INFLUENCE OF HIVE COVER MODIFICATIONS AND AMBIENT MICROCLIIMATE ON COLONIZATION OF AFRICAN HONEYBEES IN AWKA

ABSTRACT

Poor colonization of hives by African honeybees is one of the constraints facing the beekeeping sector. This study aimed to determine the influence of some hive cover modifications on the colonization of African honeybees in Awka. The hive covers of top bar hives were modified by insulating them with different materials and grouped into four treatments, namely: T1 (plywood), T2 (warped boards), T3 (polyvinyl chloride ceiling material), and T4 (foam). At various months, data on the ambient microclimate (temperature and relative humidity) and the number of hives colonized per treatment were collected. The colonization rate was highest in treatment 1 (100%), followed by treatment 2 (33.33%) while treatments 3 and 4 (0.00%) had the least. Hive treatments did not significantly affect the colonization of honeybees ($p = 0.09$). Treatment 1 colonized in the months of July, October, and November, while that of Treatment 2 occurred in December. Months had significant effect on the mean colonization of African honeybees ($p<0.05$). The mean colonization of hives and ambient temperature had a negative correlation while there was a positive correlation between the mean colonization of hives and ambient relative humidity. Hive covers insulated with ply wood were recommended since they achieved earlier colonization than other treatments.

Keywords: Hive Cover, Colonization, Ambient microclimate, African honeybees, Awka

INTRODUCTION

Honeybees are among the most researched economic insects in the world because of their crucial role in agriculture (Human *et al*., 2015). African honeybees are referred to as vital participants in food security in Nigeria because of their crucial involvement in pollination annually (Fasasi & Afolabi, 2019). Additionally, honeybee projects provide employment for the plethora of young people without work in many communities (El-Sayyad *et al.*, 2019). Despite the fact that more farmers are considering honeybee farming as a means of boosting their income (Alamu *et al.*, 2014), low productivity and subpar colonization by African honeybees have been a significant barrier. Other factors that negatively impact the establishment and performance of African honeybees raised in top bar hives include lack of knowledge about the best time to install hives, inappropriate skill in bee management practises, colony absconding, poor construction of modern hives, delays in hive colonization, and low honey yield (Kumsa and Takele, 2014; Babarinde *et al.,* 2015; Ononye & Akunne, 2019).

Furthermore, the temperature and humidity of the surrounding environment have a large influence on the effectiveness in growth and production of honeybees, necessitating some modifications to the beehives (Abou-shaara *et al*., 2013; Abou-Shaara, 2014). It is advised that materials that can isolate heat and humidity be used to make modern apiculture hives more suited for honeybee colonies. (Erdoğan, 2019). Insulation for hive covers is essential in the winter when temperatures may fall below zero (Mohamed & Miguel, 2021). Hive covers are still considered useful for improving honey bee colony thermoregulation (St. Clair *et al*., 2022). A recent study by Alburaki and Corona (2021) revealed that different hive construction materials (such as wooden and polyurethane materials) can reduce temperature and humidity fluctuations.

The addition of insulation or extra layers around the hive cover (Abbott, 2016) are also suitable modifications of beehives used for beekeeping due to their good ventilation, heat insulation, and the naturalness of the surfaces with which bees come into contact (Erdoğan, 2019). The paucity of information on the influence of hive cover modifications and ambient microclimate on the colony establishment of African honeybees in Awka formed the basis of this study.

MATERIALS AND METHODS

Study Area

This study was carried out in the Honeybee Research Centre of the Department of Zoology, Nnamdi Azikiwe University, Awka from January, 2022 to December, 2022. The study area lies within geographical coordinates of 6°15'13''N, 7°6'41''E. According to the National Statistical

Book (1998), Awka in Nigeria's tropical rain forest zone has two distinct seasons: the rainy season, which lasts from April to October and is followed by five months of dryness, and the dry season (November - March). The region experiences the Harmattan, a particularly dry and dusty wind, from late December to early January. It is distinguished by a grey haze that reduces visibility and blocks the sun's rays (NSB, 2010).

