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Efficiency of supplementary feeding of honey bee, *Apis cerana indica* (Fab.) during dearth period in northern hill region of Chhattisgarh

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Abstract

Major problem in beekeeping is to maintain good strength of honeybee colonies during prolonged dearth periods in our country. This problem is also faced by beekeepers of northern hilly region of Chhattisgarh. In subtropical part of Chhattisgarh, summers are very harsh for honey bees as enough bee flora are not available during this period. In the present study, an attempt has been made to test the acceptability of artificial diets as food supplement fed to bee, *Apis cerana indica* (Fab.) colonies during dearth periods on colony parameters like sealed brood and unsealed brood. The mean sealed and unsealed brood area of bee colonies during all four months of observation revealed that out of 10 diets, the artificial diet in D₇ (Parched Gram Flour 50% + Fresh pollen from flowers 20% + Glucose 20% + Sugar 10%) recorded the maximum sealed brood area of 663.43 cm² whereas the minimum sealed brood area of 258.35 cm² in control (without added any artificial diet). Similarly, maximum unsealed brood area was recorded in D₇ as 846.43 cm² and minimum was recorded in control with 338.27 cm² during the study period.

Keywords: Chhattisgarh, dearth period, Indian bee, supplementary feeding

Introduction

Beekeeping plays an important role in Indian economy, as it directly impacts agricultural sector through pollination. As per report published for the year 2019-20 by the Ministry of Agriculture and Farmer's Welfare, Govt. of India, the total geographical area of India is 328.7 million hectares, out of which 198.4 million hectares is the gross cropped area and 140.1 million hectares is the net sown area (source: http://agricoop.nic.in/sites/default/files/Annual_rpt_2016-17_E.pdf). As per an estimate, it requires approximately 50 million honey bee colonies to pollinate this crop area, but we have only 30 lac bee colonies in our country (source: <http://pib.nic.in/newsite/printrelease.aspx?relid>). India has huge potential of natural and cultivated vegetation that have great possibilities for beekeeping. Five species of honeybees are commonly recognized i.e. rock bee (*Apis dorsata*), Indian bee (*A. cerana indica*), little bee (*A. florea*), stingless bee (*Tetragonula* sp.) and European bee (*A. mellifera*). Among these five, only *A. cerana indica* and *A. mellifera* are domesticated by human (Akratanakul, 1990) [1].

The Indian honey bee produces large quantity of honey as well as imparts pollination services for thousands of years which are endemic in most of the Asian countries. It is mostly preferred for domestication in India, Pakistan, Nepal, Burma, Bangladesh, Sri Lanka and Thailand. It is a subspecies of bees and also known as the Indian honey bee and in the name of many honey bees i.e. Asian hive bee, Asian honeybee, Asiatic bee, Mee bee, Chinese bee, Eastern honeybee and Fly bee. It is found in a variety of climatic situations, including chilly locations at higher latitudes and elevations, dry, semi-desert habitats, and tropical climes, similar to *A. mellifera*. It is ideal for beekeeping as it is comparatively non-aggressive than *A. dorsata* and it's hard to find swarming behaviour in these bee colonies. Honey bees are considered as important bio-indicators of environment. Honey bees and flowers are classical examples of mutualism and co-evolution. India is an important honey producer, in the financial year 2020-21 about 59999.24 metric tons natural honey worth of Rs. 716.13 Crore (US \$96.77 Million) have been exported to the world as reported by Agricultural and Processed Food Products Export Development Authority (APEDA), Government of India. The major states of honey production in India are Punjab, Haryana, Rajasthan, Himachal Pradesh, Uttar Pradesh, Bihar, Tamil Nadu and West Bengal.

