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HIVE TEMPERATURE REGULATION IN COLONIES OF WEST AFRICAN HONEYBEE (*APIS MELLIFERA ADANSONII* LATREILLE) (HYMENOPTERA: APIDAE) DURING THE WET AND DRY SEASONS.

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ABSTRACT

Apis mellifera adansonii Latreille (Apidae) is the dominant honeybee species found in Nigeria and other West African countries, a warm climate. These honeybees are not known to be confined to their nest for long period despite the warm climate. The bees abscond and swarm regularly unlike the European species of bees. In Ile-Ife, Osun State, Nigeria, a town located in 7.55°N and 4.533°E, a study of thermoregulatory capacity of 16 colonies of *Apis m. adansonii* in 4 apiaries was carried out for 18 months. The results obtained were used to evaluate the differences in the mean colony cluster temperatures, and the fluctuations of the mean colony clusters' temperatures with ambient. Although the material used in making the hives and the volume has latent effect on the colony cluster temperature. The colony temperatures were significantly different ($F_{3, 48}$ = 3.81, P = 0.0157). However, there were no significant differences between the mean colony cluster temperatures in Apiaries 1 and 3 and between 2 and 4 ($T_{3, 48}$ = 2.01063, P = 0.3718 (P > 0.05). The colony temperatures were significantly different from the ambient in all the apiaries ($F_{1, 16}$ = 25.58, P = 0.0001). Temperature generated by the bee colonies and the hives triggers many behavioural and physiological reactions. Hence, this study contributes towards the development of standard hives with adequate ventilation for regulation of colony temperature; understanding of the swarm biology, behaviour and colony organization in *Apis mellifera adansonii.*

Keywords : *Apis mellifera adansonii*, thermoregulation, colony cluster, ambient temperature, apiary, hive.

INTRODUCTION

Insects like any other animals depend on ambient temperature to perform most of their life activities like flight, foraging, nursing young ones and growth (Plath, 1934). Many scientists hold the view that insects are poikilothermic, i.e. they cannot regulate their body temperature which varies with the environmental conditions. Mohammed (1961) observed some insects with limited degree of heterothermy are able to maintain their body temperature little higher or lower than that of their environment. Insects employ several methods to raise their body temperatures above the ambient temperature, with many generating temperatures exceeding 98.6° Fahrenheit (37° Celsius). In the hot tropical climates, where the environmental temperature is high, the stimulus to cool the body and nest is high (Jones and Oldroyd, 2007). According to Heinrich (1981) thermoregulations in honey bees have been studied for many years at hive or colony-level while thermoregulations by individual bees have not been well studied. Colonies of honey bees can keep their temperature within fairly narrow limits over a wide range of the ambient temperatures (Simpson, 1961).In the day time, the temperature increases and decreases at night time (Mizue *et al*, 2008). In temperate regions, honeybees decrease and increase their colony temperatures during summer and winter periods respectively (Himmer, 1932). However, in Africa, where maximum temperatures may be very high, the reduction of the brood nest temperatures is an important aspect of thermoregulation (Fletcher, 1978).

Honeybee hives temperature typically remains steady at ~35 degrees centigrade (95 degrees Fahrenheit), (Karl von Frisch, 1974). The bees retain their nest heat over the long term by selecting a good nesting site that is tightly sealed and enclosed. For example, feral/wild colonies often nest in a structure providing an empty cavity such as a hollow tree (Mathis and Tarpy, 2007). Bees are unable to regulate the hive temperature with their internal body temperature; instead, they regulate their temperature using behavioural, physiological and morphological mechanisms (Heinrich, 1981). The behavioural thermoregulation mechanisms used by bees to keep the nest temperature cool and warm include: wing fanning in alate workers to drive warm air away from the nest while in stationary positions, cooling by evaporation of water distributed by workers throughout the nest and in hollows on the margins of capped brood cells (Ishay and Barenholz-Paniry, 1995); tongue lashing by workers which as a process of making water droplets into thin layers or films with their tongues to act as cooling mechanisms (Dyer and Seeley, 1991; Jacklyn, 1992). When the temperature is too low bees generate metabolic heat by contracting and relaxing their flight muscles and the vibration generates heat in the muscles (Winston,1987) and bees also thermo-regulate their environment by clustering together (Sumpter and Broomhead, 2000).