Source of Materials

The hard wood species known as Iroko (*Milicia excelsa*), which was utilized to build the hive, was purchased from the Timber market in Awka, Anambra State. The building materials Department of the Eke Awka market in Awka was where the various materials (ply wood, warped board, PVC ceiling, and foam) used to make hive covers were acquired.

Hive Treatment and Installation

Based on the various hive cover insulating materials utilised, a total of twelve (12) modified top bar hives made with *Milicia excelsa* were divided into four treatments (T1, T2, T3, and T4). The hive treatments T1I-III, T2I-III, T3I-III, and T4I-III were each replicated three times. Plywood was used to insulate the hive covers in Treatment 1 or the control, warped boards were used in Treatment 2, PVC (polyvinyl chloride) ceiling insulation in Treatment 3, and foam was used to insulate the hive covers in Treatment 4 (Plate 1).

T1 T2 T3 T4

Plate 1: Hive treatments (T1, T2, T3 and T4) with different hive cover insulators

Before being utilized to build hives, the timber boards were heaped with spacers in a well-ventilated timber shed for a period of four months to dry (Mbobua, 2013). Each hive cover was constructed from a wood frame and covered with corrugated iron sheets. Each hive had two hive entrances (4 x 1 cm), 2 cm wide frame bars, and a 3 mm bee space between the frame bars (Ononye & Akunne, 2019).

Baiting hives

Each of the hives were cleaned, baited using beeswax. The hives were baited between 6:00 - 8:00 am with forty grams (40 g) of beeswax which were melted and smeared on the hive entrances, frame bars and the main cover boards with the aid of a brush. The hives were allowed to dry after which they were installed (Ande *et al*., 2008; Ononye & Akunne, 2019). The baited hives each were kept on metallic stands (46 cm high) within the apiary in the month of January, 2022. The hive were randomly placed at a distance of 10 meters from each other while the hive entrances were faced to the east (Babarinde *et al*., 2012). During this experiment, the hives environment were kept clean before and after colonization (Adedeji *et al.*, 2014).

Data Collection

For 2 minutes, the thermo-hygrometer was positioned outside each beehive to measure the relative humidity and ambient temperature. This was done every day from 7:00 am to 10:00 am for three times per month (Akunne *et al*., 2015). 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 two times per week for one hour between 8:00 am to 9:00 am while the number of hives colonized in each treatment and the date of colonization were recorded.

The relationship between ambient temperature and relative humidity to colonization rates of African honeybees were determined by running a correlation analysis of the data generated from the ambient temperature, relative humidity readings and colonization of African honeybees during the study period (Ononye, 2018).

A linear model was proposed and fitted using Microsoft Excel, 2019 version for mean colonization of hives using temperature and humidity as independent variables (Akunne, 2011; Ononye, 2018).

The model is stated thus:

$Y_1 = B_0 + B_1X_1 + B_2X_2$.

Where: Y_1= Colonization; B= Constant; X_1= Ambient temperature; X_2= Ambient relative humidity

Data Analysis

The ambient temperature, and relative humidity was compared among months using One Way Analysis of Variance (ANOVA). Tukey Honestly Significant Difference test was used to separate the sample means using IBM statistics software (version 25). Due to the scaling of the dataset and the dataset not being normally distributed (Shapiro-Wilk value; $W = 0.15207$, p-value < 0.05). Two-Way ANOVA analysis (done by fitting a Generalized Linear Model (GLM) in R software) was used to ascertain the interaction of the treatments and ambient microclimate variables (mean temperature and relative humidity) on mean colonization. It was also to used determine the interaction of the months and ambient microclimate variables (mean temperature and relative humidity) on mean colonization. However, Pearson Product Moment Correlation analysis was used to determine the relationship between ambient temperature and relative humidity to colonization. All data analysis was done using SPSS computer package (version 25) (IBM Corp., 2011). However, Microsoft Excel, 2019 was used to plot the graphs.