Major problem that beekeepers are facing in our country is to maintain good colony strength of honeybees during prolonged dearth periods. Summers in the tropical and subtropical sections of our country are especially difficult for honey bees because there isn't enough bee flora available during this time. The periodical dearth periods may result into dwindling and even death of bee colonies (Zaytoon *et al.* 1988; Saffari *et al.* 2010) [20, 14]. It becomes utmost important for the bee keepers to shift their colonies either physically to a bee flora rich region or to provide them with pollen artificially. But this migration and artificial provision of pollens has some disadvantages. The shifting of bee colonies is a tedious work, which causes huge loss to honey bees in terms of mortality during transportation (Mishra, 1995) [12]. To shift colonies to distant places, a lot of time, money, and labors are required. Secondly, beekeepers usually neither collect nor feed natural pollen to bee colonies, and pollen is not easily available in the market commercially. It is important to feed the bee colonies with protein rich pollen substitute so that beekeeping activity can be enhanced and strength of colonies is maintained. It has been a matter of keen interest for beekeeping industries to produce artificial diets for honey bees (Haydak, 1935) [6].

Some researchers have worked out different formulations of artificial diet of honeybees (Standifer *et al.* 1960; Haydak, 1967; Doull, 1968; Stranger and Gripp 1972; Herbert and Shimanuki, 1978; Chhuneja *et al.* 1992; Srivastava, 1996; Saffari *et al.* 2006; DeGrandi-Hoffman *et al.* 2008) [17, 8, 5, 18, 9, 2, 16, 3, 21] and various substitutes have been suggested with different compositions (Sihag and Gupta, 2011; Kumar *et al.*, 2013) [15, 10]. In the present study, an attempt has been made to test the acceptability of artificial diets and stored pollen as food supplement fed to bee colonies during dearth periods on colony parameters like sealed brood, unsealed brood and number of bee covered frames.

Materials and Methods

A polliniferous material was collected from Ambikapur and adjoining area in large quantity during the peak of flowering period. Samples were kept in glass jar stopper with cotton plug and stored in refrigerator at 5 °C and one sample at normal room temperature. Experiment was conducted on the 30 colonies of *A. cerana indica* (Fab.) during dearth periods (May-Aug, 2017) in the apiary maintained under AICRP on Honey Bees and Pollinators at Raj Mohini Devi College of Agriculture & Research Station, Ambikapur (Chhattisgarh). One group was kept as control to which no artificial diet was provided. The various diet formulations which were tested during the course of studies are mentioned below. All the selected colonies were equalized in the first week of May. All the treatments were replicated three time and treatment details are as under: -

Diet 1: Parched Gram Flour (50%) + Stored Pollen at 5 °C (20%) + Glucose (20%) + Sugar (10%)

Diet 2: Pea Flour (50%) + Stored Pollen at 5 °C (20%) + Glucose (20%) + Sugar (10%)

Diet 3: Corn Flour (50%) + Stored Pollen at 5 °C (20%) + Glucose (20%) + Sugar (10%)

Diet 4: Parched Gram Flour (50%) + Stored Pollen at room temperature (20%) + Glucose (20%) + Sugar (10%)

Diet 5: Pea Flour (50%) + Stored Pollen at room temperature

(20%) + Glucose (20%) + Sugar (10%)

Diet 6: Corn Flour (50%) + Stored Pollen at room temperature (20%) + Glucose (20%) + Sugar (10%)

Diet 7: Parched Gram Flour (50%) + Fresh Pollen from flowers (20%) + Glucose (20%) + Sugar (10%)

Diet 8: Pea Flour (50%) + Fresh Pollen from flowers (20%) + Glucose (20%) + Sugar (10%)

Diet 9: Corn Flour (50%) + Fresh Pollen form flowers (20%) + Glucose (20%) + Sugar (10%)

Diet 10: Control (without added any diet substitute)

Observations were recorded

After feeding with different artificial diets, the observations (bee colony strength as unsealed brood, sealed brood) were recorded at a regular interval of fifteen days from 1st May to 31st August. Supplementary diets were also provided to all the experimental colonies excluding control in addition to the pollen and pollen substitute at every week. Regular cleaning was done in colonies at weekly intervals to avoid other inflations and ant attack.

