Research Article

IMPACT OF SUPPLEMENT DIETS ON FLIGHTS OF CROSS BREED HONEYBEE (*Apis mellifera* L.)

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ABSTRACT

An experiment was conducted to evaluate the response of supplement diets on flight activities of cross breed honeybee (*Apis mellifera* Lin.) in Chitwan, Nepal. The experiment consisted of five replications and four feeding treatments: feeding low dose sugar (syrup of 166 g sugar); feeding high dose sugar (syrup of 333 g sugar); feeding modified diet (syrup of 166 g sugar + 30 g pollen substitute); and control (no diet supplement except 250 g sugar honey candy to prevent from starvation). Each hive (replication) consisted of five-framed *A. mellifera* colony, which were fed for six days with four days breaks in each feeding and altogether eleven feedings were provided. Sugar syrup feeding stimulated bee foragers flights by 908-987% out-going and 578-704% in-coming, respectively. Modified diet (low dose sugar syrup combined with pollen substitute) was suitable for off-season management of honeybee colonies, which supported high rate of flight activities i.e. 3.3 times out-going and 2.8 times in-coming as compared to the control colonies. Other treatments were intermediate types. The combined diet also showed higher flights than feeding low dose sugar syrup alone indicating necessity of feeding appropriate diet during off-season under Chitwan condition for good flight and foraging activities of honeybees.

Key words: Pollen substitutes, sugar syrup/sugar-honey candy, out-going, in-coming, cross breed

INTRODUCTION

Flight is the initiation by the honeybee foragers while foraging is the final task performed by them. Wide variation occurs on honeybee flight activities during different hours of the day and on different days of the year (Reddy, 1980). Vergheese and Prasad (1980) found that the foraging activities remarkably increased with the increment of broods in the hive. However, the adverse weather creates unfavorable condition for biological revival of the honeybees and affects the gathering of nectar and pollen (Towrek, 1995).

Unavailability of pollen and nectar results very low foraging. Low temperature along with foggy weather during December-January causes shortage of pollen for honeybees in Kathmandu valley and hills. Singh *et al.* (2000) mentioned that a beekeeper should handle honeybee colonies in a special manner during bad weather conditions especially in rainy and hot summer seasons. Thapa and Dangol (1987/88) suggested planting of bee plants, which supply nectar and pollen during summer and monsoon seasons for sustained improvement of honey sources in Chitwan area, otherwise diet supplement is necessary during off-season for the continuous development of honeybee colonies. Therefore, the study was undertaken for off-season management of honeybee colonies with appropriate diet supplement, including syrup and pollen substitute feeding during dearth period which is essential for stationary beekeeping maintaining colony strength and maximum honey production during flow season.

MATERIALS AND METHODS

The experiment was conducted in Bharatpur, Chitwan (Sub-tropical region) in RCBD with four treatments and with five replications. Each hive with five framed colonies of a cross breed, *A. mellifera* was considered as an experimental unit and hives facing in different directions as blocks. The different treatments were: i) feeding low dose sugar (syrup of 166 g sugar); ii) feeding high dose sugar (syrup of 333 g sugar); iii) feeding modified diet (166 g sugar syrup+30 g pollen substitute), per day for 6 days with 4 days breaks; and iv) untreated control (no sugar and no pollen substitute, but in case of honey exhaustion, feeding sugar-honey candy (5:1) @ 250 g at a time to prevent from starvation).

The ingredients used to prepare the substitute were soybean 75 parts, sugar 125 parts, skim milk 25 parts, yeast 2 parts, yolk 15 parts, and honey 20 parts (Thapa and Pokhrel, 2002). All the hives were placed with one-meter hive to hive distance and all other necessary management practices i.e. provision of safe water, pest control, use of comb foundation, removal of descended combs and removal of spare combs were common to all the treatments. To assess the flight and foraging of honeybee colonies fed with different diets, the observations were recorded on excited flights and foraging.

Excited flight

The number of out-going and in-coming honeybees at the hive entrance per five minutes was recorded at 5:00 pm before feeding and within an hour after artificial feeding.

Foraging flight

The number of foragers out-going and in-coming at the hive entrance was recorded per five minutes. To find out the effect of temperature on foraging the observation was recorded four times a day: 6:00-7:00 am, 8:00-9:00 am 2:00-3:00 pm and 5:00-6:00 pm in summer and autumn, respectively. From the last week of November, the recording time was delayed two hours in early morning and two hours before noon and one hour earlier in the evening in winter, respectively.

