



Research Article

FEEDING PREFERENCE OF INDIAN HONEYBEE *Apis cerana indica* F. ON DIFFERENT POLLEN SUBSTITUTE DIETS

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Abstract- The study was carried out in Department of Agricultural Entomology Tamil Nadu Agricultural University, Coimbatore during 2014-15 to find out the feeding preference of Indian Honey bee (*Apis cerana indica*) on different pollen substitute (PS) diets, which resemble natural pollen in nutritional values. For preparing pollen substitute diets locally available nutritional rich ingredients was selected such as pulses powder along with skimmed milk powder, Honey, Glucose and powdered sugar. It was found that red gram based diet was more alluring to the honey bees compared to other formulations, as the colonies fed with Parched red gram flour (PRGF) based PS recorded the lowest number of days to consume the diet with a mean of 5.2 days followed by Parched bengal gram flour (PBGF) based diet (5.9 days) Parched horse gram flour (PHGF) based diet took longest time (7.3 days). In the case of number of bees feeding on each diet PRGF based diet was consumed rapidly compared to other diets with a mean of 41.5 bees per day followed by Parched black gram flour (PBGF) based and PBeGF based PS with a mean of 38.3 and 35.8 bees per day respectively. Honey bees preferred the PS diets provided on 1.5 mm nylon compared to butter. Sugar feeding can also be given in dearth periods along with PS diets.

Keywords- Pollen substitute, Diet, *Apis cerana indica* and Parched redgram flour, Artificial feeding

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Introduction

Bee keeping is a vital and longstanding practice, which helps in enrichment of crop yield through pollination services. Honey bees depend on pollen and nectar for their food but these provisions are not available to the bees right through the year [1], which causes the depletion of the on hand honey stores in the colony. There may also be a shortage of pollen, bees then reduce the amount of brood that they rear [2, 3]. So quick dwindling and perishing of honey bee colonies have been observed due to non-availability of flowers and rapid consumption of stored honey and pollen. The natural bee flora starts disappearing in the month of April causing dearth of food (pollen and nectar) for bees. The periodical dearth periods of pollen result into low nutritional reserves, which adversely affect the colony performance due to stoppage or reduction of egg laying and brood rearing. As the Honey bee absconds due to non-availability of food resources and depletion of food reserves [4,5], the best way to maintain the honey bee colonies and bee health is to substitute the natural resources with artificial diets such as pollen substitutes (PS). Some of the experiments were conducted on pollen substitutes for *A. mellifera* [6, 7], but the practice of feeding *A. cerana* with pollen supplement or substitute has been hardly done by beekeepers in India [8-10]. So in the preset study different pulses based pollen substitute diets were prepared which are in par with nutritional value of natural pollen. An attempt was made to study the feeding preference of Indian honey bee on different pollen substitutes.

Materials and Methods

The experiment was conducted in the Apiary, Department of Agricultural Entomology maintained in the botanical garden, TNAU, Coimbatore.

The following pollen substitute treatments on weight basis were administered to three colonies in each treatment, which served as replicates

T1-	Defatted soya flour 23% + skimmed milk powder 27% + sugar 5% + glucose 10% + honey 35% (DSF based diet)
T2-	Parched red gram powder 26% + skimmed milk powder 24% + sugar 5% + glucose 10% + honey 35% (PRGF based diet)
T3-	Parched bengal gram powder 26% + skimmed milk powder 24% + sugar 5% + glucose 10% + honey 35% (PBeGF based diet)
T4-	Parched black gram powder 26% + skimmed milk powder 24% + sugar 5% + glucose 10% + honey 35% (PBGF based diet)
T5-	Parched green gram powder 26% + skimmed milk powder 24% + sugar 5% + glucose 10% + honey 35% (PGGF based diet)
T6-	Parched horse gram powder 26% + skimmed milk powder 24% + sugar 5% + glucose 10% + honey 35% (PHGF based diet)

The pulse grains were parched before powdering and passing through sieve so as to get fine powder and the feeding preference of the honey bee was studied.