Results and Discussion

1. Effect of various supplementary diets on colonies growth as sealed brood area of Indian bee (*A. cerana indica*) during dearth period of 2017

The present studies were carried out to find the effect of 10 various protein rich supplementary diets on colonies growth as sealed brood area of Indian bee (*A. cerana indica*) during dearth period. The results (Table 1 & Fig. 1) showed that all the bee colonies accepted artificial diets and improved their brood area significantly ($P < 5\%$). The mean sealed brood area of all four months of observation revealed that out of 10 diets, the diet in D₇ (Parched Gram Flour 50% + Fresh pollen from flowers 20% + Glucose 20% + Sugar 10%) recorded the maximum sealed brood area of 663.43 cm² followed by D₉ (Corn Flour 50% + Fresh Pollen form flowers 20% + Glucose 20% + Sugar 10%), D₄ (Parched Gram Flour 50% + Stored Pollen at room temperature 20% + Glucose 20% + Sugar 10%) and D₈ (Pea Flour 50% + Fresh Pollen from flowers 20% + Glucose 20% + Sugar 10%) which were recorded 566.57, 553.07 and 514.20 cm², respectively. Bee colonies without added any diet substitute (control) was recorded minimum growth 258.06 cm² of sealed brood area. The other remaining artificial diets recorded sealed brood area that was less than D₇ (Parched Gram Flour 50% + Fresh pollen from flowers 20% + Glucose 20% + Sugar 10%), D₉ (Corn Flour 50% + Fresh Pollen form flowers 20% + Glucose 20% + Sugar 10%), D₈ (Pea Flour 50% + Fresh Pollen from flowers 20% + Glucose 20% + Sugar 10%) and D₄ (Parched Gram Flour 50% + Stored Pollen at room temperature 20% + Glucose 20% + Sugar 10%). However, all the artificial diets recorded significantly higher sealed brood area in comparison to control (without added any diet substitute).

Among the different periods of observations, there was no any significant difference observed in the sealed brood area under different artificial diets during the 1st and 2nd fortnight of May 2017. But after that from the 1st fortnight of June, the sealed brood area started decline in all beehives and reached to minimum level of 326.68 cm² sealed brood area in the 2nd

fortnight of June 2017. During this period the maximum sealed brood (551.12 cm²) was recorded in diet D₇ (Parched Gram Flour 50% + Fresh pollen from flowers 20% + Glucose 20% + Sugar 10%) which was on par with D₉ (Corn Flour 50% + Fresh Pollen form flowers 20% + Glucose 20% + Sugar 10%) with 416.67 cm² sealed brood, while minimum of 144.00 cm² sealed brood received in diet D₁₀ (control). Similarly, in the 2nd fortnight of August the highest of 971.75 cm² sealed brood area was noticed in diet of D₇ (Parched Gram Flour 50% + Fresh pollen from flowers 20% + Glucose 20% + Sugar 10%) while lowest of 73.69 cm² sealed brood area was found in D₁₀ (control). However, in different diets, the maximum level of sealed brood area was noticed during 2nd fortnight of August 2017 with an average of 668.56 cm².

2. Effect of various supplementary diets on colonies growth as unsealed brood area of Indian bee (*A. cerana indica*) during dearth period of 2017

In 2017, the data (Table 2 & Fig. 2) on effect of various artificial diets on colonies growth as unsealed brood area of Indian bee (*A. cerana indica*) during dearth period revealed that the maximum of unsealed brood area was observed in D₇ diet (Parched Gram Flour 50% + Fresh pollen from flowers 20% + Glucose 20% + Sugar 10%), with an average of 846.43 cm² followed by D₉ diet (Corn Flour 50% + Fresh Pollen form flowers 20% + Glucose 20% + Sugar 10%), D₄ diet (Parched Gram Flour 50% + Stored Pollen at room temperature 20% + Glucose 20% + Sugar 10%) and D₈ diet (Pea Flour 50% + Fresh Pollen form flowers 20% + Glucose 20% + Sugar 10%) with 777.61, 719.25 and 700.06 cm², respectively. The minimum unsealed brood area was observed in D₂ diet (Pea Flour 50% + Stored Pollen at (5 °C) 20% + Glucose 20% + Sugar 10%) with 596.92 cm² followed by D₃ diet (Corn Flour 50% + Stored Pollen at (5 °C) 20% + Glucose 20% + Sugar 10%), D₁ (Parched Gram Flour 50% + Stored Pollen at (5 °C) 20% + Glucose 20% + Sugar 10%), D₅ diet (Pea Flour 50% +