RESULTS

Table 1 shows the colonization of African honeybees as influenced by hive cover modification at various months. The Table revealed that the highest colonization rate was recorded in treatment 1 (100%) followed by treatment 2 and 4 (33.33%) while treatment 3 (0.0%) had the least. The hive treatments did not significantly affect mean colonization rates ($p>0.05$).

Figure 1 shows the monthly colonization of African honeybees during the study period. The colonization of Treatment 1 was observed in the months of July, October, November while that of Treatment 2 occurred in December. However, months had significant effect on the mean colonization of African honeybees ($p<0.05$).

Table 2 revealed that the highest mean ambient temperature was recorded in the month of May (31.57 °C) followed by December (31.09 °C) while the least in the month of August (25.32 °C). The highest mean ambient relative humidity was recorded in the month of September (88.40%), followed by August (88.25%) and the least in the month of January (47.27%). There was a significant difference in the monthly ambient temperatures and relative humidity (P<0.05) during the study period.

The mean ambient temperature had a significant effect on the mean colonization rate (P<0.05) while the mean ambient relative humidity had no significant effect on colonization (p>0.05). The result further showed that the interaction of treatments with mean ambient temperature was not significant (P>0.05). The mean ambient temperature and months also had no significant interaction P>0.05).

The result further revealed a negative correlation between the mean colonization of hives and ambient temperature (r = -0.116, p=0.72). However, a positive correlation between the mean colonization of hives and ambient relative humidity (r = 0.03, p=0.92). The linear model Y = -0.0073x + 0.2989 shows that for every unit decrease in ambient temperature, colonization increased by 0.007 unit (Figure 2). The linear model; Y = 0.0003x + 0.0638 implies that for every unit increase in ambient relative humidity, colonization increased by 0.0003 unit (Figure 3).

Table 1: Colonization of African honeybees as influenced by hive covers at various months

Treatments	No. of Hives Installed	Months colonized												Total hives colonized (%)
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
T1	3	0	0	0	0	0	0	1	0	0	0	1	0	3(100)
T2	3	0	0	0	0	0	0	0	0	0	0	0	1	1(33.33)
T3	3	0	0	0	0	0	0	0	0	0	0	0	0	0(0.00)
T4	3	0	0	0	0	0	0	0	0	0	0	0	1	1(33.33)
Total	**12**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**1**	**2**	**5(41.67)**