Days to consume the diet

The number of days taken by bees to consume the diet fully was recorded. Observations were recorded on daily basis to find out which diet is consumed fully. The number of days taken to complete the diet can be an indication of its palatability and feeding preference to bees

Choice test for finding feeding preference of honey bees

Feeding preference of honey bees was tested by providing simultaneously all the

six different diets in the form of patties, 2g each placed on the top of brood frames in a choice test to find out the most preferred diet to the bees. Three hives were used as replications. The following observations were recorded

Number of bees feeding on each diet

The number of honey bees feeding on each diet was observed on day 1 and day 2 after providing the diet. The diet, which had greater number of bees, was considered to be more preferred food for the bees.

Feeding preference by Indian bees on PS provided on different media

Based on literature it was found that butter paper was the most common medium on which PS was provided to honey bees. Disadvantage with use of butter paper for providing PS was the honey bees chewed the paper and the litter was found on the bottom board which also attracted the wax moth to lay eggs. So a medium which cannot be chewed by honey bees was selected; a nylon mesh of 1.5 mm size was compared with butter paper. The number of days taken by bees to consume the diet was recorded to know which medium is suitable for providing the PS.

Experiment to find effect of providing sugar solution on consumption of pollen substitute

Honey bees collect nectar and pollen from flowers. During the period of dearth the

bees may be starved of either pollen or nectar or both. Providing sugar solution by mixing sugar and water in the ratio of 1:1 is practiced by beekeepers to fulfil the nectar requirement of bees. It is essential to find out if providing pollen substitute will affect the consumption of sugar solution or pollen vice-versa. Hence an experiment was done by providing both sugar solution and PS simultaneously to honey bees and comparing with provision of sugar solution and pollen substitute on different days. The days taken to consume the two forms of food were recorded. This experiment will help to plan the schedule of providing sugar solution and pollen substitute

Results

Days to consume the diet

The number of days to consume/ hoard each diet was recorded in all the six months of observation [Table-1]. Among the treatments, colonies fed with PRGF based PS recorded the lowest number of days to consume the diet with a mean of 5.2 days followed by PBGF based diet (5.9days), PBeGF based diet and soya based diets (both in 6.1 days). Diet consumption was rapid in the months of October and November 2014 with mean values of 3.6 and 3.9 days, respectively and the slowest in February 2015 (8.5 days). PHGF based diet took longest time (7.3 days). In February 2015 in the honey flow season, the honey bees feeding on PHGF based diet took 9.7 days while PRGF based diet was completed in 7.0 days.

Table-1 Consumption rates of different pollen substitutes by Indian honey bees (TNAU, Coimbatore, 2014-15)

Tr. No.	Pollen substitute	Quantity (g / frame- strength of bees)	No of days taken by bees to consume each diet in different periods						
			Oct 14	Nov 14	Dec 14	Jan 15	Feb 15	Mar 15	Mean
T ₁	DSF 23% + SMP 27% + S 5% + G 10%+ H 35%	2.0	3.3 _a	3.7 _a	5.7 _{ab}	7.3 _{ab}	8.7 _{ab}	7.7 _{ab}	6.1 _{ab}
T ₂	PRGF 26% + SMP 24% + S 5% + G 10%+ H 35%	2.0	3.3 _a	3.0 _{ab}	5.0 _a	6.7 _a	7.0 _a	6.0 _a	5.2 _a
T ₃	PBeGF 26% + SMP 24% + S 5% + G 10%+ H 35%	2.0	3.3 _a	3.3 _{ab}	5.7 _{ab}	8.0 _{ab}	8.3 _{ab}	7.7 _{ab}	6.1 _{ab}
T ₄	PBGF 26% + SMP 24% + S 5% + G 10%+ H 35%	2.0	3.0 _a	3.7 _{ab}	5.7 _{ab}	8.0 _{ab}	8.0 _{ab}	7.3 _{ab}	5.9 _{ab}
T ₅	PGGF 26% + SMP 24% + S 5% + G 10%+ H 35%	2.0	4.3 _a	4.7 _{ab}	6.7 _b	8.7 _b	9.3 _b	8.3 _b	7.0 _c
T ₆	PHGF 26% + SMP 24% + S 5% + G 10%+ H 35%	2.0	4.0 _a	5.3 _b	6.7 _b	9.0 _b	9.7 _b	9.3 _b	7.3 _c
T ₇	No added diet	Nil	-	-	-	-	-	-	-
	Period Mean		3.6 _A	3.9 _A	5.9 _B	7.9 _C	8.5 _D	7.7 _C	
	CD 0.05 T		0.7						
	CD 0.05 P		0.7						
	CD T x P		1.7						