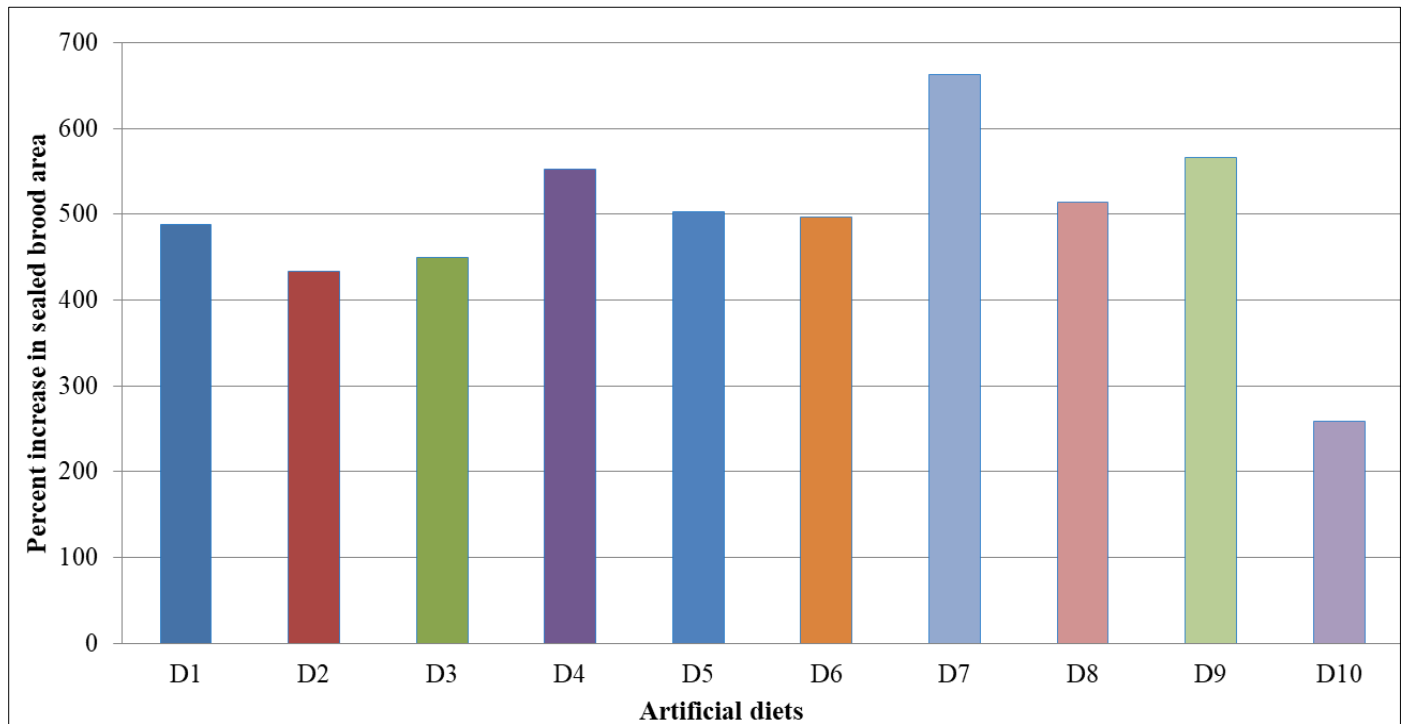
Stored Pollen at room temperature 20% + Glucose 20% + Sugar 10%) with 665.12, 675.02 and 684.42 cm², respectively but these diets were showed greater unsealed brood than D₁₀ control (without added any diet substitute) which was recorded lowest of 338.27 cm² unsealed brood area. In four month of observations, the maximum unsealed brood area was recorded in the 2nd fortnight of August with an average of 975.24 cm² while minimum of 514.88 cm² unsealed brood area was observed in the 1st fortnight of June which coincided with little bee flora available in surrounded area during the study period.