RESULTS AND DISCUSSION

Effect of diets on flight stimulation

The flight of worker honeybees after ten minutes of feeding increased significantly as compared to control colonies (Table 1). However, flight stimulation was observed irrespective to syrup dose (Figure 1). The flight of out-going honeybees increased by 910.20% with low dose, 987.20% with high dose, and 908.43% with modified diet (low dose syrup combined with pollen substitute) feeding. In-coming numbers increased by 610.59% with low dose, 704.39% with high dose and 577.88% with modified diet feeding, respectively.

Table 1. Variation on flight stimulation of the honeybee colonies fed with different diets, Chitwan, 2000/01

Treatments	No. of bees/colony/5 minutes	
	Out-going	In-coming
Low dose sugar (syrup of 166 g sugar)	355.6 (18.82) a	335.4 (18.28) ab
High dose sugar (syrup of 333 g sugar)	374.0 (19.24) a	366.8 (19.11) a
Modified diet (syrup of 166 g sugar + 30 g pollen substitute)	359.2 (18.87) a	306.4 (17.50) b
Control (Check)	25.8 (5.06) b	38.8 (6.21) c
Mean	278.7 (15.5)	261.85 (15.27)

Means followed by a common letter in column are not significantly different at 5% level by DMRT., Figures in parenthesis indicate square root transformed values.

Effects of diets on seasonal flights

The out-going forager intensity was significantly influenced by different diets and dates (Table 2). The foragers flight (out-going) was significantly higher with all three diets, compared to control colonies from 42nd day onwards, and in 189th day of feeding the flight was the highest with modified diet (low dose syrup + pollen substitute) fed colonies than others but the flight between low and high dose sugar syrup feeding did not differ each other. The number of out-going foragers declined in all the colonies from August to early September except during niger (*Guizotia abyssinica* L.f.) Cass. flowering period when artificial pollen consumption rate was also remarkably decreased.

The in-coming forager intensity was also significantly influenced both by diets and dates (Table 3). The highest number of in-coming bees was observed in modified diet (low dose syrup + pollen substitute) fed colonies after one-half months of feeding. The number of bees in-coming with low dose and high dose syrup fed colonies were also significantly different from the control but did not significantly differ with each other, after five months of feeding.

The number of in-coming foragers remarkably decreased in early September when no bee flora was available in the vicinity. With the blooming of niger (*G. abyssinica*) in late September the number of incoming

foragers increased and reached its peak during January when buckwheat (*Fagopyrum esculentum* Moench.), niger (*G. abyssinica*) and mustard (*Brassica rapa* L.) crops were in full blooms. In February, the queen was caged for mite (*Tropilaelaps clareae* L.) control, which decreased broods in the colony and the foraging activity as well.

Table 2. Variation on out-going foragers of the honeybee colonies fed with different diets, Chitwan, 2000/2001

Treatments	Number of bees/colony/5 minutes										
	1-day 6-Aug	21-day 26-Aug	42-day 21-Sep	63-day 10-Oct	84-day 31-Oct	105-day 22-Nov	126-day 13 -Dec	147-day 3-Jan	168-day 22 -Jan	189-day 13-Feb	T-mean
Low dose sugar (syrup of 166 g sugar)	210.8 (15.50) EF a	151.0 (12.24) F a	130.4 (11.16) F ab	257.6 (15.87) DE b	347.0 (18.30) CD a	363.0 (19.00) CD b	402.2 (19.92) C b	596.0 (24.39) B b	856.0 (29.20) A b	356.0 (18.80) CD b	367.0 (18.34)
High dose sugar (syrup of 333 g sugar)	203.0 (14.17) DEF a	152.2 (12.12) FG a	87.8 (9.15) G bc	186.2 (15.53) EF b	216.0 (14.04) DEF b	312.0 (17.45) CD b	400.2 (19.93) BC b	486.8 (21.95) AB b	632.0 (24.94) A c	271.8 (16.43) CDE b	294.8 (16.37)
Modified diet (syrup of 166 g sugar + 30 g pollen substitute)	197.2 (13.90) F a	176.8 (13.21) F a	170.0 (12.94) F a	605.0 (23.71) D a	374.0 (19.19) E a	744.00 (27.23) C a	978.2 (31.25) B a	1053.4 (32.43) B a	1429.0 (37.68) B a	664.0 (25.71) CD a	639.2 (23.75)
Control (Check)	197.6 (13.95) BC a	105.2 (9.79) DE a	62.4 (7.59) E c	198.4 (13.94) BC b	165.0 (12.61) CD b	167.0 (12.38) CD c	182.8 (13.22) BCD c	272.8 (16.46) B c	438.6 (20.79) A d	146.8 (11.90) CD c	193.7 (13.26)
D-mean	202.2 (14.13)	146.3 (11.84)	112.7 (10.21)	311.8 (13.16)	275.5 (16.04)	396.5 (19.02)	490.9 (21.08)	602.3 (23.81)	838.9 (28.16)	359.9 (18.21)	373.7 (17.92)