DSF- defatted soy flour, SMP-skimmed milk powder, PRGF-parched red gram flour, PBeGF-parched bengal gram flour, PBGF-parched black gram flour, PGGF-parched green gram flour, PHGF-parched horse gram flour, S - sucrose powder, G- glucose, H- honey, FS- frame-strength

Mean of three replications. In a column, means followed by a common alphabet are not significantly different by LSD (p= 0.05); in a row, means followed by a common uppercase alphabet are not significantly different by LSD (p= 0.05)

Number of bees feeding on each diet

All the diets under the experiment were provided to a hive at the rate of 2g each to find the feeding preference as a choice test by counting the number of bees feeding each diet. The observations were recorded for two days at five minutes per day, observations revealed that PRGF based PS had more number of bees in both the days with a mean of 41.5 bees per day followed by PBGF based and PBeGF based PS with a mean of 38.3 and 35.8 bees per day respectively [Table-2]. The lowest number of bees was found in PHGF based diet with a mean of 20.3 bees per day. Mean number of bees in day one was 33.3 and in day two was 32.0. It was found that the PRGF based diet was completed in minimum number of days by honey bees with a mean of 2 days followed by PBGF and PBeGF based PS which were consumed by the bees in 2.3 and 2.7 days, respectively [Table-3]. PHGF based PS was less preferred by bees compared to other PS which was completed only in 5.3 days.

Feeding preference by Indian bees on PS given on two different media

Feeding preference of PS provided on two different media was tested. The number of days to completely consume each diet was evaluated. It was observed that, PS provided as patties on 1.5 mm nylon mesh was more preferred by bees

with a mean of 3.5 days to completely consume the diets while patties provided on butter paper were consumed in 4.4 days [Table-4]. PRGF based diet provided on nylon mesh was consumed in a short period of 2.3 days, while the same provided on butter paper was consumed in 3.7 days. Similar values were recorded in all other diets.

Overall observations recorded revealed that PRGF based PS provided in 1.5 mm nylon mesh was preferred by bees as the number of days taken by bees to complete the diets was less.

Effect of providing sugar solution on consumption of PS and vice-versa during dearth period

An experiment was conducted to find out the effect of sugar feeding on consumption of PS and vice-versa. The number of days to consume each was observed, observations revealed that when both sugar solution and PS were given simultaneously to a hive it had taken 2 days to completely consume sugar solution and 4.0 days to completely consume PS. when PS was given on first day and sugar solution was given on second day it had taken 4.0 and 2.0 days to consume, respectively. When sugar solution was given on first day and PS were given on second day it had taken 1.4 and 4.4 days to consume respectively

[Table-5]. When both the sugar solution and PS was given separately, it had taken 1.4 days to complete sugar solution and 3.8 days to complete pollen substitute.

