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Article Title: Compatibility Assessment of Artificially Combined Honey Bees (*Apis mellifera scutellata* L.) Colonies in South West Mau Forest, Kenya

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ABSTRACT

A pretest post test compatibility test was performed on artificially combined honey bee colonies in semi natural habitat of Itare South West Mau forest over sixteen weeks in July/October period. Five feral honey bee (*Apis mellifea scutellata*) colonies were randomly selected then sub divided and matched pairwise to form ten new intercolony nucs prior to hiving.The foraging season was characterized by *Xanthoxylum gilletii* pollen bloom,*Polyscius falcatus* and *Croton macrostachynus* nectar flow.Matched colonies were translocated into a breeder hive and provided daily with supplementary feeds mainly composed of sugar syrup.There was no difference between months and number of bees observed over four months experimental period (F=1.55, df = 3,92, P=0.207, α = 0.05). The maximum mean in experimental hives was observed in $H_3(C_3C_4)$= 14±1.4 and lowest in $H_4(C_4C_5)$=10±1.2 which were significantly less than control (H_c = 15± 2.1). The number of foragers observed was highest in H_1 (C_1C_2)= 19 ± 0.8 but H_5 was incompatible and collapsed after two months and eventually empty hive was observed at the end of experiment. Some matched colonies show functional compatibility and was able to depict sign of active foraging. Induced swarming revealed 80% success thus possibility of increasing honey yield, propolis, pollen & other hive products by boosting colony foraging fitness due to population increase can be achieved.Control colony (Hc) show significant difference with H_1 & H_3, P = 0.009, t = -0.012 for H_1 and t= -0.219 for H_3 with α= 0.05 respectively.

Key Words : Swarming, nucs, foraging, brood, pollen, *Apis mellifera scutellata*, compatibility, breeder hive, *.Xanthoxylum giletii, Polyscius falcatus.*

INTRODUCTION

Honey bees (*Apis mellifera*) are facing a myriad of challenges from interacting stressors including diseases, parasite mites, pesticides and substandard diet all of which affect their ability to stay healthy and perform daily chores effectively (Alaux et al, 2010). Recently, decline of managed colonies have been noted on many continents and several causes including parasites (*varroa destructor* & *Acarapis woodi*) pathogens (*Nosema spp* and bee viruses), pesticides, contaminated water and use of antibiotics (Kevan et al, 2007) Honey bees has ecological importance as a natural pollinator of wild flora and crops, moreover managed honey bees have economic importance with hive products including honey, pollen, wax, propolis and royal jelly (Mahesshwari,2003). Floral nectars are the major source of carbohydrates for bees containing among other things sugars, amino acid, vitamins, organic acids, metal, alkaloids ,protein and oil (Bogdanov et al, 2004).Beekeeping is a means to expand livelihoods and make the best use of available resources, floral nectar and pollen diversity. A survey of beehives in Kakamega and Kirinyaga revealed that hive occupation varied between 40-70%. A recent survey in Kitui by DANIDA (2005) showed occupation rate of between 30-75% (Carroll,2006). This rates revealed the need to frequently stock the hives with new colonies. The primary goal of every beekeeper is to maximize the number of bees in a colony at the same time that the colony has the potential to produce the maximum amount of honey. There is a powerful numerical effect of keeping large colonies over