Means followed by a capital letter in row and small letter in column are not significantly different at 5% level by DMRT, Figures in parenthesis indicate square root transformed values

Table 3. Variation on in-coming foragers of the honeybee colonies fed with different diets, Chitwan, 2000/2001

Treatments	Number of bees/colony/5 minutes										
	1-day 6-Aug	21-day 26-Aug	42-day 21-Sep	63-day 10-Oct	84-day 31-Oct	105-day 22-Nov	126-day 13 -Dec	147-day 3-Jan	168-day 22 -Jan	189-day 13-Feb	T-mean
Low dose sugar (syrup of 166 g sugar)	196.0 (13.90) D a	207.2 (13.57) D ab	163.3 (12.67) D ab	300.0 (17.70) CD b	407.0 (19.70) BC ab	415.8 (19.80) BC b	355.4 (18.59) C bc	570.6 (23.79) B b	812.8 (28.41) A b	373.6 (19.26) BC b	380.2 (18.69)
High dose sugar (syrup of 333 g sugar)	235.2 (15.28) CD a	198.4 (13.97) DE ab	120.0 (10.58) E b	339.0 (18.25) BCD b	368.0 (18.26) BCD ab	388.0 (19.42) BC b	419.8 (20.36) B b	493.6 (22.15) AB b	662.2 (25.53) A bc	238.2 (15.39) CD bc	346.2 (17.92)
Modified diet (syrup of 166 g sugar + 30 g pollen substitute)	222.8 (14.88) E a	282.2 (16.31) E a	259.2 (15.88) E a	588.0 (23.21) D a	500.0 (22.16) D a	816.0 (28.45) BC a	896.2 (32.52) B a	1069.4 (32.52) B a	1322.4 (36.21) AB a	619.4 (24.85) CD a	657.6 (24.44)
Control (Check)	202.0 (14.04) BC a	131.8 (10.72) CD b	86.8 (8.93) D b	274.8 (16.39) B b	272.8 (16.33) B b	246.0 (14.98) BC c	238.6 (14.89) BC c	287.8 (16.83) B c	462.0 (21.40) A c	167.8 (12.86) BCD c	237.0 (14.74)
D-mean	214.0 (14.53)	204.0 (13.64)	157.4 (12.02)	375.5 (18.77)	386.8 (19.11)	466.5 (20.66)	477.5 (20.94)	605.5 (23.82)	814.9 (27.89)	349.8 (18.09)	405.2 (18.95)

Means followed by a capital letter in row and small letter in column are not significantly different at 5% level by DMRT, Figures in parenthesis indicate square root transformed values

Effect of diets on diurnal flight

Intensity of foraging flight varied in different time of the day and was greatly influenced by diets and temperature (Table 4). The foraging flight was the highest in the late morning followed by afternoon while it was low early in the morning and evening. The minimum foraging rate in early morning and evening was due to the low temperature (below 20^0C) and shortened day length (Table 5). The highest number of out-going bees

