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Settlement and Performance Evaluation of *Apis mellifera yemenitica* in Relation to Beewax Foundation Use in Modern Hives

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Abstract: Twenty indigenous (*Apis mellifera yemenitica*) honeybee colonies were transferred from the traditional log hives into modern movable frame (Langstroth) hives and divided into 4 Groups. Each group was provided with a modified frame to assess the effect of frame-type on colony settlement, wax secretion, sugar syrup and pollen consumption, sealed brood area, honey and pollen storage. Role of sugar syrup and pollen patty feeding was also evaluated for easy *Apis mellifera yemenitica* establishment in modern hives under Riyadh conditions. In treatment A and B where the frames were provided with complete wax foundation sheets and one inch wide wax foundation stripe, respectively showed complete colony's settlement. In treatments C the wired frame without wax foundation sheet and in treatment D where the frames were without wire and wax foundation sheets out of 5 could settle only 3 and 2- *Apis mellifera yemenitica* colonies respectively. The food consumption rate remained high in treatment B followed by A, C and D, respectively whereas the sealed brood area, honey and pollen storage were found maximum in treatment A followed by B, C and D, respectively. The dimensions of the hive cells were found different in frames with the wax foundation sheet and without wax foundation sheet. The bees constructed larger cells 27/sq. inch in frames with wax foundation sheets and smaller cells 34/sq. inch in frames without wax foundation sheets.

Key words: *Apis mellifera yemenitica*, colony settlement, colony performance, beewax foundation, log hives, langstroth hives

INTRODUCTION

In Saudi Arabia honeybees are traditionally kept in hollowed-out trunks (log hives) of date palm and acacia. About 70% of the local beekeepers are still using the traditional hives, as they believe that modern hives do not suit to indigenous bees (*Apis mellifera yemenitica*). Some of them also claim that they have tried the modern hives but the bees did not settle in those hives. From our initial investigations we found that some of the beekeepers who used the modern hives, they did not use wax sheet foundation and/or did not feed sugar syrup and pollen patty while hiving the local bees.

There are several beekeeper families who are using traditional ways of beekeeping for hundreds of years and pass it on generations to generations[1]. Apart from log hives other primitive hives such as log and clay pots hives that are sealed on one end and with a narrow opening on the other end are also still used in many parts of the world especially in Africa. These hives are insufficient where honeybees produce a substantial quantity of honey and wax[2].

The comb foundation was made in mid of 19th century. It contained a sheet of pure wax embossed on both sides, which is inserted in a wooden frame that provides a base for the honeybees to construct wax comb. The use of wax foundation sheet has great advantages such as construction of straight combs that allow easy and rapid manipulation of the honeybee colonies. It greatly facilitates the honey harvesting from the supers. Moreover it also safe about half of the honey and a lot of labor that is required in honeybee comb construction[2]. Gillette[3] discovered and Skowronek [4] confirmed that bees produced marginally less wax when supplied with beewax foundation than when not.

Hepburn[5] reported that Comb construction sapped the colony's energy supplies through the costly production of wax from the sugars in collected honey. Whitcomb[6] described that in comb construction from foundation consumed about 3.8 kg of honey for the secretion of 453 g of wax. The total cost of 1 kg comb construction had conservatively estimated at 6.25 kg of honey[7]. The bees that were fed on sugar or honey during wax secretion or comb construction can continue to produce wax for longer time. The exact quantity of sugar syrup or honey needed for the production of one pound of wax had never been ascertained but it is probably between eight to sixteen pounds[8]. Metabolic rate and

sucrose consumption and wax production and metabolic rates were highly correlated[9].

Inadequate pollen nutrition after worker eclosion interferes with normal wax gland development and so inhibits construction[10]. Taranov[11] experimentally proved that pollen feeding presented promising results while producing wax. He also depicted that if a young bee is only fed on sugar solution alone during wax production it looses about 20% of body protein in 15-days of intensive wax production. He also found a relationship between the amount of wax production and the quantity of pollen collected in the hive. Protein deficient bees/deprived of pollen produce significantly less wax than do bees with access to pollen[10,12].