Early work by Smith (1960) suggested the problem of regular absconding of *adansonii* colonies in the Tropics is due to a lack of water. In the hives, a shortage of water could lead to the inability of bees to cool the hives, thus leading to overheating and eventual absconding behavior. The West African honeybees *Apis mellifera adansonii* have an inferior capacity for regulating the brood nest temperature (Darchen, 1973 as temperatures were recorded between the hour of 06:00 and 08:30 in the morning cited by Fletcher, 1978). He demonstrated that the honey bees of Gabon have a poor capacity for regulating the brood nest temperature compared to *Apis mellifera ligustica.* Fletcher (1978) observed, there is no where this West African honeybees *Apis m. adansonii* were confined to the nest for very long periods like the European bees, this he believed must have evolved from poor physiological thermoregulation. The current study was performed as part of research work on factors affecting population growth of foraging worker bees. Temperature measurements allowed comparisons to be drawn between the colony cluster and ambient temperatures, thus allowing us to explain the collective thermoregulation capacity of *A.m. adansonii.*

MATERIAL AND METHODS

Thirty two experimental colonies of West African honey bees *Apis mellifera adansonii*. were raised, each colony nests in a Kenya Top bar hives (KTB) consisting of 21 top bars, hive body with 24cm by 15cm dimension, a hollow space of 35 litres and the hives were made of hard wood *Terminalia macroptera* (Black afara). Eight of the colonies each were distributed into four apiaries (1,2,3 and 4) set up in the Agricultural Teaching and Research Farm of Obafemi Awolowo University, Ile-Ife, Osun State, Southwestern Nigeria with a geographical co-ordinate of 7.55°N and 4.533°E. The colonies were kept under full shade of trees, and retained in the same locations of the apiary throughout the wet and dry seasons and the duration of the research. .

Four colonies were randomly selected in each of the four apiaries set up and temperature data for the ambient and colony cluster were collected for two years. A hand-held precision digital thermometer 16” F (Thermo Probe TL1W-16-F) fixed on to the middle of the bee cluster in the hives was used. Measurements of colony cluster when the bees have not begun to forage. Similarly, the ambient temperatures were recorded at same time.

Mean of daily and monthly colony cluster temperatures for all the replicates were analyzed and comparison were drawn between the mean colony cluster temperatures and out of hive temperatures, apiary by apiary and by colony type using three-way ANOVA by PROC GLM within SAS 9.2 (SAS Institute 2010). All the means were compared by Least Squared Difference (LSD) with a significant set at ($P \leq 0.05$). Test of significant differences were carried out between the mean colony cluster temperatures among the apiaries and between the mean colony cluster and ambient temperatures.

RESULT AND DISCUSSION

Colony cluster temperature significantly increased ($p< 0.05$) as the weather changed from wet to dry season (Fig. 1). The colony cluster temperatures range from minimum of 29º to maximum of 37º Celsius against the ambient temperature at minimum of 26º and maximum of 29º Celsius throughout the year from wet to dry season (Tables 1,2, Fig. 1) showing the West African honeybee clusters conserve temperature and the hives provide some insulation, this view supports Saville (2000).

