EFFECT OF FEEDING VARIOUS DIET FORMULATIONS TO HONEY BEE COLONIES DURING DEARTH PERIOD UNDER GWALIOR (INDIA) CONDITIONS

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ABSTRACT: Six protein rich artificial diets were formulated keeping in mind the nutritional requirements of honeybees. Diets were prepared with the help of various protein rich ingredients *viz.* defatted soy flour, parched gram, brewer's yeast, soy protein hydrolysate, spirulina, skimmed milk powder and natural pollen. These diets were fed to *Apis mellifera* colonies in the form of patties on top bars of hive during summer dearth periods, 2010. The results on the preference of bees for the formulated diets showed that diet 3 (defatted soy four, brewer's yeast and soy protein hydrolysate powder) proved to be most effective with 723.4 cm^2 sealed brood area, 5.8 total bee covered frames and 9138.6 bee population. The performance of all experimental colonies was found to be better as compared to control colonies.

KEY WORDS: *Apis mellifera*, Gwalior, diet formulation, dearth period, brood, protein hydrolysate.

In India, major problem in beekeeping is to maintain good strength of honeybee colonies during dearth periods. In tropical and subtropical parts of our country, summers are very harsh for honey bees as enough bee flora is not available during this period. The condition is more severe in central parts of our country where dearth periods are little longer as compared to other parts. The periodical dearth periods may results into dwindling and even death of bee colonies. Therefore during these periods, special care should be taken in management of bees. The first option is migration of bee colonies but it also includes lots of labour, time and money. The other option is to feed the bee colonies with protein rich artificial diet so that brood rearing activity can be enhanced and strength of colonies is maintained. The necessity of artificial diets to honey bees has been long standing interest to the beekeeping industry (Haydak, 1935, 1936). Different type of artificial diets have been formulated and their effect on various colony parameters were observed by many researchers (Haydak, 1967; Standifer et al., 1960; Doull, 1968; Stranger & Gripp 1972; Herbert & Shimanuki, 1978; Chhuneja et al., 1993, Saffari et al., 2006, DeGrandi-Hoffman et al., 2008, Sihag et al., 2011). In India, work on the artificial diet formulation has been carried by some workers (Chhuneja et al., 1992; Srivastava, 1996; Sihag et al., 2011) and various substitutes have been suggested with different compositions. In the present study, an attempt has been made to compare the effect of various diet formulations fed to bee colonies during dearth periods on colony parameters like brood rearing, bee strength and number of bee covered frames, so that suitable pollen substitute can be developed to improve beekeeping practice in India.

MATERIAL AND METHODS

Experiment was conducted on the colonies of *Apis mellifera* during dearth periods (April to September, 2010) in the apiary maintained in Charak Udyan, Jiwaji University, Gwalior (India). The experimental colonies were manipulated to equalize six frames strength. One group was kept as control to which no any artificial diet was provided. The various diet formulations tested during the course of studies are mentioned below:

Diet 1: SF (16.7%) + PG (16.7%) + BY (16.7%) + S (33.3%) + G (16.7%)
Diet 2: DSF (20.7%) + BY (20.7%) + SP (8.3%) + S (33.3%) + G (16.7%)
Diet 3: DSF (16.7%) + BY (16.7%) + SPH (16.7%) + S (33.3%) +G (16.7%)
Diet 4: DSF (16.7%) +BY (16.7%) + SPH (8.3%)+P (8.3%)+S (33.3%)+G (16.7%)
Diet 5: SP (16.7%) + H (83.3%)
Diet 6: DSF (30%) + BY (10%) + SMP (10%) + S (50%)
(DSF: Defatted Soy Flour, PG: Parched Gram, BY: Brewer's Yeast, SKM: Skimmed Milk Powder, SPH: Soy Protein Hydrolysate, SP: Spirulina, P: Pollen, S: Sugar, G: Glucose, H: Honey)

Diet formulations were continuously fed to the colonies in the form of patties by placing them on the top bars of hive (Fig. I). The worker brood area in the colonies was recorded for every 21 days interval with the help of measuring frame (wire grid) consisting of squares, each of one inch^2 (Seeley & Mikhetev, 2003; Amir & Peveling; 2004) (Fig. II). The values thus obtained were then converted into cm^2 by multiplying with a factor of 6.45. The bee strength in the colonies was recorded by the photographic method (Jeffree, 1951). The collected data was tabulated, transformed and subjected to statistical analysis (ANOVA) following Randomized Block Design (RBD).