Todd and Reed[13] found a positive correlation between amount of pollen stored and brood reared. Honeybee longevity, the amount of brood reared and honey production is reduced when protein consumption is inadequate[14]. Colonies deficient in pollen had 57% less brood and 76.8% fewer dead bees than normal colonies. However, when provided with pollen later they had even slightly more brood than normal colonies[15].

Dodologlu *et al.*[16] reported that colonies housed in wooden hives achieve superior performance over polystyrene hives for selected performance characters. He also pointed out that brood area was significantly increased in colonies that received supplementary feeding such as sugar syrup and bee cake.

The aims of this study was to assess the acceptance of the indigenous bees for the modern hive, the effect of frame-type on colony settlement and the importance and the amount of sugar syrup and pollen patty required for hiving the indigenous package of bees under Riyadh conditions.

MATERIALS AND METHODS

Twenty honeybee colonies of *Apis mellifera yemenitica* were taken from Jizan to Riyadh, Saudi Arabia in traditional hives (Log hives) during Jan., 2001. The colonies were fed on sugar syrup until the beginning of the experiment on March 10 and lasted until May 10, 2001. The colonies were of similar strength (an average of 3-bees covered combs). Colonies were divided into 4 Groups (5 colonies/group) and each group was provided with modified modern-frame.

Group A: Complete-sheet foundation frame: The colonies of this group were hived in Langstroth hives and provided with five new complete-sheet foundation-frames (of European bee-type). Their queens were caged (in Benton cage) for 48 h on the floor of the bottom board and then released. Each colony was fed with two litters (50%) sugar solution (in Division board feeder) and 200 g of pollen patty on the top of the frames every two days for 10-days after hiving. Measuring-cylinder and sensitive balance were used to measure the remaining solution and pollen patties, respectively.

Group B: Strip-sheet foundation frame: This group was treated as Group A, except that the colonies provided with strip-sheet foundation frames. The strip-foundation was (one inch-width and 16 inch-length) embedded in the groove of the Langstroth frame.

Group C: Non-wired-frame: The frames of this group were wired without sheet foundations and treated as Group A.

Group C: None wired-frame: Non-wired Langstroth frames without sheet foundations were used for this group and the colonies were treated as Group A.

Colony settlements, quantity of sugar syrup and pollen patties consumption were estimated for each group 10-days after hiving. The quantity of honey and pollen stored, were also estimated in sq. inches. The worker sealed brood area was estimated (in sq. inches) 2 weeks after hiving. The wax built area was estimated (in sq. inches) 4 times after hiving: 10, 20, 30 and 60-days, respectively. The measurements were made with a wire grid. The dimensions of worker-cells (number of worker-cells/inch squire, worker-cell width and worker-cell depth) were recorded after 10-days in the different Groups using Verniar caliper.

RESULTS

Results revealed a high colony settlement in treatments A and B where all colonies settled. In treatment C out of 5 only 2-colonies absconded while 3-settled (Table 1). In treatment D only 2-colonies could settle where the colonies were provided with frames without wire grid and wax foundation. The colony number 3 in treatment D absconded twice and rehived again. The colony No. 1 in treatment C also absconded (once) but rehived again. Results showed a significant difference between the treatments that were provided with wax foundation sheets and the treatments without the sheets.