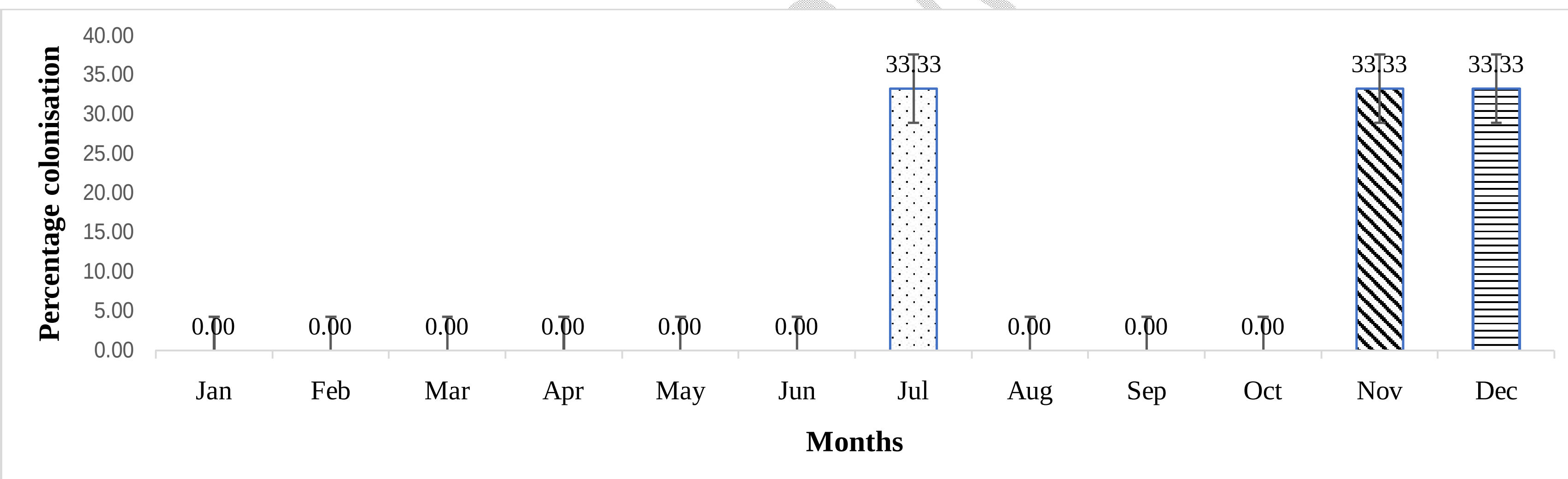

Figure 1: Percentage colonization of African honeybees at various months

Table 2: Monthly Mean ambient temperature, relative humidity and colonization during the study

	Ambient temperature				Ambient relative humidity			
Months	Minimum	Maximum	Range	Average	Minimum	Maximum	Range	Average
January	24.6	32.46	7.86	30.19[cd]±2.036	42.28	50.73	8.45	47.27[a]±2.407
February	28.33	33.48	5.15	30.81[cd] ±1.542	51.48	68.70	17.22	58.55[b]±5.182
March	28.05	35.76	7.71	30.71[cd] ±2.246	55.95	78.10	22.15	67.56[c]±6.921
April	27.76	34.05	6.29	30.67[cd] ±1.905	59.73	84.90	25.17	72.80[cd]±8.707
May	30.83	32.83	2.00	31.57[cd] ±0.729	70.33	88.00	17.67	78.52[d]±5.178
June	29.53	31.25	1.72	30.41[cd] ±0.547	84.00	88.70	4.70	86.17[e]±1.322
July	24.18	29.95	5.77	28.39[bc]±1.803	85.50	88.90	3.40	87.51[e]±1.099
August	22.13	27.5	5.37	25.32[a]±1.755	87.00	89.40	2.40	88.25[e]±0.739
September	24.05	29.98	5.93	27.10[ab]±1.725	85.80	90.50	4.70	88.40[e]±1.457
October	24.05	29.98	5.93	27.10[ab]±1.725	83.02	88.42	5.40	85.69[e]±1.608
November	24.64	33.18	8.54	29.94[cd]±2.381	65.35	78.80	13.45	74.28[d]±3.328
December	24.69	36.02	11.33	31.09 [d]±3.542	43.49	57.33	13.84	50.20[a]±4.456

Columns sharing similar superscripts are not significantly at P>0.05

Table 3: Relationship between Mean ambient temperature, relative humidity and colonization

		Colonization		
Colonisation				
Mean Ambient Temperature	Pearson Correlation	-.116	1	
	P-value	.719		
Mean Ambient Relative Humidity	Pearson Correlation	.032	-.622*	1
	P-value	.921	.031	

*. Correlation is significant at the 0.05 level (2-tailed).

