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Brood rearing efficiency in indigenous honeybee *Apis cerana* in Kullu valley of Himachal Pradesh

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Abstract
The present study on brood rearing efficiency was conducted at Katrain in Kullu Valley of Himachal Pradesh, India, situated at 32.1^0 N and 77.2^0 E longitude with an altitude of 1473 m amsl. The field experiments at Katrain, Kullu showed 20 to 100 per cent variations in per cent brood survival rate during different periods of observation. Studies on brood rearing efficiency revealed that per cent adult emergence on egg basis during the months of March and August averaged to 55.22 and 61.22 respectively. The per cent adult emergence from sealed brood was observed to be 70.08 $\pm$ 22.86 and 90.20 $\pm$0.59 during March and August, 2010-11 respectively. The variations exhibited by the *Apis cerana* colonies on these two parameters at the same locality during the different periods of observation cannot be accounted for the inherent factors alone.

Keywords: Brood survival rate, brood rearing efficiency, *Apis cerana*, Indian Himalayas

Introduction
The Indian hive bee, *Apis cerana* F. is found almost in all parts of the country, except perhaps the cold and hot deserts because of non-availability of flora. Beekeeping with *A. cerana* is a common practice among rural communities in India. Indigenous methods of keeping bee colonies in log and wall hives are still common in Himachal Pradesh despite the fact that modern beekeeping started here in 1934 (Sharma *et. al*., 2000) [1]. Himachal Pradesh is very rich from the bee resources point of view. There are at present four species of the *Apis.* Of these, *A. cerana* F., *A. dorsata* F., *A. florea* F. are native to India and *A. mellifera* L. was introduced in the country during 1960's (Atwal and Goyal, 1973) [2].

Apis cerana has many valuable characteristics of biological and economic importance. These include their industrious nature, being less prone to the attack of wasps, and a high level of resistance to nosema disease and ectoparasitic mites, *Varroa jacobsoni* and *Tropilaelaps clareae* that plague *A. mellifera*. However, this native hive bee species has not been popular amongst the beekeepers because of several behavioural characteristics like frequent swarming, absconding, tendency to rob, production of a large number of laying workers, and low honey yield. There was another blow to beekeeping with *A. cerana* due to epidemic of Thai sac brood disease in 1984-85 which killed more than 95 per cent of the colonies in the state (Rana, 1987) [3] resulting in the loss of valuable genetic material. Due to all these factors, at present, there were only few colonies of *A. cerana* in the modern hives in the state (Rana *et. al*., 2000) [4] and beekeeping with *A. cerana* has been replaced to a great extent by exotic *A. mellifera*, since the latter performs excellent in areas having abundance of bee flora and intense honey flow. But in most parts of Himachal Pradesh beekeeping with *A. mellifera* is successful only by adopting migratory beekeeping. On the other hand *A. cerana*, being frugal in its requirements, exploits every available flora and can even work in areas not very rich in bee flora. Moreover, in Himachal Pradesh, *A. cerana* is the only bee species widely spread in the forest areas since *A. dorsata* and *A. florea* are highly migratory and are mostly confined to low lying areas. The colonies of *A. mellifera* are restricted only to modern hives. Hence *A. cerana* plays an important role even in forest ecosystem for maintaining biodiversity. Due to promotion of beekeeping with *A. mellifera,* the population of *A. cerana* is declining rapidly threatening its existence in the Himalayan region.

Honey production in a bee colony largely depends on its population which in turn is dependent on brood rearing efficiency. In the plain variety of *A. cerana*, Woyke (1976) [5] has reported scattered brood due to low level of brood rearing efficiency which could be due to irregular egg laying, high degree of inbreeding or some other reasons. Since the present population of *A. cerana* has come from mere 1 to 5 per cent of the colonies which escaped the wrath of Thai sac brood, chances of inbreeding become more. Hence, it will be useful to study brood rearing efficiency of the present stock of *A. cerana*.

The efficiency of brood production in a honeybee colony has a direct influence on worker population and because of this it also affects honey production and queen and drone rearing, as well as further brood production. Studies on the brood survival rate in case of *A. cerana* are lacking except for the work of Woyke (1976) [5]. He reported that the brood of *A. cerana indica* (plain variety) was very scattered. It was found that scattered brood was caused by the fact that many larvae were not reared to sealing stage. This was mainly due to interaction between pollen availability and unknown internal colony factors, which were responsible for the great variations between individual colonies. Main cause of the scattered brood as reported by Woyke (1976) [5] was that the number of eggs laid gave rise to more larvae than the bees could rear, particularly during poor pollen flow. The workers are reported to eat older larvae and produce royal jelly for feeding the queen and young larvae. However, the impact of sex alleles (*i.e.* inbreeding) as determined for *A. mellifera* has not been studied in *A. cerana*. The research work was therefore conducted with the objective of understanding brood rearing efficiency of *A. cerana* in Kullu valley of Himachal Pradesh.