RESULTS AND DISCUSSION

Brood area: The maximum (peak) amount of sealed brood area was observed in the colonies given diet 3 (723.4 cm^2 per colony) followed by the colonies given diet 4 (658.8 cm^2 per colony). The differences with regards to these two diets were statistically at par. Significant differences was observed in the sealed brood area in the colonies given diet no. 2, 6 and 1; values being 640.5, 521.4, 485.7 cm^2 per colony respectively. Minimum sealed brood area (330.1 cm^2 per colony) was recorded in the control colonies (Table I). Findings of the present study that the colonies fed on the artificial diets reared significantly more brood than control colonies, are endorsed by the observation of Chhuneja et al. (1993a); Nabors (2000); and Castangnino et al. (2004) who reported an increase in brood rearing by bees fed pollen substitutes and supplements.

Number of frames covered by bees: The effect of feeding diet formulations was observed and recorded for the number of frames covered by bees. The results revealed that irrespective of different feeding periods, maximum number of frames covered by bees was recorded in the colonies given diet 3 and 4 respective values being 5.81in both the cases (differences statistically at par). Lowest number of frames (5.0) covered by bees per colony was recorded in the control colonies (Table II). The results are in close agreement with the result obtained by Abbas et al. (1995); Guler (1999) who reported that number of bee covered frames are positively affected by feeding protein-rich diet to the bees.

Bee strength: Bee strength was observed by counting the number of bees present on the frames inside the bee colonies. The results revealed that, irrespective of different periods of colony development, maximum bee population

was observed in the colonies given diet no. 3 (9138 bees per colony) which was significantly different from all other treatments, followed by the colonies given diet 4, 6, 1, 2 and 5; values being 8501.6, 8193.3, 8122.7, 8054.3 and 7850 bees per colony respectively (Table III). Inferences from the present investigations that the bee population is increased by supplementing the pollen substitute with pollen or its extracts are in line with the observation of Peng et al. (1984), Saffari et al. (2006), DeGrandi-Hoffman et al. (2008) who reported that colonies fed on protein patties had significantly higher adult bee population than the unfed control colonies.

At the end of study, it can be concluded that protein rich artificial diets must be provided to bee colonies during dearth periods so that strength of colonies can be maintained for the next honey flow season.

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Table I. Effect of feeding diet formulations on amount of brood area (cm^2) in *Apis mellifera* colonies.

Treatment / Period	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	Control	MEAN
18th April	1607.7 (3.20)*	1687.3 (3.22)	1213.0 (3.08)	1033.3 (3.01)	1193.7 (3.07)	1250.0 (3.08)	1421.7 (3.15)	1344.6 (3.11)
9th May	918.0 (2.96)	1473.3 (3.16)	960.0 (2.98)	730.7 (2.85)	748.3 (2.87)	1027.0 (3.01)	740.3 (2.86)	942.5 (2.95)
30th May	327.0 (2.50)	564.0 (2.73)	422.0 (2.62)	369.7 (2.56)	213.3 (2.32)	288.0 (2.45)	155.3 (2.17)	334.2 (2.48)
20th June	120.3 (2.03)	101.0 (2.00)	278.3 (2.44)	356.7 (2.55)	26.0 (1.02)	147.3 (2.11)	28.7 (1.42)	151.1 (1.94)
11th July	118.7 (2.06)	128.7 (2.10)	402.0 (2.60)	356.0 (2.54)	38.3 (1.48)	136.0 (2.12)	0.0 (0.00)	169.3 (1.90)
1st Aug	107.3 (2.02)	231.0 (2.35)	459.0 (2.66)	435.0 (2.63)	125.7 (2.05)	368.0 (2.55)	16.7 (0.91)	249.0 (2.17)
22nd Aug	231.3 (2.32)	412.0 (2.57)	756.0 (2.87)	747.7 (2.86)	140.0 (2.13)	437.0 (2.61)	108.0 (2.02)	404.6 (2.48)
12th Sept	456.7 (2.65)	527.3 (2.71)	1297.0 (3.11)	1242.0 (3.09)	240.0 (2.36)	518.0 (2.71)	165.0 (2.21)	635.0 (2.69)
MEAN	485.7 (2.47)	640.5 (2.61)	723.4 (2.79)	658.8 (2.76)	340.6 (2.16)	521.4 (2.58)	330.1 (1.89)	
$CD_{0.05}$	T (Treatment) 0.13 I (Brood cycle) 0.14 T X I (Treatment X Brood cycle) 0.36							

*Values in parentheses are log transformed values

Table II. Effect of feeding diet formulations on number of frames covered by bee colonies.