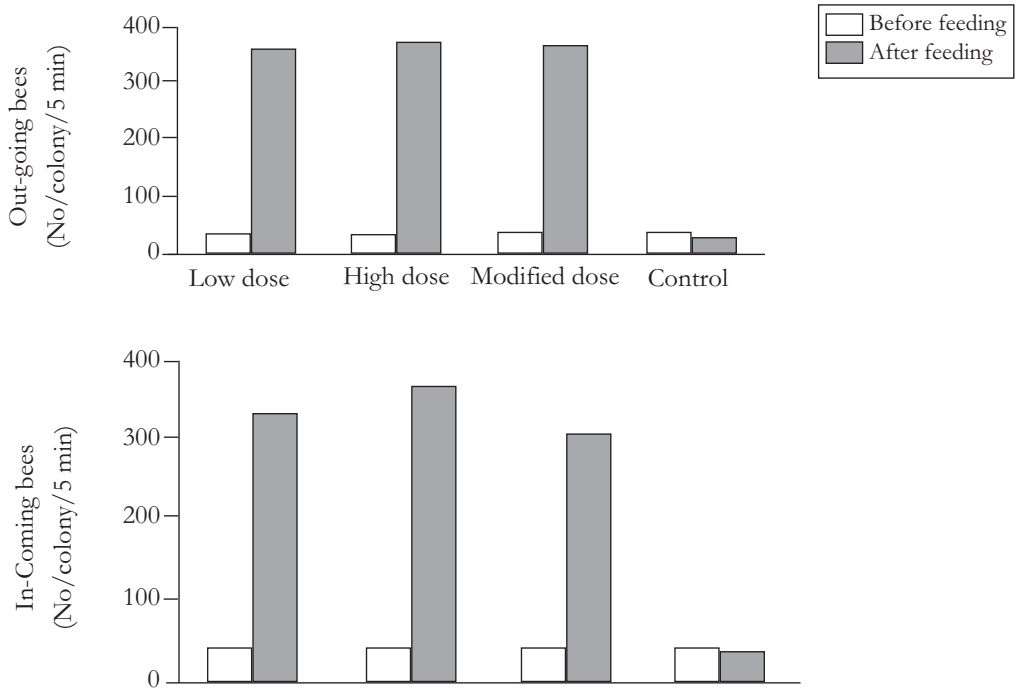

Figure 1. Flight stimulation of worker bees fed with different diets, Chitwan, 2000

(29.0 bees/ colony/ 5 minutes) was with modified diet (low dose syrup+30 g pollen substitute) fed colonies, but the highest in-coming bees (24.0 bees/colony/5 minutes) were observed with low dose syrup colonies indicating efficiency of bee foragers fed with diets. The foraging rate in the late morning was the highest (658 out-going and 675 in-coming bees/colony/5 minutes) with modified diet (low dose syrup + pollen substitute) as compared to control that had the lowest bees (162 out-going and 203 in-coming bees/colony/5minutes). Similar results were observed during afternoon but with smaller number of bees. However, during evening, the highest number of out-going bees (23 bees/colony/5 minutes) was observed from low dose syrup fed colonies and in-coming bees (40 bees/colony/5 minutes) from high dose syrup fed colonies. It shows that foraging flight rate in the evening and in the early morning was highly influenced by day length and temperature but in late morning and afternoon by diet.

Table 4. Variation on pollen foragers of the honeybee colonies fed with different diets, Chitwan, 2000/2001

Treatments	Number of bees/colony/5 minutes										
	1-day 6-Aug	21-day 26-Aug	42-day 21-Sep	63-day 10-Oct	84-day 31-Oct	105-day 22-Nov	126-day 13 -Dec	147-day 3-Jan	168-day 22 -Jan	189-day 13-Feb	T-mean
Low dose sugar (syrup of 166 g sugar)	118.8 (10.52) DE a	71.2 (7.79) E ab	114.0 (10.38) DE ab	183.0 (13.36) CD b	116.0 (10.19) DE ab	93.4 (9.45) E b	221.6 (14.85) BC ab	309.23 (17.53) AB a	399.2 (19.83) A a	98.6 (9.91) E ab	172.5 (12.38)
High dose sugar (syrup of 333 g sugar)	118.0 (10.61) BCD a	88.4 (9.30) CD a	76.4 (8.33) D bc	158.0 (12.48) ABC a	74.0 (8.47) D b	113.0 (10.15) BCD b	166.0 (12.69) AB b	182.0 (13.23) AB b	249.6 (15.52) A b	56.6 (7.45) D b	128.2 (10.83)
Modified diet (syrup of 166 g sugar + 30 g pollen substitute)	120.4 (10.71) EF a	82.8 (9.07) F ab	168.4 (12.91) DE a	318.0 (17.18) BC a	156.0 (12.35) DEF a	234.0 (15.23) CD a	311.4 (17.57) BC a	395.6 (19.79) AB a	518.2 (22.79) A a	138.8 (11.72) EF a	244.4 (14.93)
Control (Check)	120.4 (10.71) B a	41.0 (5.89) D b	53.6 (7.18) CD bc	123.0 (10.43) BC b	70.0 (8.21) BCD b	42.0 (6.20) D c	86.8 (9.15) BCD c	116.2 (10.73) B b	249.8 (15.65) A b	49.4 (6.99) D b	95.2 (9.11)
D-mean	119.4 (10.64)	70.8 (8.01)	103.1 (9.70)	195.5 (13.36)	104.0 (9.80)	120.6 (10.26)	196.5 (13.50)	250.8 (15.35)	354.2 (18.43)	85.8 (9.02)	160.1 (11.81)

