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Studies on correlation coefficient (r) between different parameters of *Apis mellifera* queen-less colonies in Mid Hill of North West Himalayas

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Abstract
The study was conducted to determine Correlation coefficient (r) between different parameters of *Apis mellifera* queen-less colonies under the conditions of Kangra valley. *Apis mellifera* Linnaeus colonies of different strength viz. 4, 8, 10, 12 bee frames covered with bees frames using modified Doolittle method of queen rearing was assessed. Per cent queen cells finished were found to be significantly correlated with strength of the colony i.e. frames covered with bees as well as weight of bees, area of sealed brood in a colony and consumption of sugar syrup (r = 0.8254, 0.8355, 0.6625, respectively). The same colony can be used both as starter as well as finisher colony.

Keywords: Honeybees, beekeepers, *Apis mellifera,* queen less.

1. Introduction
Honeybees play a vital role in the pollination of large numbers of agricultural and horticultural crops. As a matter of fact, the main significance of honeybees and beekeeping is pollination, whereas hive products like honey, wax, pollen, royal jelly, bee venom propolis, etc are of secondary value. Many agricultural and horticultural crops do not yield seeds or fruits without cross-pollination of their flowers by honeybees and other insects.
Beekeeping is an environment friendly, agro-forestry based, traditionally adopted occupation among the mountain communities and is the part of natural and cultural heritage [1-4]. The queen holds the most important position in the colony of honeybee. Many techniques of rearing queen bees have been developed to allow beekeepers to reproduce a good stock to replace old or undesirable queens in their colonies, or to start new colonies [5]. For the successful rearing of the queen bee, it demands suitable conditions. The quality of the queen bee determines the benefits received from honey bee colony as through the queen, via its progeny, the productivity, temperament and behavior of the colony can be manipulated by the beekeeper. There are various environmental factors which affect the quality of the queen bees, as well as the rearing season and the rate of queen development is also influenced by the meteorological conditions [6, 7]. The aim of the present investigations was to study the correlation coefficient (r) between different parameters of *Apis mellifera* queen-less colonies.

2. Material and methods
Correlation study of different (11) parameters of queen-less colonies were carried out during 2013-14 at the Bee research station Nagrota Bagwan, CSKHPKV, Palampur altitude 907.31 m amsl, between 32º07′ North latitude and 76º24′ East longitude.

2.1 Equipments used: Standard Langstroth hives, which accommodate 10 full depth frames in each brood and supers, placed on iron stand of about 23 cm height were used. Queen excluders, having a wooden frame with the dimensions of super in length and width were used between the brood chamber and super to restrict the queens in the brood chamber in queen right colonies. Wooden, full depth standard Langstroth frames modified to hold two wooden ‘cell bars’ hanged at a distance of about 5.5 cm from top bar and 6 cm from each other on side bars were used. Each cell bar was fastened with 1 cm thick wax strip base to hold queen cell cups with grafted larvae in the brood nest for the development. For the preparation of ‘queen cell cups’ and wax strips as ‘base for the cell cup’, clean bee wax was used.

A wooden dipping stick about 10 cm long (A.I. Root, USA), having 9.5 mm diameter at a point 12 mm from the tip tapering to 8 mm at the tip as described by [8] was used to prepare the queen cell cups. 'Chinese push in grafting needle' was used for grafting larvae in the queen cell cups. White crystallized sugar was used to prepare 60%. Solution for artificial feeding to the colonies during the course of queen rearing. Old, dark coloured *A. mellifera* worker combs were used to obtain the larvae of the desired age for grafting. Fine nylon net bags (75 cm x 40 cm), funnel (fabricated with GI sheet) and a bee brush in addition to hive tool and bee-veils, etc. were used to dislodge and collect the honey bees of a colony to weigh them.

2.2 Data recording: The builder cum finisher colonies were inspected to record colonies' parameters *viz.* colony strength, brood area and weight of the bees. The strength of the colony was recorded taking an account of frames visibly fully covered by bees. Brood area in the colony was estimated by measuring its length and breadth on different frames with a scale. Total bees (without queen bee) in a colony were dislodged by shaking them over GI funnel fitted with a nylon net bag of known weight. Remaining foragers coming to colony and accumulated there during next ½ h were re-shaken into another bag of known weight. All of the bees were weighed and released back to the parent colony.

A mug containing 1 liter of 60% sugar syrup and marked with the level on the wall of mug was placed inside the colony near to bees i.e. touching its edge to the combs. At an interval of 24 h the consumed sugar syrup was replenished to its old level by pouring measured quantity of the syrup. The added quantity was recorded daily. In a colony having no space left in the brood chamber, super was added to accommodate the feeding mug.

The builder cum finisher colony were adjusted as H, P, SB, EB, YL, GL, P, OL, EB, H

Where (H = honey frame, P = pollen frame, SB = sealed brood, EB = emerging brood,

YL = young larvae, GL = grafted larvae, OL = old larvae) to attract nurse bees for initiating and nursing the grafted larvae [8-10].