Treatment / Period	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	Control	MEAN
18th April	6.0 (2.44)*	6.0 (2.44)	6.0 (2.44)	6.0 (2.44)	6.0 (2.44)	6.0 (2.44)	6.0 (2.44)	6.0 (2.44)
9th May	5.8 (2.41)	6.0 (2.44)	5.7 (2.39)	5.9 (2.44)	5.7 (2.39)	5.8 (2.41)	5.8 (2.41)	5.8 (2.41)
30th May	5.5 (1.36)	5.6 (2.37)	5.8 (2.41)	5.9 (2.43)	5.3 (2.30)	5.6 (2.37)	5.7 (2.39)	5.6 (2.37)
20th June	5.2 (2.28)	5.1 (2.26)	5.6 (2.37)	5.5 (2.35)	4.9 (2.22)	5.0 (2.25)	5.2 (2.29)	5.2 (2.29)
11th July	4.7 (2.17)	4.9 (2.21)	5.5 (2.35)	5.6 (2.37)	4.5 (2.12)	4.7 (2.18)	4.9 (2.21)	5.0 (2.23)
1st Aug	4.7 (2.18)	4.7 (2.17)	5.6 (2.36)	5.7 (2.38)	4.3 (2.08)	4.5 (2.12)	4.5 (2.12)	4.8 (2.20)
22nd Aug	4.5 (2.12)	4.9 (2.21)	5.9 (2.44)	5.7 (2.38)	4.3 (2.08)	4.5 (2.12)	4.0 (2.02)	4.8 (2.20)
12th Sept	4.5 (2.14)	4.8 (2.19)	6.1 (2.48)	6.0 (2.45)	4.3 (2.07)	4.7 (2.18)	4.1 (2.04)	4.9 (2.22)
MEAN	5.1 (2.26)	5.2 (2.29)	5.8* (2.41)	5.8* (2.41)	4.9 (2.21)	5.1 (2.26)	5.0 (2.24)	
$CD_{0.05}$	T (Treatment) 0.02 I (Brood cycle) 0.03 T X I (Treatment X Brood cycle) 0.07							

*Values in parentheses square root transformed value

Figure I. Feeding of pollen patties on top bars of bee hive.

Table III. Effect of feeding diet formulations on bee strength.

Treatment / Period	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	Control	MEAN
18th April	9252.7 (3.96)*	9151.3 (3.96)	9487.3 (3.97)	9149.3 (3.96)	9056.3 (3.95)	9375.3 (3.97)	9347.0 (3.97)	9259.8 (3.96)
9th May	9163.7 (3.96)	9159.3 (3.96)	9083.7 (3.95)	9049.3 (3.95)	8762.3 (3.94)	9134.3 (3.96)	9103.3 (3.95)	9065.1 (3.95)
30th May	8642.3 (3.93)	8592.7 (3.93)	9219.3 (3.96)	9063.3 (3.95)	8140.3 (3.91)	8645.7 (3.93)	8657.3 (3.93)	8708.6 (3.93)
20th June	8148.3 (3.91)	7931.3 (3.89)	8926.3 (3.95)	8366.3 (3.92)	7673.3 (3.88)	7937.7 (3.89)	8234.7 (3.91)	8173.9 (3.91)
11th July	7526.3 (3.87)	7427.3 (3.87)	8650.3 (3.93)	8328.7 (3.92)	7123.7 (3.85)	7557.3 (3.87)	7939.0 (3.89)	7793.2 (3.89)
1st Aug	7468.3 (3.87)	7209.3 (3.85)	8729.7 (3.94)	8614.7 (3.93)	6929.0 (3.84)	7533.3 (3.87)	7257.0 (3.86)	7677.3 (3.88)
22nd Aug	7326.3 (3.86)	7574.3 (3.87)	9207.7 (3.96)	6091.7 (3.60)	7244.3 (3.86)	7548.0 (3.87)	6903.7 (3.83)	7413.7 (3.84)
12th Sept	7454.0 (3.87)	7574.0 (3.87)	9802.0 (3.99)	9353.0 (3.97)	7874.7 (3.89)	7815.3 (3.89)	6560.3 (3.81)	8035.2 (3.90)
MEAN	8122.7 (3.90)	8077.3 (3.90)	9138.6* (3.96)	8501.6 (3.90)	7850.0 (3.89)	8193.3 (3.91)	8000.3 (3.89)	
$CD_{0.05}$	T (Treatment)				0.04			
	I (Brood cycle)				0.04			
	T X I (Treatment X Brood cycle)				0.12			

*Values in parentheses are log transformed value

Figure II. Frame sized wire grid used to measure brood area.