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Original research article

Microclimate, Colonization, Colony Strength and Absconding of *Apis mellifera adansonii* Reared in Hives with Modified Entrances

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Abstract Poor construction of hives is one of the factors that adversely affects the establishment and performance of African honeybees reared in top bar hives. The hive entrances of top bar hives were modified and assigned T1 (with one flight entrance on the hive floor); T2 (with one entrance each at the right and left edge of the hive floor; T3 (with one flight entrance at the middle of the hive wall) and T4 (with two flight entrances on the hive wall and right edge of the hive floor). The hives were constructed and installed in May, 2016 in the Honeybee Research Centre of the Department of Zoology, Nnamdi Azikiwe University, Awka. Each hive treatment was replicated three times in a completely randomized design. Colonization rates, hive and ambient temperature as well as relative humidity, colony strength, and absconding rates were monitored and recorded. The results revealed that T4 had the highest temperature (30.63°C) while treatment 2 had the least (30.13±1.24°C). There was no significant differences in temperature among the treatments. Relative humidity inside hive significantly varied among treatments. T3 had the highest (77.94%) and the lowest (75.04%) RH was recorded in T1. The temperature variation was highest in T4 (7.77°C) while the lowest in T2 (4.10°C). The relative humidity variation was highest in T2 (24.12%) while the lowest in T3 (18.41%). Colonization rate was the highest in T3 and 4 (66.67%) while least in T1 (0.0%). The hive treatments did not significantly affect colonization rates. The colony strength of T4, 3, 2, and 1 were excellent, good, poor and zero, respectively. Absconding rate was the highest (100%) in T2 and T3 while the least (50%) in T4. Based on the observations, hive with two flight entrances on the hive wall and right edge of the hive floor (T4) showed better performance to the colony trapped, strength increment and reduce absconding rate of honeybees. However, strategies should be adopted in advance by beekeepers to prevent absconding of bees.

Keywords Hive entrances, Microclimate, Colonization, Colony strength, Absconding, Honeybee

INTRODUCTION

The issue of poor colony establishment of the African honeybees (*Apis mellifera adansonii*) is one of the major challenges facing the apicultural sector in Africa (Ononye and Akunne, 2017). This is why humans have been making several inputs to optimize and sustainable the artificial honey hives for optimal production of honey and other hive products (Akunne *et al*., 2015). However, the type of hives used for rearing honeybees affects the beekeeper's income. For instance, the types of hives used in traditional beekeeping are the reasons for the low productivity, loss of colonies and poor processing of hive products. This is why top bar hives are now used in modern beekeeping as an improvement over the traditional method (Babarinde *et al*., 2012).

Maintaining honeybees in a suitable hive is a promising method for trapping them and enhancing their per-

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formance (Ononye and Akunne, 2017). Hitherto, farmers find it difficult to select and construct suitable hives for their beekeeping activities (Magnum, 2001). Even though more farmers are interested in rearing honeybees as a way to increase their income (Alamu *et al*., 2014), their ignorance of the number of hive flight entrances to adopt, inappropriate skill on bee management practices, colony absconding, poor design of modern hives and low honey yield has constrained them (Kumsa and Takele, 2014).

In past several studies and efforts had been made with respect to hive types (Ande *et al*., 2008b), hive dimension and flight entrance (Babarinde *et al*., 2012) on colony establishment of African honeybees. Researchers have reported low rates of colonization and high absconding rate (Adedeji and Aiyeloja, 2014) of African honeybees. Based on the paucity of information on the proper hive entrances, we evaluated the effects of different entrance positions on microclimate, colonization, colony strength and absconding of *Apis mellifera adansonii* in Awka, South-eastern Nigeria.