The larvae grafted in the cups were inspected on the 3rd day of grafting. These were considered 'accepted' when the larvae remained in the cup and fed by the bees. When the cup was found sealed, it was considered as 'Finished cell'. The Depth (rim to inner bottom of the cell) and outer width of the queen cell were measured with Vernier caliper after the queen has emerged out of it. To record the weight of the queen, it was taken out of colony after one day of its emergence. Then it was placed in a vial of known weight and weighed.

Statistical analysis: The recorded data was subjected for correlation analysis and Regression analysis of the different colonies parameters. Significance of the correlation coefficient was evaluated through t test at 5% probability.

Plate 1.1: Queen Cell starter cum finisher colony

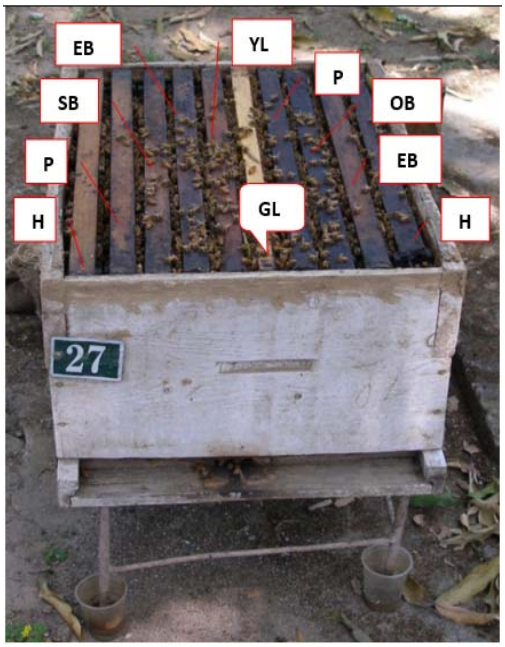

Plate 1.2: Queen rearing

Location of different provisions and grafted larvae in *A. mellifera* cell builder cum finisher colony

(H = honey frame, P = pollen frame, SB = sealed brood, EB = emerging brood,

YL = young larvae, GL = grafted larvae, OL = old larvae)

3. Results

The analysis of the data revealed significant correlation coefficients (r) between queen cells finished (both in queen cell cups distanced at 2 cm as well as 1.5 cm or in total cups and cups in total) and strength of the colony i.e. frames covered with bees (0.8217, 0.7680, 0.8254) or weight of bees (0.8414, 0.7564, 0.8355), area of sealed brood (0.6361, 0.6669, 0.6625) in a colony, and consumption of sugar syrup (0.6883, 0.6678, 0.6994). Significant correlation had also been depicted between finished queen cells distanced at 1.5 cm or total finished cells and width of the queen cells (0.7329 and 0.6465). Also, Significant correlation had also been depicted between brood in a colony (both in unsealed brood as well as sealed brood or in total brood and brood in total) and weight of bees in colony (0.5689, 0.7449, 0.8330). Significant correlation coefficients (r) between sugar syrup consumed and strength of colony, weight of bees, sealed brood, total brood in colony (0.7529, 0.6712, 0.9350, 0.6679) (table 1.1).

Table 1.1: Correlation coefficient (r) between different parameters of colonies, queen cell cups finished, queen cells size and weight of emerged queens in queen-less colonies

	Weight of bees in colony (g)	Unsealed Brood in a colony (cm^2)	Sealed Brood in a colony (cm^2)	Total brood in a colony (cm^2)	Queen cell cups finished 2.0 cm (%)	Queen cell cups finished 1.5 cm (%)	Total queen cell cups finished (%)	Depth of queen cell (mm)	Width of queen cell (mm)	Sugar Syrup Consumed (litre)	Weight of Queen (mg)
Strength of colony (BF)	0.9805*	0.5481	0.8253*	0.8676*	0.8217*	0.7680*	0.8254*	0.0808	0.3692	0.7529*	-0.3041
Weight of bees in colony (g)		0.5689**	0.7449*	0.8330*	0.8414*	0.7564*	0.8355*	0.1395	0.3536	0.6712**	-0.2405
Unsealed Brood in a colon (cm^2)			0.2239	0.8080*	0.1962	0.0864	0.1656	0.0657	-0.113	0.1526	-0.4689
Sealed Brood in a colony (cm^2)				0.7552*	0.6361**	0.6669**	0.6625**	0.1855	0.2701	0.9350*	-0.0305
Total brood in a colony (cm^2))					0.5165	0.4613	0.5119	0.1563	0.0875	0.6679**	-0.3338
Queen cell cups finished 2.0cm (%)						0.8855*	0.9885*	-0.1383	0.5827	0.6883*	-0.2525
Queen cell cups finished 1.5 cm (%)							0.9455*	-0.1080	0.7329*	0.6678**	-0.0411
Total queen cell cups finished (%)								-0.1320	0.6465**	0.6994*	-0.1903
Depth of queen cell (mm)									-0.5084	0.1248	0.4367
Width of queen cell (mm))										0.2109	0.0717
Sugar Syrup Consumed (litre)											-0.1657