Means followed by a capital letter in row and small letter in column are not significantly different at 5% level by DMRT, Figures in parenthesis indicate square root transformed values

Table 5. Variation on diurnal foraging by honeybee colonies fed with different diets, Chitwan, 2000/2001

Treatments	Number of bees foraging		
	Out-going	In-coming	Pollen carrying
Early Morning (6:00 am)			
Low dose sugar syrup	22.1	23.5	4.9
High dose sugar syrup	27.9	18.4	4.5
Modified diet	28.8	20.9	6.9
Control (Check)	11.5	10.7	4.0
Late Morning (11:30 am)			
Low dose sugar syrup	370.0	352.2	153.5
High dose sugar syrup	310.6	345.6	155.0
Modified diet	658.3	673.4	253.3
Control (Check)	161.7	202.6	76.9
Afternoon (2:00 pm)			
Low dose sugar syrup	190.5	261.8	84.7
High dose sugar syrup	247.7	271.4	62.1
Modified diet	446.9	509.9	184.0
Control (Check)	177.6	192.2	70.3
Evening (5:00 pm)			
Low dose sugar syrup	22.8	33.6	9.2
High dose sugar syrup	16.5	39.7	8.1
Modified diet	20.8	26.6	6.7
Control (Check)	11.1	15.2	8.2

The flight (out-going and in-coming) was significantly different between syrup fed and control colonies. The experiment agrees that syrup feeding stimulates bees to fly as reported by Brown (1985). Feeding diets are known to stimulate flight and time of foraging (Kumar and Singh, 1998). However, no significant difference was observed on the initiation and cessation of bee activities between sugars fed and control colonies. It was found that the minimum temperature and day length played crucial role on the time of forager's flight. When the minimum temperature was below 20^0C from mid October and the day length was shorter, bees denied foraging at early morning or at evening. Similar results were found by Burrhill and Dietz (1981). According to them, foraging did not begin until temperature reached 12-14^{0}C. The number of foragers increased at the late morning and at the afternoon compared to early morning or evening. It also agrees to Ali and Hassan (1999) who found the maximum foraging at 9.00 am. Foraging intensity is dependent to climate i.e. rain, temperature, humidity and wind velocity and pasture availability (Mirsha, 1995; Thapa and Dangol, 1987/88; Sihag, 1998; Singh *et. al.*, 2000; Morse and Hooper 1985; Towrek, 1995). Low temperature, high humidity and fogging caused food shortage, which ceased foraging (Entomology Division,1996).The foraging intensity was very low during summer and rainy season which was related to unavailability of pasture. Thapa and Dangol (1987/88) reported that the availability of pollens nectar yielding plants in Chitwan during the period was very low which is related to reduced colony strength.

Modified diet (pollen substitute + syrup fed colonies) has shown maximum flight activity i.e. out-going and in-coming of honeybees. It is directly related to high brood rearing, increased bee strength, and higher honey production as reported by Painkiw and Page (1999) and Free (1967). They found that higher the brood pheromone, brood with higher foraging rate.

Syrup feeding stimulates flight and robbing. So candy feeding is preferred. Modified diet (low dose syrup together with 30 g pollen substitute) per five framed *A. mellifera* colony is useful for off-season management which gave the highest foraging rate (3.3 times out-going and 2.8 times in-coming) than control colonies and was found better than any other treatments. Higher the foraging intensity, higher the brood rearing, colony strength and ultimately the highest honey yield in the subsequent flow season (Pokhrel and Thapa, 2001). Hence, feeding management with suitable diets of the honeybee colonies during dearth period is essential.

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