Table-2 Choice test to find the feeding preference of Indian honeybees based on number of bees feeding on PS (TNAU, Coimbatore, 2014-15)

Tr. No.	Pollen substitute	Quantity (g / hive)	No of bees feeding on the PS per 5 min*		
			Day-1	Day-2	Mean
T ₁	DSF 23% + SMP 27% + S 5% + G 10%+ H 35%	2.0	32.7 _c	31.0 _{bc}	31.8 _c
T ₂	PRGF 26% + SMP 24% + S 5% + G 10%+ H 35%	2.0	43.7 _a	39.3 _a	41.5 _a
T ₃	PBeGF 26% + SMP 24% + S 5% + G 10%+ H 35%	2.0	37.7 _{bc}	34.0 _{abc}	35.8 _b
T ₄	PBGF 26% + SMP 24% + S 5% + G 10%+ H 35%	2.0	41.0 _{ab}	35.7 _{ab}	38.3 _{ab}
T ₅	PGGF 26% + SMP 24% + S 5% + G 10%+ H 35%	2.0	27.0 _d	29.3 _c	28.2 _d
T ₆	PHGF 26% + SMP 24% + S 5% + G 10%+ H 35%	2.0	18.0 _e	22.7 _d	20.3 _e
	Period mean		33.3 _A	32.0 _A	
	CD 0.05 T		3.9		
	CD 0.05 P		2.2		
	CD T x P		5.5		

DSF- defatted soy flour, SMP-skimmed milk powder, PRGF-parched red gram flour, PBeGF-parched bengal gram flour, PBGF-parched black gram flour, PGGF-parched green gram flour, PHGF-parched horse gram flour, S - sucrose powder, G- glucose, H- honey, FS- frame-strength

Mean of three replications. In a column, means followed by a common alphabet are not significantly different by LSD (p= 0.05); in a row, means followed by a common uppercase alphabet are not significantly different by LSD (p= 0.05)

Table-3 Choice test for finding feeding preference of honey bees based on number of days to consume the PS (TNAU, Coimbatore, 2014-15)

Tr. No.	Pollen substitute	Quantity (g / hive)	No. of days to consume the PS
T ₁	DSF 23% + SMP 27% + S 5% + G 10%+ H 35%	2	3.3 _b
T ₂	PRGF 26% + SMP 24% + S 5% + G 10%+ H 35%	2	2.0 _a
T ₃	PBeGF 26% + SMP 24% + S 5% + G 10%+ H 35%	2	2.7 _{ab}
T ₄	PBGF 26% + SMP 24% + S 5% + G 10%+ H 35%	2	2.3 _a
T ₅	PGGF 26% + SMP 24% + S 5% + G 10%+ H 35%	2	4.3 _c
T ₆	PHGF 26% + SMP 24% + S 5% + G 10%+ H 35%	2	5.3 _d

DSF- defatted soy flour, SMP-skimmed milk powder, PRGF-parched red gram flour, PBeGF-parched bengal gram flour, PBGF-parched black gram flour, PGGF-parched green gram flour, PHGF-parched horse gram flour, S - sucrose powder, G- glucose, H- honey, FS- frame-strength

Mean of three replications. In a column, means followed by a common alphabet are not significantly different by LSD (p= 0.05); in a row, means followed by a common uppercase alphabet are not significantly different by LSD (p= 0.05)

Table-4 Feeding preference by Indian bees on pollen substitutes given on two different media (TNAU, Coimbatore, 2014-15)

Tr. No.	Pollen substitute	Quantity (g / FS of bees)	Number of days to consume the diet provided on different media		
			Patties provided on butter paper	Patties provided on 1.5mm nylon mesh	Mean
T ₁	DSF 23% + SMP 27% + S 5% + G 10%+ H 35%	2.0	3.7 _{B_a}	3.0 _{A_a}	3.0 _a
T ₂	PRGF 26% + SMP 24% + S 5% + G 10%+ H 35%	2.0	3.7 _{B_a}	2.3 _{A_a}	3.5 _a
T ₃	PBeGF 26% + SMP 24% + S 5% + G 10%+ H 35%	2.0	4.0 _{B_a}	3.0 _{A_a}	3.5 _a
T ₄	PBGF 26% + SMP 24% + S 5% + G 10%+ H 35%	2.0	4.0 _{B_a}	3.0 _{A_a}	5.0 _b
T ₅	PGGF 26% + SMP 24% + S 5% + G 10%+ H 35%	2.0	5.7 _{B_b}	4.3 _{A_b}	5.5 _b
T ₆	PHGF 26% + SMP 24% + S 5% + G 10%+ H 35%	2.0	5.7 _{B_b}	5.3 _{A_c}	
	Method mean		4.4 _B	3.5 _A	
	CD 0.05 T		0.6		
	CD 0.05 P		0.4		
	CD T x P		0.9		