small one, research has shown that four small colonies do not produce as much honey as the same number of bees kept in the same hive over the same period (Larry,2013).
Development of a colony is strongly associated with the weather, pollen and availability of nectar, with plenty of pollen supply and nectar flow, the queen bee is fed more as a consequence she lay more eggs. Generally when the peak colony strength reaches its maximum, most brood cells are capped and the honey is gathered in the honey combs. Eventually the space for bees become scarce and there is less space for queen to lay eggs forcing her to expel her pheromone and the colony get ready to swarm.
The flowering of plants and nectar flow are influenced by seasonal weather pattern (Jay, 2004). In Molo area, good management of bees combined with good weather conditions yield upto 20kg per hive per one harvest, however in poor season and poor management, the hive yields as little as 3 kg per hive have been obtained (Carroll,2006). Beekeeping follows seasonal cycles in tropics & it is more difficult to note the seasonal cycle since there is no period when the colony is totally inactive. The major problems affecting beekeepers include lack of knowledge or management of beehives in Molo, cold climate in the area make bees abscond or leave the hive (Carroll, 2006).The choice of a new nest site is ecologically critical for an insect colony. In swarm finding insects, or those that move as colonies from one site to another, this choice is one of the best available example of distributed, non hierarchical decision making process in animals (Kirk, 2007). The mass movement of the colony to the new site is triggered by a quorum sensing mechanism when sufficient scouts are present at one of the alternatives and movement itself is coordinated by different mechanism in different insects (Kirk, 2007). Reproductive swarming is part of the annual life cycle of honey bee colony and takes place when honey bees increase in their population; it is controlled by destroying all queen cells in the hive (Jacob et al, 1992). Overcrowding in hive causes the colony to rear additional queens in specially created queen cells, when the first new queen emerges from the queen cell, half or more of the bees vacate the hive.

MATERIALS AND METHOD

Identification of feral colonies

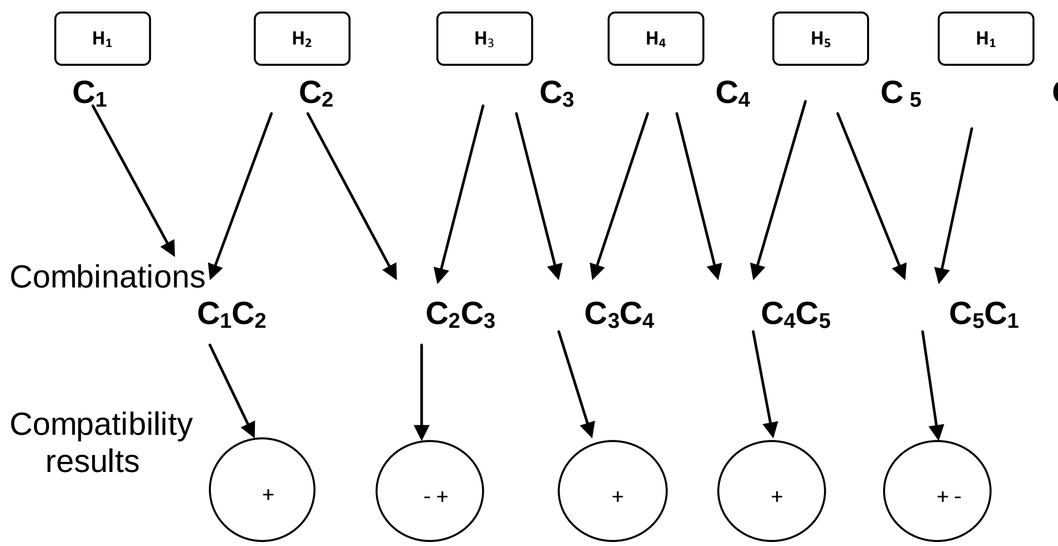
Colonized KTBH hives were identified in the forest for sub division and induced inter colony compatibility. Identification of prolific & active colony was based on frequency of bees in and out of the hive, thus population was the main index of good performing colony. Feral colonies in harvestable hollows were also used in the experiment.

Division & translocation

Five colonies were each divided into two equal parts, the swarm was observed carefully and a comb with honey was in between the swarm so that two halves were obtained. After sub division, the colonies were translocated into breeder hive and matched as shown in figure1. below. Only two combinations were performed with each new colony consisting of members from two different colonies.

Frequency of observation

The hives were monitored and assessed for four months with number of bees in and out of the hive as the main variable of interest. A total of 48 measurements per hive were performed with three observations per week. Each hive was visited for ten minutes at around 10.00am and all bees in and out of the hives were counted.