2. Material and methods

The present investigations were carried out in the apiaries of Regional Horticulture Research Sub-Station of Dr. Y.S. Parmar University of Horticulture and Forestry at Katrain, Kullu situated at 32.1ºN and 77.2ºE longitude with altitude of 1473 m amsl under the DST project during the year 2010-11. The methodology followed for the present investigations is as follows:

One centimeter wide plastic strip, was fixed firmly between the top and bottom bars of the experimental brood frame for marking the cells, Row numbers of cells were written on the strip. Brood frames prepared in this manner were placed in the centre of brood nest of the experimental colonies for egg laying by the queen. On the next day, marked frame was removed and cells containing eggs were counted and marked (recording row number and cell number) for the presence of eggs. For determining brood rearing efficiency of each colony, eggs in the frames were marked. Observations on the number of eggs hatched, number of larvae sealed and number of adults emerging from the sealed cells were recorded. Brood rearing efficiency was determined for six and five colonies during the months of March and August. Time taken by a worker bee to develop from egg to the adult stage was recorded. Emergence of adults on egg basis was also calculated. Data was recorded during the months of March (after winter) and August (autumn).

The data were statistically analyzed using Randomized Block Design, after undertaking the necessary transformations (Gomez and Gomez, 1984) [6]. The other statistical tests viz., t-test, standard errors, coefficient of variation and correlation were also used for analysis of the data.

3. Results and Discussion

This experiment was conducted to understand the brood rearing efficiency and the results obtained are presented in tables 3.1 and 3.2. The results are discussed as follows:

3.1 Brood rearing efficiency at Katrain during the month of March

Observations recorded during March, 2011 indicated that the egg hatch in 6 different colonies ranged between 12.38 to 82.07 per cent with an average value of 44.78 ± 11.46 per cent. The number of larvae sealed in different colonies ranged between 0 to 92.10 per cent. Only two colonies viz. 3-K and 12-K had high level of larval sealing (92. 10 and 91.22%). On an average, larval sealing was to the level of 42.54 ± 17.54 per cent. Adult emergence from the sealed brood ranged between 0 to 100 per cent with an average value of 70.08±22.86 per cent. There was no adult emergence in four colonies (2-K, 6-K, 10-K and 17-K) while in one colony (12-K), it was 100 per cent. If adult emergence is calculated on egg basis, it was 54.54 and 55.91 per cent (with an average value of 55.22 per cent) in 3-K and 12-K, respectively.

Table 3.1: Brood rearing efficiency of *A. cerana* colonies at Katrain (District Kullu) during the month of March

Colony number	Egg hatch (%)	Larvae sealed (%)	Adult emergence from sealed brood (%)	Percent adult emergence on egg basis
2-K	31.30	10.00	0	0
3-K	69.09	92.10	85.71	54.54
6-K	28.03	27.02	0	0
10-K	12.38	0	0	0
12-K	67.74	91.22	100	55.91
17-K	82.07	21.17	0	0
Mean	44.78	42.54	70.08	13.35
S.E (±)	11.46	17.54	22.86	

3.2 Brood rearing efficiency at Katrain during the month of August

Observations recorded on the five colonies during the month of August indicated that the egg hatch ranged between 66.66 to 100 per cent with an average value of 80.23 ± 6.60 per cent. Only one colony (2B-K) had 100 per cent egg hatch. Level of larval sealing in different colonies ranged between 54.41 to 100.00 per cent with an average value of 84.60±8.26 per cent. Only one colony (2B-K) had cent per cent larval sealing. The adult emergence from the sealed brood in different colonies ranged between 88.88 to 91.89 per cent with an average value of 90.20 ± 0.59 per cent. Emergence of adults on egg basis during this month ranged between 30.90 to 91.66 per cent with an average value of 61.22. Colony number 2B-K had maximum per cent adult emergence (91.66%).

Table 3.2: Brood rearing efficiency of *A. cerana* colonies at Katrain (District Kullu) during the month of August

Colony number	Egg hatch (%)	Larvae sealed (%)	Adult emergence from sealed brood (%)	Percent adult emergence on egg basis
2B-K	100.00	100.00	91.66	91.66a
6-K	67.27	54.41	91.89	30.90
12-K	76.23	88.73	88.88	55.44
13-K	90.84	97.82	89.62	79.08b
16-K	66.66	90.90	90.00	50.00
Mean	80.23	84.60	90.20	61.22
S.E (±)	6.60	8.26	0.59	

Brood survival rate and brood rearing efficiency are two different parameters for studying brood rearing in honey bee colonies, the former restricted mostly to disappearance of young worker brood whereas the latter for level of adult emergence from the laid eggs. The results revealed that per cent adult emergence on egg basis during March month at Katrain averaged to 55.22 per cent. In some colonies. there was no adult emergence though sealed brood was present in these colonies. The survival level of larvae at hatching stage averaged to 44.78 ±11.46 per cent, at sealing stage 42.54 ±17.54 per cent and at adult emergence from the sealed brood averaged to 70.08 ± 22.86. Similarly, during August month adult emergence averaged to 61.22 per cent. Here, egg hatch averaged 80.23 ± 6.6 per cent, larvae sealed 84.6 ± 8.26 per cent and adult emergence from the sealed brood as high as 90.2 ± 0.59 per cent. These observations, thus, point out that brood rearing efficiency of the *A. cerana* colonies varied at the same locality during different periods of observations and thus it cannot be accounted for the inherent factors.

4. Conclusion

The efficiency of brood production in a honeybee colony has a direct influence on worker population and because of this it also affects honey production and queen and drone rearing, as well as further brood production. Brood survival rate and brood rearing efficiency are two different parameters for studying brood rearing in honeybee colonies, the former restricted mostly to disappearance of young worker brood, whereas, the latter for level of adult emergence from the laid eggs. Studies on these two important aspects in case of *Apis cerana* F. are lacking for the hilly and mountainous areas of India. By combining different strategies economical beekeeping may be possible with *A.cerana* on small scale at farmers'/orchardists' level.

5. References

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