DSF- defatted soy flour, SMP-skimmed milk powder, PRGF-parched red gram flour, PBeGF-parched bengal gram flour, PBGF-parched black gram flour, PGGF-parched green gram flour, PHGF-parched horse gram flour, S - Sucrose powder, G- Glucose, H- Honey

Mean of three replications. In a column, means followed by a common alphabet are not significantly different by LSD (p= 0.05). In a row, means followed by a common upper case alphabet are not significantly different by LSD (p= 0.05)

Discussion

Days to consume the diet

Hives fed with PRGF based PS recorded the lowest number of days to consume

the diet with a mean of 5.2 days [Fig-1] followed by PBGF based diet (5.9 days), PBeGF based diet and soya based diets (both 6.1 days). Diet consumption was rapid in the months of October and November 2014 and slow in February 2015.

[11] found that the average daily consumption (g/day) was 4.65, 2.96, 2.26, 1.42 and 1.29, respectively, with expeller-processed soyabean flour consumed at a significantly faster rate than the others. This product has 6-8% fat compared with 2% for solvent-extracted soyabean flour: it is suggested that a fat content of 6-10% in protein supplements could increase consumption. Our findings corroborate with this suggestion as PRGF contains oil and is superior to DSF which does not contain oil.

Table-5 Effect of providing sugar solution on consumption of PS and vice-versa during dearth period (TNAU, Coimbatore, 2014-15)

	Order of providing PS and sugar solution	Days to consume food*	
		Sugar solution	Pollen substitute
T ₁	Sugar solution and PS provided simultaneously	2.00 _b	4.00 _{ab}
T ₂	PS provided first day, Sugar solution next day	2.00 _b	4.00 _{ab}
T ₃	Sugar solution provided first day, PS next day	1.40 _a	4.40 _b
T ₄	Sugar solution only provided	1.40 _a	---
T ₅	PS only provided	---	3.80 _a
	CD (p=0.05)	0.52	0.47

*Mean of 5 replications, sugar solution provided at 250ml / hive, PS provided at 12g / hive

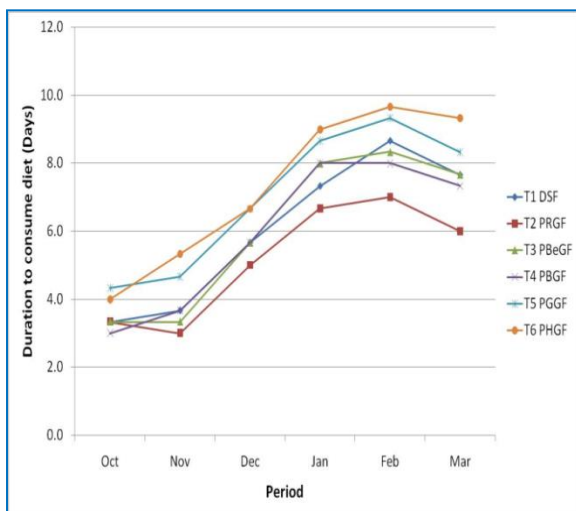


Fig-1 Consumption rate of different pollen substitutes by Indian honeybees (TNAU, Coimbatore, 2014-15)