The data revealed significantly more wax secretion in treatment A: 739 sq.inches (3.08 combs and 1280 sq. inches (5.3 combs) followed by treatment B, 441.6 sq. inches (1.8 combs) and 923 sq. inches (3.84 combs) whereas in Group C wax -build area was recorded 187.2 sq. inches (0.87 comb) and 203 sq. inches (0.84 comb) per 10-days and per 60-days, respectively (Table 2). The

Table 1: Settled and absconded colonies 10-days after hiving in various treatments

	Treatments			
Colonies	Complete wax sheet foundation frame	One inch wax Strip foundation frame	Without wax wired foundation frame	Wireless without wax foundation frame
1	Settled	Settled	Settled	Abscond
2	Settled	Settled	Settled	Abscond
3	Settled	Settled	Abscond	Settled
4	Settled	Settled	Abscond	Abscond
5	Settled	Settled	Settled	Settled
Settlement	Complete	Complete	Partial	Partial

Table 2: Wax building, sugar syrup and pollen consumption recorded in honeybee colonies provided with various frame types

Treatments	Wax building (sq. inches) (10-days)	Wax building (sq. inches) (60-days)	Sugar consumption (g) (10-days)	Pollen consumption (g) (10-days)
Complete wax sheet foundation frame	739.2a	1280.0a	2068.0b	282.4ab
One inch wide wax strip foundation frame	441.6b	923.0b	3472.0a	343.6a
Without wax foundation wired frame	187.2c	203.0c	1048.4c	193.2abc
Without wax foundation and wire frame	110.4cd	115.0cd	295.6cd	122.1bcd
LSD	161.0	164.0	857.7	165.0

$\alpha = 0.05$

Table 3: Sealed brood, honey and pollen storage recorded in honeybee colonies provided with various frame types

Treatments	Sealed brood (sq. inches) (15-days)	Honey stored (sq. inches) (10-days)	Pollen stored (Sq. inches) (10-days)
Complete wax sheet foundation frame	235.60a	240.00a	36.20a
One inch wide wax stripe foundation frame	214.60ab	112.60b	27.20ab
Without wax foundation wired frame	107.20c	26.20c	18.00c
Without wax foundation and wire frame	68.40cd	15.60cd	9.60cd
LSD	94.89	31.95	15.28

$\alpha = 0.05$

Table 4: The effect of beeswax foundation on comb construction behavior of honeybees

		Treatment B			
Traits	Treatment A	Cell on strip	Cell bellow strip	Treatment C	Treatment D
No. of workers cells/sq. inches	27.02	27.80	34.20	34.20	34.30
Worker cell widtg (mm)	5.18	4.92	Not Recorded	4.68	4.84
Worker cell depth (mm)	10.1	9.69	Not Recorded	9.69	9.13

Group D showed the smallest wax-build area, 110.2 sq. inches (0.46 comb) and 115 sq. inches (0.48 comb) after 10-days and 60-days, respectively. The analysis of variance exhibited a significant difference between all treatments except C and D that had not been provided with wax foundation. Whereas the one comb=240 sq. inches).

Treatment B presented the highest consumption rate (3442 mL) followed by treatment A (2068 mL), treatment C (1747 mL) and treatment D (739 mL), respectively (Table 2). The analysis of variance revealed a significant difference among all treatments except treatments C and D.

The maximum pollen-patties were consumed in treatment B followed by treatments A, C and D, respectively. The analysis of variance showed a no significant difference between all treatments except treatment B and D (Table 2).

Table 3 indicated that treatment A (235.6 sq. inches) showed the largest brood area followed by treatment B (214.6), treatment C (178.6) and treatment D (171), respectively. The analysis of variance revealed a significant difference between the treatments provided with foundation sheet and without foundation sheet but non-significant difference between treatments AB and CD.

Table 3 revealed that the treatments followed the same ranking sequence as in wax-secretion and sugar consumption. The maximum honey storage was recorded in treatment A (240 sq. inches) followed by B (112.6), C (43.6) and D (38), respectively. Treatment A exceeded B because this group was provided with large surface wax-foundation area than the latter. The analysis of variance revealed a highly significant difference between all treatments except treatments C and D.

The pollen storage remained maximum in treatment A 3 6.2 sq. inches followed by treatment B 27.2, C 25.5 and D 24, respectively (Table 3). Results revealed a significant difference between the treatments where the foundation sheets were provided and the treatments without sheets.

