrum* and *Parthenium hysterophorus* which showed that above mentioned activity took place during morning hours from 0540-0900, 0730-1020, and 0800-0845 hours, respectively. No such activity took place during hot hours of the day (above 40^{O}C). Pollen foraging on *Cannabis sativa* took place during morning and evening when the temperature was comparatively lesser. Such observations were already been confirmed by same author [9-12]. Maximum pollen collection was noted from 1200 to 1400 hours at midday in winter when the temperature was 25-30^{O}C in case of *B.napus*. Similar type of results were also given earlier [3, 26, 42, 44, 45]. However such behaviour might be due to time related plant physiology, instinct responses of honey bees and environmental factors. Temperature seemed major factor influencing pollen foraging. Similar conclusions were drawn by other workers [31].

Queen-less colonies gathered more (about double) honey stores and pollen collection decreased to one fourth as compared to control hives. The reason behind it was, when the queen was absent then egg-laying and brood rearing did not take place. So no royal jelly was required, thus demand for pollen and pollen collection decreased significantly. Such observations were also reported earlier [17]. It was also noticed that colonies in same apiary, which were similar in all respects collected significantly different amount of pollen, which indicated that pollen collecting activity might be controlled genetically (genetic variation). Similar types of ideas have also been given by many workers [6-8, 14, 19, 20, 25, 36, 38, 39].

4. Conclusion

From above discussion it may be concluded that for more pollen collection, number of colonies in the apiary must be according to the availability of floral rewards in the vicinity. Decrease in the pollen collection was recorded in the apiaries with more number of colonies. Removal of extra pollen stores from hives, providing empty comb adjacent to open brood, more area under larvae, fertile queens in colonies, abundant pollen providing flora in vicinity and suitable temperature helped to collect the more amount of pollen. Honeybee colonies with natural instinct (genetic) to collect comparatively more amount of pollen may be selected for breeding to increase the pollen yield of apiaries. Collected pollen should be preserved and used to serve colony needs during dearth periods in the future. Food supplements and other valuable products are also prepared from pollen for human consumption. Thus present study will help to make apiculture more profitable. As pollen gatherers are also efficient pollinators, research will go in long way to make crop pollination programme more successful along with establishment of beekeeping.

5. Acknowledgment

Author is extremely thankful to Prof. O. P. Agarwal, S.O.S.in Zoology, Jiwaji Universty Gwalior and DR. R. C. Mishra, Former Executive Director, National Bee Board, New Delhi for providing profound knowledge regarding various aspects of apiculture.

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