The present study was done with *A. cerana indica* and it was reported that the maximum sealed brood area was found in diet D₇ (Parched Gram Flour 50% + Fresh pollen from flowers 20% + Glucose 20% + Sugar 10%) which was 663.43 cm² while minimum was found in D₁₀ (control) *i.e.*, 258.06 cm² during dearth period of the month of May to August that differed from study conducted by Tej and Srinivasan (2016)^[19] who used red gram based artificial diet (Purchase red gram flour 26% + skimmed milk powder 24% + sucrose powder 5% + glucose 10% + honey 35%) on *A. cerana indica* and founded an increased in sealed brood area of 815.2 cm² and minimum of 450.1 cm² in the month from October 2014 to March 2015. A similar study was conducted by Kumar *et al.*, (2013)^[10] who reported that feeding *A. mellifera* with pollen substitute containing defatted soy flour, brewer's yeast and protein hydrolysate powder resulted in 2155 cm² sealed brood whereas control colonies recorded 731 cm² sealed brood area. Dodologlu and Emsen (2007)^[4] found higher brood area of honey bee *A. mellifera* (2677.08 cm²) when given supplementary diet of 2 unit honey and 1 unit pollen as compared to control (1824.15 cm²) in May to August. While, Sihag and Gupta (2011)^[15] reported that semi solid diet of soybean was the most preferred artificial diets to bee colony growth in comparison to mungbean, chick pea and pigeon pea diets.

Table 1: Effect of various supplementary diets on colonies growth as sealed brood area of Indian bee (*A. cerana indica*) during dearth period of 2017

Artificial diets	Sealed brood area (cm ²)								Overall mean
	May		June		July		August		
	1 st Fortnight	2 nd Fortnight	1 st Fortnight	2 nd Fortnight	1 st Fortnight	2 nd Fortnight	1 st Fortnight	2 nd Fortnight	
D ₁	583.00	573.08	473.17	293.83	390.35	400.47	515.33	680.00	488.65
D ₂	671.80	629.28	444.60	211.67	237.42	284.48	434.69	556.35	433.79
D ₃	613.97	542.77	412.02	270.85	301.00	331.40	461.00	660.77	449.22
D ₄	643.78	648.01	560.44	393.00	430.19	460.95	578.48	709.68	553.07
D ₅	627.96	595.78	527.33	317.01	357.41	372.40	511.50	709.50	502.36
D ₆	523.67	598.70	473.33	336.96	373.65	396.15	540.33	731.85	496.83
D ₇	640.00	638.22	621.00	551.12	515.33	601.36	768.67	971.75	663.43
D ₈	620.24	595.00	444.96	331.67	363.78	422.25	584.33	751.36	514.20
D ₉	661.33	581.58	454.35	416.67	435.63	505.35	637.00	840.67	566.57
D ₁₀	690.03	497.36	325.67	144.00	149.33	135.78	48.67	73.69	258.06
Overall mean	627.58	589.98	473.69	326.68	355.41	391.06	508.00	668.56	
Factors	SE(d)	SE(m±)	CD at 5%						
Factor (P)	19.01	13.44	37.55						
Factor (D)	17.01	12.02	33.59						
Factor (P X D)	53.78	38.03	106.21						

Diet 1: Parched Gram Flour (50%) + Stored Pollen at 5 °C (20%) + Glucose (20%) + Sugar (10%), Diet 2: Pea Flour (50%) + Stored Pollen at 5 °C (20%) + Glucose (20%) + Sugar (10%), Diet 3: Corn Flour (50%) + Stored Pollen at 5 °C (20%) + Glucose (20%) + Sugar (10%), Diet 4: Parched Gram Flour (50%) + Stored Pollen at room temperature (20%) + Glucose (20%) + Sugar (10%), Diet 5: Pea Flour (50%) + Stored Pollen at room temperature (20%) + Glucose (20%) + Sugar (10%), Diet 6: Corn Flour (50%) + Stored Pollen at room temperature (20%) + Glucose (20%) + Sugar (10%), Diet 7: Parched Gram Flour (50%) + Fresh Pollen from flowers (20%) + Glucose (20%) + Sugar (10%), Diet 8: Pea Flour (50%) + Fresh Pollen from flowers (20%) + Glucose (20%) + Sugar (10%), Diet 9: Corn Flour (50%) + Fresh Pollen form flowers (20%) + Glucose (20%) + Sugar (10%), Diet 10: Control (without added any diet substitute)