The data depicts that the bees in treatment A built larger cells similar to European bees (27.02 worker cells were recorded/sq. inch where as worker-cell width and depth were recorded as 5.18 and 10.1 mm, respectively (Table 4). In treatment B the bees showed a peculiar habit, since it built two types of cells. The cells on the strips that were offered to the bees on the upper part of the comb were similar in size as in treatment A, but larger (27.8 cells/inch squire) than below the strip (on the lower part of the comb). The number of worker-cells were recorded 32.25 cells/sq. inch whereas their width and depth was measured as 4.92 and 9.69 mm, respectively in lower part of the comb. In treatments C and D the cell size remained smaller as compared to treatments A and B which resembled the cells built in the Log hive. However, slight differences were observed between C and D. Group

C measured: 34.3 cells/inch squire and 34.48 for Group D. The worker-cell width were 4.84 and 4.83 mm and the worker-cell depth were 9.34 and 9.13 mm for Group C and D, respectively.

DISCUSSION

The findings of the present study have clearly indicated that *Apis mellifera yemenitica* bee colonies can be successfully transferred and reared in modern hives (movable-frame hive) if the hives are provided with the wax foundation sheets, while hiving the *Apis mellifera yemenitica* bee colonies. Even one-inch wide stripe of wax foundation sheet can lead to complete settlement of the indigenous bee colonies in modern hive as appeared in the treatment B. But without wax foundation sheets settlement chance become slimmer and bee colonies can lost due to absconding as found in treatment D.

The results have shown that wax secretion/comb construction is greatly influenced by the frame type as in treatment A where full wax foundation sheets were added, the wax building was recorded maximum. In treatment D where no wax foundation sheet was added most of the colonies absconded while those settled built a very small wax area. Wax foundation sheets facilitate the bees for rapid comb construction. Moreover, provision of wax foundation sheets safe about half of the honey and intense labor required for comb construction[2]. The results did not agree with Gillette[3] and Skowronek[4] who claimed that bees produce marginally less wax when supplied with beeswax foundation than when not.

The food consumption rate also greatly effected by frame-type as the maximum sugar and pollen consumption was witnessed in treatment B where one-inch wide stripe of wax foundation sheet was provided for comb construction. The reason behind this consumption might be that bees needed more energy to build large surface area of sheet foundation as compared to treatment A where the full wax foundation sheets were provided as reported by Hepburn[5] that comb construction sapped the colony's energy. Whitcomb[6] found that about 3.8 kg of honey is required to secrete 1 453 g of wax and Morse[8] stated that probably eight to sixteen pounds of honey or sugar syrup is used for the secretion of one pound of wax. Metabolic rate and sucrose consumption and wax production and metabolic rates are highly correlated[9].

The sealed worker brood area, honey and pollen storage remained maximum in the frame-types provided with wax foundation sheets as compared to frame-types devoid of sheets. The phenomenon can be attributed to the fact that bees performance regarding pollen and honey storage increases with more wax building that increases the pollen and honey storage area. Moreover, it is very important that the indigenous bees must be provided with pollen patties and sugar syrup while hiving them into modern hives for efficient settlement. Taranov[11] reported that with sugar syrup, provision of pollen is also necessary because if a bee will only be fed on sugar syrup it will loose about 20% of its body protein in 15-days of intensive wax production. Brood area was significantly increased in colonies that received supplementary feeding such as sugar syrup and bee cake[10].

The colonies with complete wax foundation sheet as in treatment A surpassed the colonies provided with stripe foundation sheet as in treatment B in wax building, brood area and honey and pollen storage. Moreover, bees provided with complete wax foundation sheets build larger cells similar to European bees that greatly affects the behavior of the indigenous bees for building wax (the dimensions of the cells) that has a key role in combating with ecto-parasitic mite *Varroa jacobsoni*.

Therefore, we can conclude that provision of beeswax foundation, sugar syrup and pollen patty can play an effective role for efficient and successful colony establishment.

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