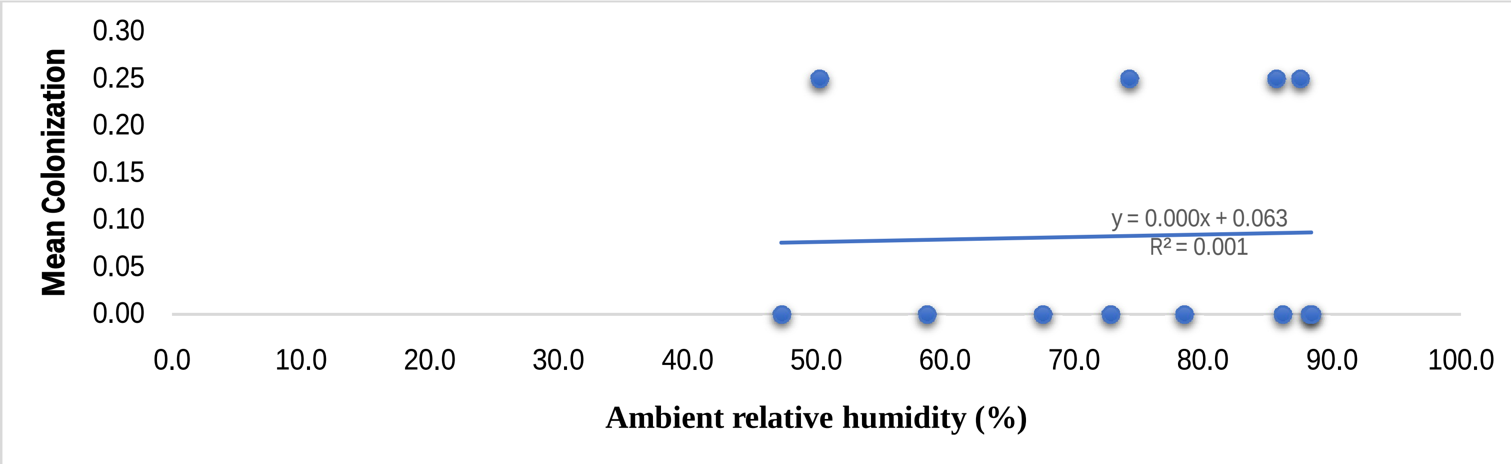

Figure 2: Relationship between ambient temperature and colonization of African honeybees