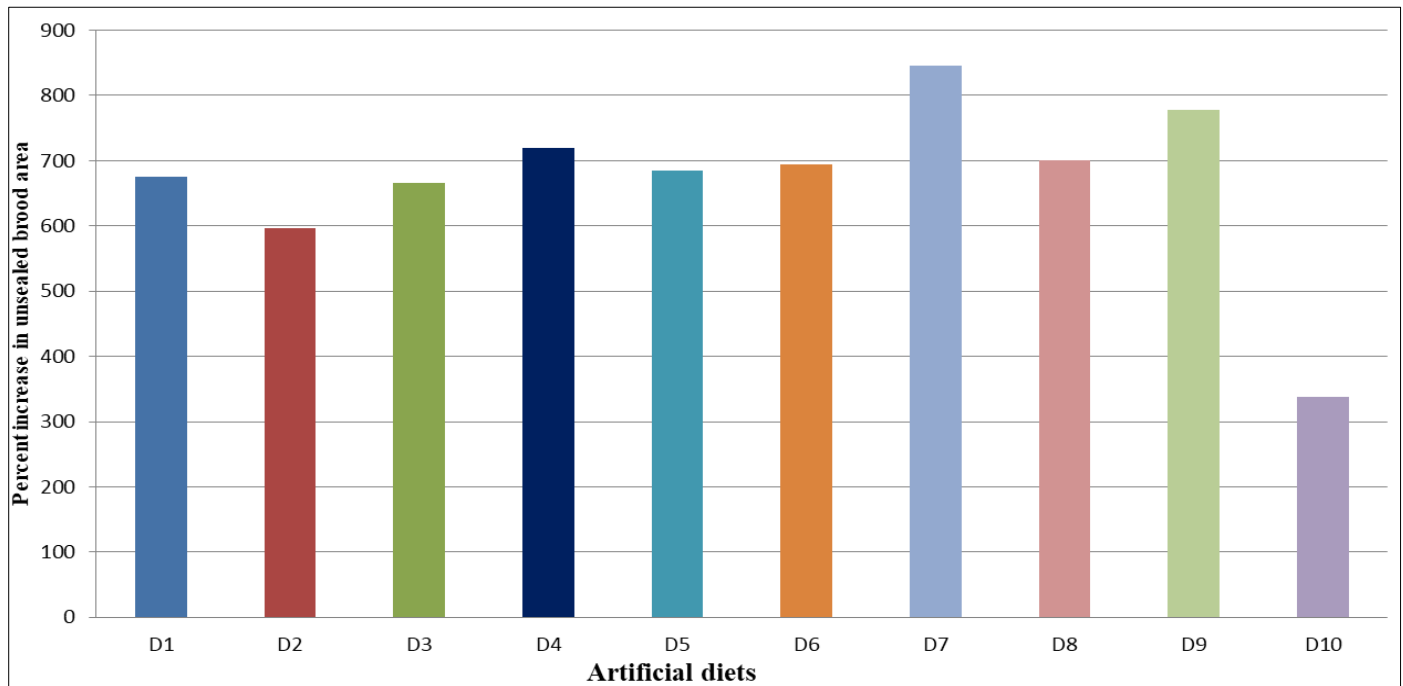
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Fig 1: Effect of various supplementary diets on colonies growth as sealed brood area of Indian bee (*A. cerana indica*) during dearth period of 2017

Table 2: Effect of various supplementary diets on colonies growth as unsealed brood area of Indian bee (*A. cerana indica*) during dearth period of 2017

Artificial diets	Unsealed brood area (cm ²)								Overall mean
	May		June		July		August		
	1 st Fortnight	2 nd Fortnight	1 st Fortnight	2 nd Fortnight	1 st Fortnight	2 nd Fortnight	1 st Fortnight	2 nd Fortnight	
D1	654.17	530.02	520.00	562.60	561.20	699.74	812.33	1060.10	675.02
D2	690.61	591.36	502.93	455.13	494.91	567.41	640.36	832.67	596.92
D3	652.15	577.35	469.57	553.03	594.00	661.42	808.15	1005.33	665.12
D4	682.58	642.44	536.41	594.70	639.67	726.00	872.70	1059.47	719.25
D5	707.67	603.75	514.89	569.00	579.17	644.85	850.33	1005.67	684.42
D6	607.00	632.97	563.87	581.67	619.00	669.33	832.90	1050.33	694.63
D7	709.22	646.33	610.04	697.14	829.25	850.01	1095.67	1333.80	846.43
D8	666.89	603.67	517.67	584.79	610.00	701.25	845.00	1071.20	700.06
D9	680.00	619.04	533.47	584.67	715.58	803.72	1067.68	1216.69	777.61
D10	679.67	538.50	380.00	328.40	293.93	294.73	73.78	117.13	338.27
Overall mean	673.00	598.54	514.88	551.11	593.67	661.85	789.89	975.24	
Factors	SE(d)	SE(m±)	CD at 5%						
Factor (P)	23.43	16.57	46.28						
Factor (D)	20.96	14.82	41.39						
Factor (PXD)	66.27	46.86	130.89						