MATERIALS AND METHODS

Study area

The experiments were carried out in the Honeybee Research Centre of the Department of Zoology, Nnamdi Azikiwe University, Awka from May, 2016 to April, 2017. Awka lies within coordinates 6°12′N and 7°04′E (Onyido *et al*., 2011). Awka is in the tropical rain forest zone of Nigeria and experiences two distinct seasons – rainy and dry seasons, brought about by the two predominant winds that rule the area: the south-western monsoon winds from the Atlantic Ocean and the Northeast dry winds from across the Sahara Desert. The monsoon winds from the Atlantic create seven months of heavy tropical rains with average minimum rain fall of 1000 mm and maximum rainfall of 3200 mm (NSB, 1998), which occur between April and October and are followed by five months of dryness (November～March). The "Harmattan wind" is a particularly dry and dusty wind which enters the area in late December to January and is characterized by a grey haze limiting visibility and blocking the sun's rays (NSB, 2010). The temperature in the study area is generally 27～30°C between June and December but rises to 32～34°C between January and April, with the month of March experiencing the hottest temperature, i.e. 36～38°C. The relative humidity in the rainy season is 82.37% and 74.25% in the dry season (NSB, 2010).

Description of the experimental site

The Honeybee Research Centre of the Department of Zoology lies within E: 291046.427, N: 691554.263 (Akunne *et al*., 2016). It is located along the track road connecting the university primary school to the Faculty of Management Sciences of the Nnamdi Azikiwe University, Awka. It is situated close to a station of the Unizik stream and was left fallow after the incidence of bush burning in 2015.

Hive treatment and installation

A total of 12 modified top bar hives were constructed and then grouped into four treatments namely: T1, T2, T3 and T4 (see Fig. 1) were constructed for this study. Each hive treatment was replicated three times and labelled as $T1_{I\text{-}III}$, $T2_{I\text{-}III}$, $T3_{I\text{-}III}$ and $T4_{I\text{-}III}$. The T1 had one flight entrance on the hive floor; T2 had one entrance each at the right and left edge of the hive floor; T3 had one flight entrance at the middle of the hive wall and T4 had two flight entrances on the hive wall and right edge of the hive floor. These top bar hives were constructed with hard woods. The timber boards used for the hive

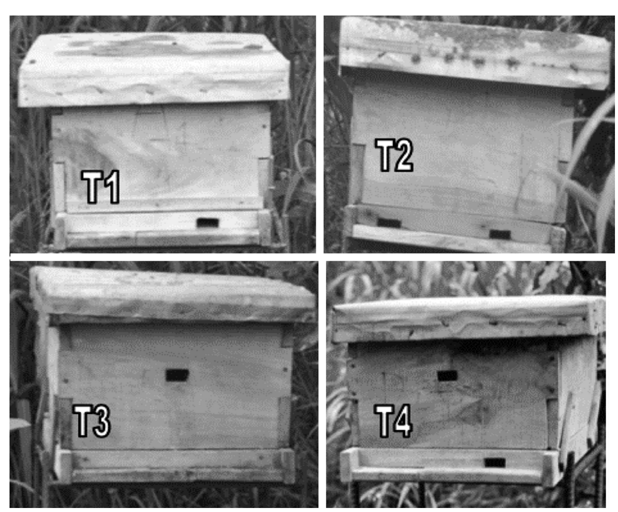

Fig. 1. Position of honey bee entrances in hive treatments (T1, T2, T3 and T4).

construction were piled with spacers in well aerated timber shed to dry for a period of four months (Mbobua, 2013). Each hive consisted of the bottom board (53.34 cm L, 35.56 cm W), main cover board (55.88 cm L, 38.1 cm W), brood chamber (52.07 cm L, 36.83 cm W, 24.9 cm H). The main cover board was made of wood covered with corrugated iron sheets. Each hive comprises of 8 top bars of 2 cm width and hive entrance (s) of 4 × 1 cm with a bee space of 3 mm between the top bars.

Each of the hives were cleaned, baited and weighed. The hives were baited between 6:00 hrs: 8:00 hrs with 40 g of beeswax which was melted and smeared on the hive entrances, top bars and the main cover boards with the help of a brush. The hives were allowed to dry after which the hives were installed (Ande *et al*., 2008a). The baited hives were kept on a metallic stand (46 cm high) under tree shades in the month of May, 2016. The hives were randomly placed at a distance of 4 m from each other while hive entrances were faced to the east (Babarinde *et al*., 2012). During this experiment, the hive's environment was kept clean before and after colonization (Adedeji *et al*., 2014).