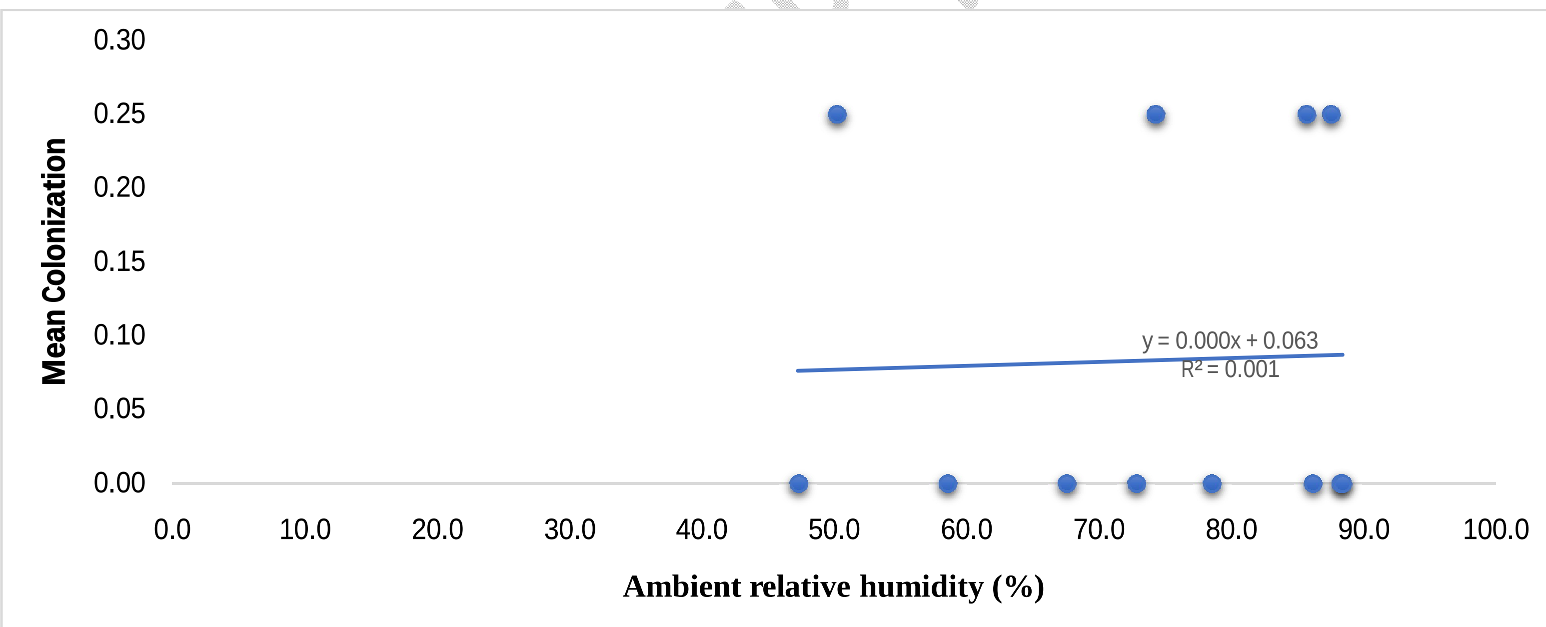

Figure 3: Relationship between ambient relative humidity and colonization of African honeybees

DISCUSSION

The result of this study showed that only the hive covers insulated with wood-based materials (plywood and warped boards) colonized during the study period. This could be attributed to the fact that African honeybees prefer woody habitats in nature. This is in line with the work by Erdoğan (2019) who earlier reported that colonies housed in wooden hives achieved superior performance over polystyrene hives. Contrastingly, previous work by Alburaki and Corona (2021) showed that hives made of polyurethane provided better insulation than hives made of softwood. It was also observed that hive covers insulated with foam did not colonize during the study period. This differs from the observation made in previous work by El-Sayyad *et al*. (2019) who stated that thermal insulation by foam is the best type of thermal insulation for bees.

The colonization of hive covers insulated with plywood and warped board were observed in the months of July, October, November and December. This observation is in contrast to those of Anumba *et al*. (2020) who observed colonization of African honeybees in the month of July, August and September in the same study area. The result also varied from earlier reports in the same study area by Ononye & Akunne (2017) who reported that colonization did not occur from the month of May to July, which marked the beginning of rainy season. Adedeji *et al.* (2014) stated that the best period for hives placement in the Niger Delta region is between August and September. The result of this study differed from that of Ojating and Ojating (2004) who stated that beehive colonization occurred in September, February, April and May. The differences in months of hive colonization from previous studies could be attributed to the variations in the ambient microclimate variables (temperature and relative humidity) in the study area.

The result further revealed that there was no significant difference in the monthly colonization of the hive treatments. This observation supports the observation by Ononye & Akunne (2017) who also noted that there was no significant difference between the monthly colonization rates of the beehives during their study.

Ambient temperature and relative humidity correlated negatively and positively with the colonization of African honeybees, respectively. This indicates that an increase in external temperature decreases colonization of African honeybees, while an increase in relative humidity increases it. The result revealed that month of the year or the ambient temperature could play a vital role in colonization, which could influence the efficacy of the hive cover used for beekeeping. This is consistent with previous findings (Abou-Shaara et al., 2013; Abou-Shaara 2014) that indicated that ambient temperature and humidity have a significant impact on honeybee colony establishment and performance. This study also agrees with the report by Li *et al*. (2019) who stated that he ambient temperature affects the affecting their life activities of bees.

CONCLUSION

This study showed that only hive covers insulated with wood-based materials (plywood and warped board) colonized during the study period. The months of colonization of African honeybees observed in this study were July, October, November, and December. Ambient temperature and relative humidity correlated negatively and positively with the colonization of African honeybees, respectively. The month of the year or the ambient temperature plays a vital role in colonization, which could influence the efficacy of the hive cover used.

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