* p ≥ 1%, ** p ≥ 5%, d f. = 11

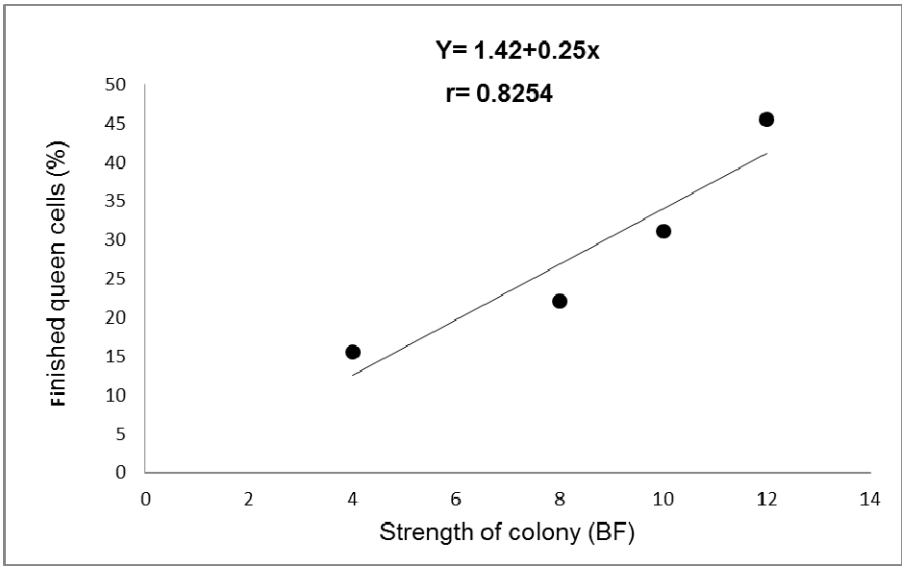

Fig 1.1: Regression line between strength of queen–less colonies and queen cells finished by them

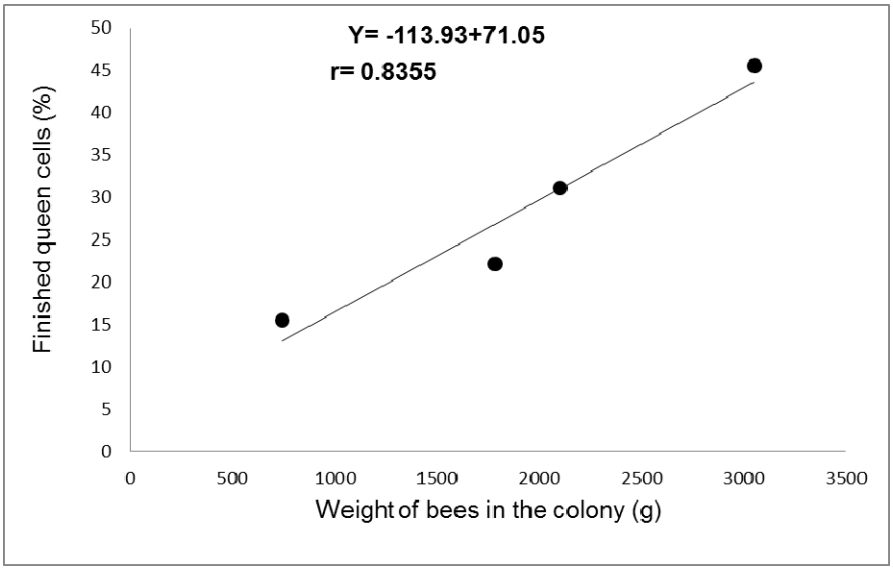

Fig 1.2: Regression line between weight of bees in queen–less colonies and queen cells finished by them

4. Discussion

The increasing number of finished queen cells with the increase of strength of colony (frames covered with bees as well as total weight of bees in colony) resulting in significant positive correlation emphasized that stronger colonies reared more number of queen cells than the smaller ones (Table 1.1). The relationship per cent finished queen cells on frames covered with bees can be expressed mathematically with the linear regression equation y = 1.42 + 0.25x and per cent finished queen cells on strength of colony in term of weight of bees and with the equation y = -113.93 + 71.05x (Fig. 1.1 & 1.2).

Positive correlation between weight of the queen with depth and width of finished queen cell, depicted that the size of the finished queen cells influenced emerging queen's weight to some extent and ultimately appeared to corroborate the influence of size of queen cell cups on queen weight observed by [11,12].

5. Conclusion

It can be deduced that good queens can be reared under conditions of Kangra valley during spring season using single story hive serving both queen cell builder as well as queen cell finisher colony.

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