Choice test for finding feeding preference of honey bees

Feeding preference of bees was studied by providing all the six diets to bees and observing how many bees are seen on each diet at a given time and also how many days are taken to consume each diet. PRGF based PS had more number of bees on both the days with 22% and 20 % of bees on day 1 and day 2 (with mean number of 41.5 bees per day) [Fig-2], followed by PBGF (20% and 19% on day 1 and day 2) and PBeGF (20% and 19% on day 1 and day 2) with a mean of 38.3 and 35.8 bees per day respectively. The lowest numbers of bees were found in PHGF based diet with 9% and 12 % of bees on day 1 and day 2 (mean of 20.3 bees per day). When the number of days to complete each diet was recorded, it was found that PRGF based diet had taken minimum number of days to complete by honey bees with a mean of 2.0 days followed by PBGF and PBeGF based PS in which bees had taken 2.3 and 2.7 days to complete the diets, respectively. PHGF based PS was less preferred by bees compared to other PS in which a mean of 5.3 days was taken by bees to complete the diet. This work is found to be first of its kind as no other study of choice test was found in literature. This work helped to understand the preference of honey bees on an assortment of PS.

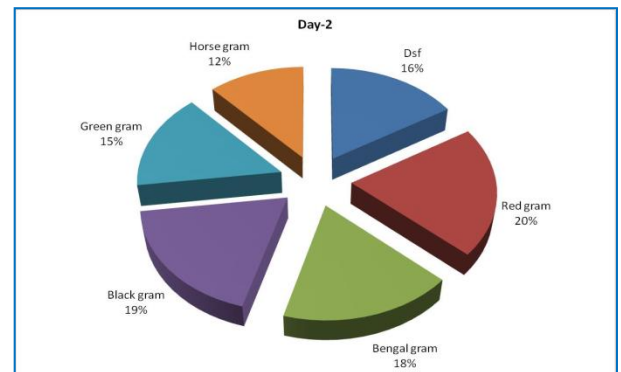
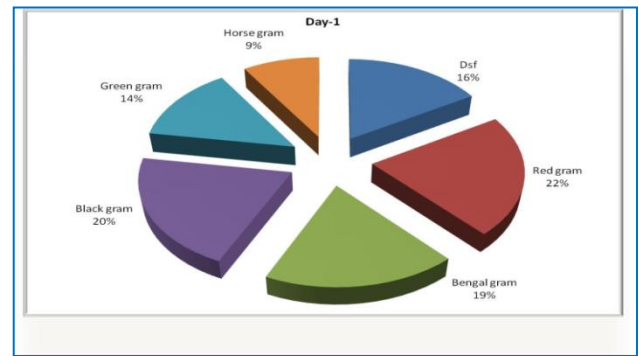


Fig-2 Choice test to find the feeding preference of Indian honeybees based on number of bees feeding on PS (TNAU, Coimbatore, 2014-15)

Feeding preference by Indian bees on PS given on two different media

Normally PS were given as diet patties wrapped in butter paper placed on top bars of colonies for feeding. However, in our study, it was found that PS was provided as patties on 1.5 mm nylon mesh was more preferred by bees to patties provided on butter paper. PRGF based diet provided on nylon mesh was consumed in a short period of 2.3 days, while those provided on butter paper took 3.7 days. Similar values were recorded in all other diets. Method of placement of PS patties is found to play a major role in its consumption and our present study helped to find that placing PS patties on 1 mm nylon mesh was better than placing them on butter paper. It was observed that the increase in feeding when kept on nylon mesh could be due to the fact that bees feed from both sides of the mesh, top and bottom and the patties do not stick to nylon mesh and comes off easily for feeding by bees. Our results were in agreement with [12] [13].

Effect of providing sugar solution on consumption of PS and vice-versa during dearth period

Impact of sugar feeding on PS and vice-versa was tested and number of days to consume each was observed. It was found that both the sugar solution and the PS were consumed completely by the honey bees within 2 and 4 days, respectively whether they were given on the same day or on different days. Thus, it can be concluded that both sugar solution and the PS are essential for the growth and development of honey bees and one cannot replace the other. Sugar solution can be a substitute for nectar requirement and PS for pollen requirement and hence both are essential for bees. It is recommended that PS and sugar solution can be provided simultaneously at recommended quantities so as to minimize labour on provision of PS and sugar solution.

Conflict of Interest: None declared

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