KEY

+ Compatible colonies — C - colony for colonies 1 to 5

_ Incompatible and collapsed — H - Hives for hives 1 to 5

-+ Two groups observed but eventually combine

+ - Two groups observed in the hive and eventually desert the hive

Figure 1. Experimental colony combination

RESULT AND DISCUSSION

Colonies from different hives show moderate success when matched with other colonies having low or diminished populations, this lead to rise in population of a colony but reduced number of colonies due to matching. Few colonies were able to propagate, multiply and prosper after induction while the rest collapsed either due to incompatibility or fighting among warring intercolony members. It was observed that colonies with fewer individuals are more compatible than matching overpopulated colonies; however Condition of the queen in the colony is also an indispensable parameter in colony combination. Some of the observed colonies were queenless destined to collapse due egg laying workers which only yield drones which doesn't perform any chores thus weakening the colony. More workers and viable queen stabilize the colony and fighting observed was initially strong when colonies were matched.

Successful colonies included those which were able to match into one colony after a short period of separation. The success of matching was significantly high in the experiment revealing compatibility of more than 90% after sixteen week period. Compatibility was observed among matched colonies except the fifth colony (c_5c_1) where matched groups were initially compatible but eventually collapsed after the fifth week of experiment. The mean number of bees observed in hive entrance taking flying in and out of the hive was high after four months in October with 13± 1.3 and lowest in July with 10 ± 0.3 for all the for months of study. However, there was no difference between months and number of bees observed in four months experimental period ($F=1.55$, df = 3,92, $P= 0.207$, $\alpha = 0.05$).The maximum mean in experimental hives was observed in $H_3(C_3C_4)$= 14± 1.4 and lowest in H_4 (C_4C_5)= 10±1.2 which were significantly less than control (H_4 = 15± 2.1). There was very weak positive correlation between number of bees observed over four (16 weeks) with Pearson correlation value of $r = 0.178$.

Control colony (Hc) show significant difference with H_1 & H_3, $P = 0.009$, $t = - 0.012$ for H_1 and $t= -0.219$ for H_3 with $\alpha= 0.05$. Significant difference between H_1 & control colony was observed and H_3 & control colony with $t= -0.012$ and $t = -0.219$ respectively for H_1 & H_3 at $\alpha=0.05$

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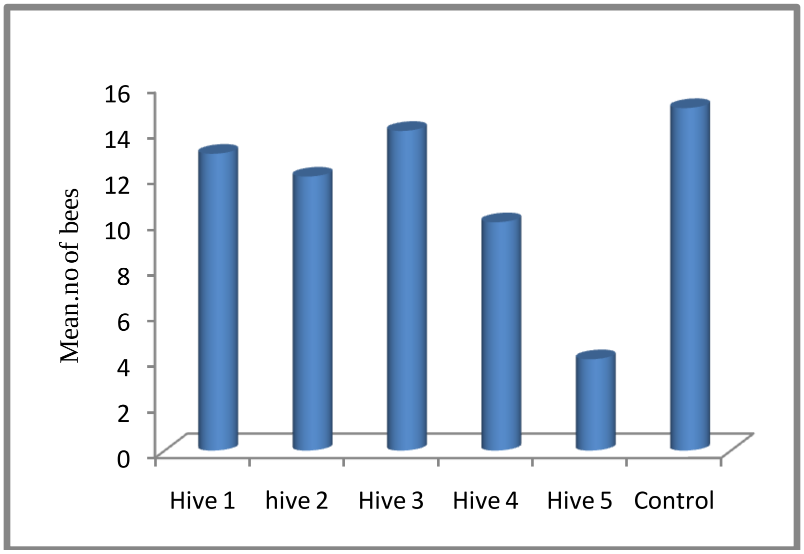

Figure 1. Mean number of bees

Table 1. ANOVA for colonies and period

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	105.458	3	35.153	1.551	.207
Within Groups	2084.500	92	22.658		
Total	2189.958	95			