Data collection

Determination of the effect of hive entrances on the microclimate of hives during the study period

Temperature (T) and relative humidity (RH) of the four hive treatments labelled $T1_{I\text{-}III}$, $T2_{I\text{-}III}$, $T3_{I\text{-}III}$ and $T4_{I\text{-}III}$ were measured and recorded with the aid of a hand-held digital thermo hygrometer {Model EUROLAB 411TH) once a week and averages determined per month for a period of 12 months from May, 2016 to April, 2017 (Ellis *et al*., 2008). The thermo-hygrometer was placed outside and inside each hive for 2 minutes, in order to record the ambient and hive temperature and relative humidity respectively. This was carried out between 7:00 to 10:00 h on each date (Akunne *et al*., 2015).

The temperature variation (TV) and relative humidity variations (RHV) of the hive treatments were determined using the formula adopted by Mogbo (2014):

$$TV = \text{Max. temp.} - \text{Min. temp.}$$
$$RHV = \text{Max. RH} - \text{Min. RH}$$

Ascertaining the effect of hive entrances on colonization and colony strength of African honeybees at various periods

The modified top bar hives labelled T1, T2, T3 and T4 including: $T1_{I\text{-}III}$, $T2_{I\text{-}III}$, $T3_{I\text{-}III}$ and $T4_{I\text{-}III}$ were monitored twice per week for one hour between 8:00 to 9:00 hours. During monitoring, the number of hives colonized in each treatment and the date of colonization were recorded. The colonization rate (CR) per treatment was expressed in simple percentages using the formula (Babarinde *et al*., 2012).

$$CR = \frac{\text{No. of colonized hives per treatment}}{\text{No. of hives installed}} \times 100$$

Where CR = Colonization rate

To determine the colony strength of colonized hive treatments labelled as T2I, T3I, T3II and T4III. It was determined once during the experiment and rated as excellent, good, poor and zero scales based on the number of worker honeybees covering three randomly inspected top bar combs from each hive treatment in the month of March, 2017 between 7:00 to 8:00 hours. Each inspection lasted for five minutes (Akunne, 2015). If 70∼100, 40∼60, <40, and 0% of the combs were covered by bees during inspection it was rated as 'excellent' (+++), good (++), poor (+), and zero (−), respectively (Aregawi *et al*., 2014).

Ascertaining the effect of hive entrances on absconding of African honeybees

The colonized hives were inspected externally on a weekly basis from August, 2016 to April, 2017 between 10:00 to 12:00 h and the number of absconded hives as well as the date of absconding for each hive treatment was recorded. The data on absconding was collected by observing the hive entrances of colonized hives for absence of honeybees. The absconding rate (AR) per treatment was expressed in simple percentages while the date of absconding was recorded (Babarinde *et al*., 2012).

$$AR = \frac{\text{No. of absconded hives per treatment}}{\text{No. of hives colonized in the treatment}} \times 100$$

Where AR = Absconding rate

Table 1. Average minimum and maximum hive temperature, temperature variation, ambient temperature and mean hive temperatures

Treatments	Min. average temp. (°C) (a)	Max. average temp. (°C) (b)	Temperature variation (b-a) (°C)	Min. average ambient temp. (°C) (a)	Max. average ambient temp. (°C) (b)	Mean hive temperature (°C) ± SD
T1	27.46	32.80	5.34	14.05	33.04	30.49 ± 1.37[a]
T2	27.08	31.18	4.10	14.05	33.04	30.13 ± 1.24[a]
T3	27.67	33.05	5.38	14.05	33.04	30.48 ± 1.35[a]
T4	28.23	32.73	4.50[a]	14.05	33.04	30.63 ± 0.69[a]

a, b, c means superscripts,
[1]Columns with similar superscripts are not significantly different at $p > 0.05$

Table 2. Average minimum and maximum hive humidity, humidity variation, mean ambient humidity and mean humidity of the four treatments