Diet 1: Parched Gram Flour (50%) + Stored Pollen at 5 °C (20%) + Glucose (20%) + Sugar (10%), Diet 2: Pea Flour (50%) + Stored Pollen at 5 °C (20%) + Glucose (20%) + Sugar (10%), Diet 3: Corn Flour (50%) + Stored Pollen at 5 °C (20%) + Glucose (20%) + Sugar (10%), Diet 4: Parched Gram Flour (50%) + Stored Pollen at room temperature (20%) + Glucose (20%) + Sugar (10%), Diet 5: Pea Flour (50%) + Stored Pollen at room temperature (20%) + Glucose (20%) + Sugar (10%), Diet 6: Corn Flour (50%) + Stored Pollen at room temperature (20%) + Glucose (20%) + Sugar (10%), Diet 7: Parched Gram Flour (50%) + Fresh Pollen from flowers (20%) + Glucose (20%) + Sugar (10%), Diet 8: Pea Flour (50%) + Fresh Pollen from flowers (20%) + Glucose (20%) + Sugar (10%), Diet 9: Corn Flour (50%) + Fresh Pollen form flowers (20%) + Glucose (20%) + Sugar (10%), Diet 10: Control (without added any diet substitute)



Diet 1: Parched Gram Flour (50%) + Stored Pollen at 5 °C (20%) + Glucose (20%) + Sugar (10%), Diet 2: Pea Flour (50%) + Stored Pollen at 5 °C (20%) + Glucose (20%) + Sugar (10%), Diet 3: Corn Flour (50%) + Stored Pollen at 5 °C (20%) + Glucose (20%) + Sugar (10%), Diet 4: Parched Gram Flour (50%) + Stored Pollen at room temperature (20%) + Glucose (20%) + Sugar (10%), Diet 5: Pea Flour (50%) + Stored Pollen at room temperature (20%) + Glucose (20%) + Sugar (10%), Diet 6: Corn Flour (50%) + Stored Pollen at room temperature (20%) + Glucose (20%) + Sugar (10%), Diet 7: Parched Gram Flour (50%) + Fresh Pollen from flowers (20%) + Glucose (20%) + Sugar (10%), Diet 8: Pea Flour (50%) + Fresh Pollen from flowers (20%) + Glucose (20%) + Sugar (10%), Diet 9: Corn Flour (50%) + Fresh Pollen form flowers (20%) + Glucose (20%) + Sugar (10%), Diet 10: Control (without added any diet substitute)

Fig 2: Effect of various supplementary diets on colonies growth as unsealed brood area of Indian bee (*A. cerana indica*) during dearth period of 2017

Conclusion

In the present study, an attempt has been made to test the acceptability of artificial diets as food supplement fed to bee colonies during dearth periods on colony parameters like sealed brood and unsealed brood. The maximum sealed and unsealed brood area was observed in D₇ diet (Parched Gram Flour 50% + Fresh pollen from flowers 20% + Glucose 20% + Sugar 10%). The storage condition of pollen has significantly influenced the colony growth of honey bees out of which freshly collected pollen with pollen substitutes has resulted in increased brood area of honey bee colonies with respect to pollen diet that was stored in room temperature and the lowest brood area was found in colonies fed with pollen diet stored at 5 degree celcius. Since, maximum brood area was found in freshly collected pollen diet, thus storage conditions resulted in poor brood area development of honey bee colonies. It can be concluded from the above study, that artificial diet is only the supplement to maintain honey bee colonies during the dearth period.

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