Table 2. Number of bees observed weekly

Period /month	**week**	**Mean No. of observed in bees**					
		H_1	**H_2**	**H_3**	**H_4**	**H_5**	**Control**
		C_1C_2	C_2C_3	C_3C_4	C_4C_5	C_5C_1	
July	W_1	11± 0.6	10±0.9	12±0.9	8 ±0.9	8±0.3	9
	W_2	10 ± 1.2	8 ± 0.9	11± 1.2	7 ± 1.5	12 ±1.4	7
	W_3	9 ± 0.9	10±0.9	12 ±	9±0.8	12±0.6	12

				0.9			
	W_4	13 ±0.9	12±0.3	12 ± 0.6	7± 1.4	10 ± 2.1	11
August	W_1	11 ± 0.8	8 ± 1.8	11±1.8	7 ± 1.5	9 ±0.9	14
	W_2	9 ± 1.1	11±1.2	14±0.6	12±0.9	10 ± 1.4	12
	W_3	14 ± 0.9	13±1.5	13±0.6	11± 0.7	3 ± 1.5	16
	W_4	16 ± 0.9	13±1.5	11±0.9	12±0.9	0.6 ± 0.6	17
Sept	W_1	11± 0.6	12 ± 0.9	10 ± 0.9	9 ± 0.6	1 ± 0.6	18
	W_2	9 ± 0.6	12± 1.7	13 ± 1.4	7 ± 0.9	0.3 ± 0.3	12
	W_3	12± 0.9	10 ± 2.0	12 ± 0.9	9 ± 0.9	0±0	18
	W_4	14± 1.2	14±0.9	15 ±1.5	12 ± 0.9	0±0	21
October	W_1	12 ± 1.4	14±0.6	17 ± 2.3	12±1.7	0±0	15
	W_2	16 ± 0.8	13±1.7	16 ±2.3	9.6 ± 1.4	0±0	22
	W_3	17± 1.4	13±0.8	19 ±1.2	13 ± 2.4	0±0	16
	W_4	19± 0.8	16 ±1.6	18 ±1.1	13 ±1.7	0±0	18

Critical observation of vegetation and sources of nectar and pollen determine the season to successfully induce colony division. Colonies can subdivide naturally when the population is extremely high or collapse if the population is too low. Flowering season is often dictated by prevailing weather conditions and recent phenomena of climate change have drastically affect colony development. The best period to induce colony division is when there is nectar and pollen bloom so that new brood can be developed. The new brood will support and progress the population of the colony. There is a powerful numerical effect of keeping large colonies over small one, research has shown that four small colonies do not produce as much honey as the same number of bees kept in the same hive over the same period (Larry,2013).Local Ogiek community in Mau forest have been successfully dividing the colonies to stock empty beehive without much difficulty. This is done after harvesting honey and dividing the combs and brood to be shared by two new colonies, however the local technique presumed that queenless colony will automatically breed the queen. The process involved timing of the right season when the forage is abundant and available. Population of colony play a significant role in determining the success of preceding colonies resulting from either dividing or matching of weaker smaller colonies. Larger colonies coupled with viable & strong queen will definitely increase the population within a short period. Brood size & combs included in colony matching also affect resurgence after matching and the proportion of workers, drones and queen in a colony determines the prolificacy in multiplication. Favorable foraging weather conditions and forage availability critically affect the amount of honey to be harvested in the season. Moderate dry season promote effective foraging as opposed to rainy season where foragers are unable to optimally gather pollen and nectar in the field. Extreme rainy season portrays poor foraging period for honey bees and may lead to wastage and rotting of forage in the field, this consequently affect the colony population. Lack of relatedness in distance colonies make it hard to match the two groups as opposed to closely related lineages, thus increasing chances of incompatible & loss of colonies.

Some individuals colony members are genetically related half and full sister lineages. Individuals in a colony are closely interrelated (David et al,2011).The colony performance is a measure of how long a colony stays in a hive without absconding and also how much the colony has grown, both have a bearing on yield on hive products (Pokhrel et al, 2006).

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