Treatment	Min. average humidity (%) (a)	Max. average humidity (%) (b)	Relative humidity variation (b-a) (%)	Min. average ambient humidity (%)	Max. average ambient humidity (%)	Mean hive relative humidity (%) ± SD
T1	65.00	88.16	23.16	57.00	84.90	75.04 ± 4.89[a]
T2	67.33	91.45	24.12	57.00	84.90	77.30 ± 5.98[ab]
T3	67.67	86.08	18.41	57.00	84.90	77.94 ± 5.13[b]
T4	67.67	88.42	20.75	57.00	84.90	76.73 ± 5.32[ab]

a, b, c means superscripts
[1]Columns with similar superscripts are not significantly different at $p > 0.05$

Statistical analysis

Data collected from hive temperatures and relative humidity were subjected to Analysis of Variance (ANOVA) and means were separated using Duncan's Multiple Range Test at 5% significant level ($p < 0.05$). The colonization rates and absconding rates of the treatments were subjected to T-test of significance using SPSS computer package (version 20) (IBM Corp., 2011). However, Microsoft Excel, 2007 was used to plot the graphs.

RESULTS

Temperature inside hive was not significantly different among treatments ($p = 0.08$) (Table 1) though T4 had the highest temperature (30.63 ± 0.69°C), followed by T1 (30.49 ± 1.37°C) while T2 had the least (30.13 ± 1.24°C). However, temperature variation was varied among treatments ($p = 0.01$) (Table 1). Temperature variation was the highest in T3 (5.38°C) followed by T1 (5.34°C) while the lowest (4.10°C) in T2 (Table 1).

Table 2 revealed that T3 had the highest (77.94 ± 5.13%) relative humidity followed by treatment 2 (77.30 ± 5.98%) while T1 had the least (75.04 ± 4.89%) without significant differences ($p = 0.12$). However, relative humidity was found significantly different among treatments ($p = 0.03$) (Table 2). The highest (24.12%) relative humidity variation was found in T2, followed by T1 (23.16%), and the lowest (18.41%) was in T3.

Table 3. Effect of hive entrances on the colonization and colony strength of African honeybees

Treatments	No of hives installed	No of hives colonized	Colonization rate (%)	Colony strength
T1	3	–	–	–
T2	3	1	33.33	+
T3	3	2	66.67	++
T4	3	2	66.67	+++
Total	12	5	41.67	

Table 3 revealed that colonization of the African honeybees was observed in T2, T3 and T4 but no colonization was observed in T1 during the study period. The colonization rate was highest (66.67%) in T3 and T4 followed by T2 (33.33%) while none was recorded in the T1 (0.0%) without statistical differences among treatments ($p = 0.08$) (Table 3). Fig. 2 showed that treatments 3 and 4 were colonized by African honeybees in the study area. There was no significant difference between the colonization rates of the hive treatments ($p = 0.08$). The colony strength of treatment 4, 3, 2, and 1 were excellent, good, poor and zero, respectively Fig.

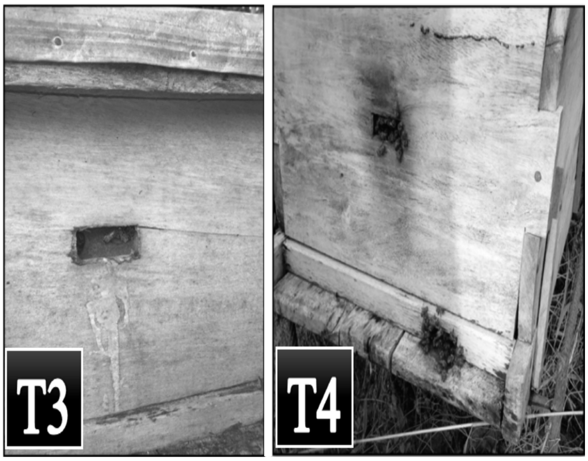

Fig. 2. Colonized T3 and T4 with showing honeybees at the hive entrance.

Fig. 3. Comb showing the distribution of honeybees in T3 and T4.

3 showed the number of honeybees covering the combs formed in T3 and T4.

Absconding rate of honey bees was significantly different among treatments ($p=0.03$) (Fig. 4). Abscond of honeybee was occurred in T2, T3, and T4 during the study period. The absconding rate was the highest (100%) in T2 and T3 while the least (50%) in T4.

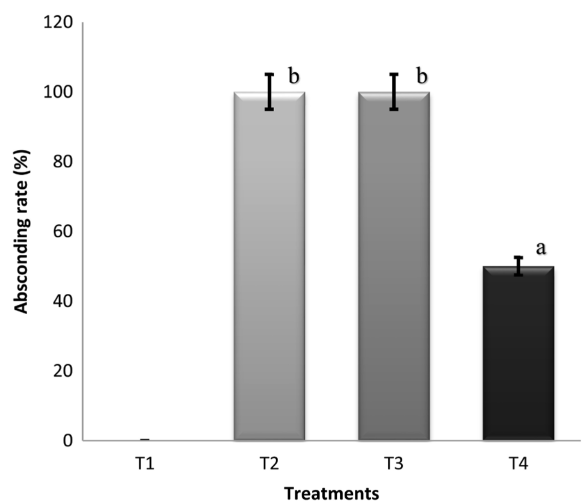

Fig. 4. Effects of hive entrances (T1, T2, T3, and T4) on absconding of African Honeybees.

DISCUSSION

The result of this study revealed that the hive entrances did not significantly affect the hive temperature. Meanwhile the mean hive temperature values (30.13~30.63°C) recorded during this study fall within the range recommended for brood development of the honeybees. Literature revealed that the brood nest needs temperature of 30~36°C to develop the brood (Abd-Elmawgood *et al*., 2015). Petz *et al*. (2004) recommended that the suitable range of internal temperature for maintaining honeybee colony is 33 to 36°C. This temperature when constant is crucial for the normal growth and development of the brood (Abd-Elmawgood *et al*., 2015).

The result revealed that treatment 3 had the highest relative (77.94±5.13%) humidity followed by treatment 2 (77.30±5.98%) while treatment 1 had the lowest. However, hive entrances did not significantly affect the internal relative humidity of the hives and ranges between 75.04~77.94%. This range is above that recommended by Ellis (2008) who reported that the humidity in the brood nest of a healthy honeybee colony to be between 50 and 60%. The reason for the variation in the relative humidity could be as a result of difference in the climatic conditions of the study areas. However, hive entrances significantly affected both temperature and relative humidity variations of the hives during the study period. This observation is similar to the observation of Mogbo (2014) who reported that housing types influenced micro climates for snail houses.

Colonization of the African honeybees was not significantly affected by hive entrances during the study period. This is in line with the findings of previous studies (Babarinde *et al*. 2012; Ononye and Akunne, 2017) who reported that colonization is not dependent on the entrance of beehives. However, treatment 4 had excellent colony strength during the study which could be attributed to its population. Previous studies on colony strength showed that hives with high population are usually stronger than those with low population (Getachew *et al*., 2015).

The absconding rate of African honeybees was higher (100%) in T2 and 3 than T4 (50%). The least absconding rate observed in T4 is an indication that African honeybees do prefer hives with two entrances (one at the right edge of the bottom board and the other at the middle of the hive wall) for better colony establishment. Previous studies revealed that African honeybees have a natural tendency to abandon their hives completely (Buckley *et al*., 2004; Kamatara, 2007). The result of this study is in contrast with the report of Adedeji *et al*. (2014) who stated that honeybees in all the hives were remarkably stable and agile in their activities and operations with 0% absconding rate. Kugonza *et al*. (2009) observed absconding rate of 29.2% in their study which was attributed to post-colonization insect.

CONCLUSIONS

This study revealed that hive entrances do not significantly affect the colonization and absconding of honeybees but significantly affected the microclimate (especially temperature and relative humidity variations) of hives. The colonization rate was highest in T3 and T4 (66.67%) while lowest in T1. T4 resulted in stronger colony strengths. The absconding rate was highest in T2 and treatments with T3 (100%) while least in treatment with one entrance each at the right and left edge of the hive floor (50%). Based on these observations, T4 was recommended since the colony trapped in it had excellent strength and reduced absconding rates. However, T3 could also be adopted by beekeepers but strategies to prevent absconding should be employed.

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