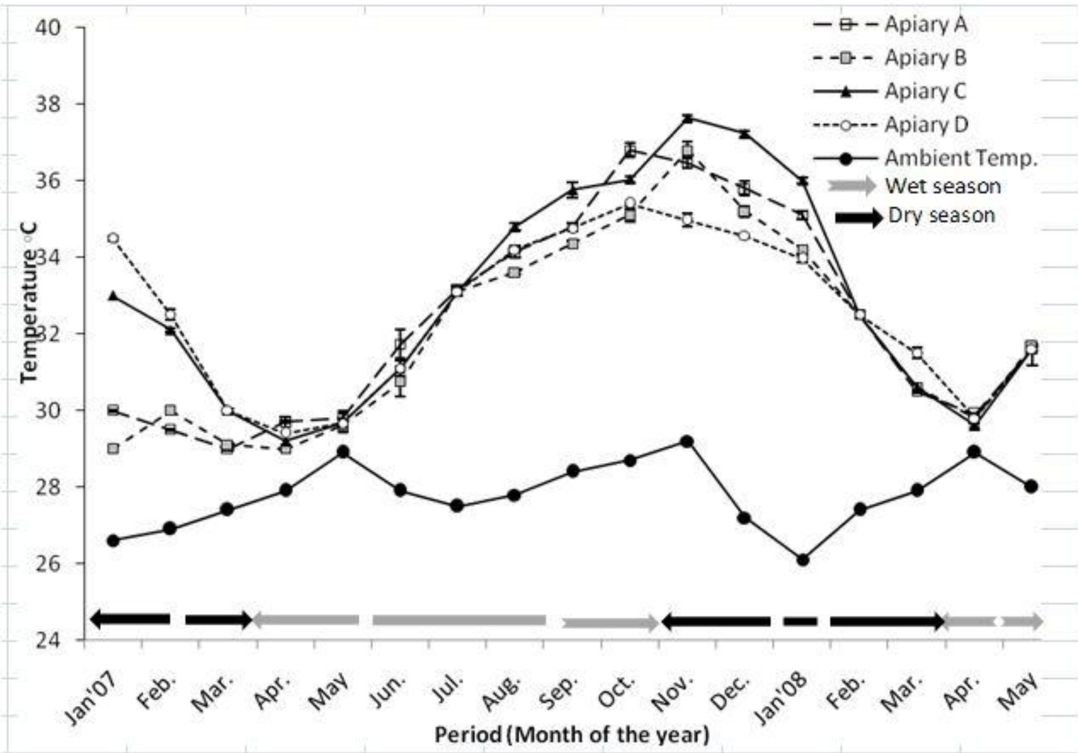

Figure 1. Colony cluster and ambient temperatures over 18 months

There was a significant difference in the colony cluster temperatures between the colonies in apiaries 1, 2, 3 and 4 ($F_{3,\ 48} = 3.81$, $P = 0.0157$ ($P < 0.05$). However, the mean of the colony cluster temperatures in all Apiaries were not significantly different ($F_{3,\ 48} = 2.01063$, $P = 0.3718$ ($P > 0.05$). In all the apiaries, the mean colony clusters temperatures were significantly different from the ambient ($F_{1,\ 16} = 25.58$, $P = 0.0001$ ($P < 0.05$) (Table 2).

Table 1. **Mean temperatures for colony clusters and ambient recorded in one month.**

Apiaries	Mean temperatures (°C)		p values
	Colony clusters	Ambient	P<0.05
1	31.45[a] (SD=0.12)	27.81[b] (SD=0.10)	0.0002
2	31.89[a] (SD=0.13)	27.81[b] (SD=0.12)	0.0004
3	31.40[a] (SD=0.11)	27.79[b] (SD=0.12)	0.0003
4	31.84[a] (SD=0.12)	27.81[b] (SD=0.13)	0.0001

Table 2. **Mean temperatures for colony clusters and ambient**

January										
	Hive Temperature (⁰C)					Ambient Temperature (⁰C)				
Apiary	1	2	3	4	Av. +SD	1	2	3	4	Average
A	30.1	29.8	30.2	29.9	30.0+0.185	26.7	26.8	26.7	26.9	26.8+0.095
B	29.7	29.3	29.4	29.6	29.5+0.182	26.7	26.8	26.7	26.9	26.8+0.95
C	32.4	32.6	32.8	32.6	32.6+0.163	26.9	26.8	26.7	26.9	26.9+0.95
D	33.7	33.4	33.4	33.5	33.5+0.141	26.7	26.8	26.7	26.9	26.8+0.95

This suggests that the honeybee clusters generate heat to raise the colony temperature. The changes in the colony cluster temperature did not correspond to the ambient temperature changes. This suggests the bee colonies keep their cluster temperature within the limit over and below the range of ambient temperatures. Similarly, the result further revealed there were irregular fluctuations of colony clusters temperature with ambient temperature among the individual colonies in all the apiaries (Fig. 1).

The result and observation of thermoregulation capacity of *Apis mellifera adansonii* agreed with the observations made by Fletcher (1978) that the range of colony cluster temperatures inconsistently fluctuate with the ambient temperatures.

The sets of data applied in this research allowed for a limited interpretation of colony cluster temperature regulation by *Apis mellifera adansonii* in the tropical climate. In addition to the hives which were made of hard wood and of small volume that provides a little insulation than the straw hives, design with large volume generally lower temperatures than those with smaller volume (Saville *et al*., 2000).

West Africa has a relatively warm climate which at times is a serious problem for colony survival and management but the bees have been known for a behavioral regulatory mechanism of swarming and not confined to a nest for a long time which in variance to the European bees in the warm and extremely cold temperate that are much more confined to their hives (Fletcher, 1978). Hence, the commonly used Kenya top bar hives in the tropics need to be modified with introduction of a vent to dissipate cluster heat, keep the cluster temperature closer to the ambient. This will help to complement a control mechanism of thermoregulation, reduce frequent swarming and promote sustainable beekeeping. However, there is a need for further study in this area.

CONCLUSION

Colony cluster is a factor that regulates the colony activities; it is greatly influenced by the ambient temperature, nature and design of hives and the thermoregulatory behaviour of the bee species. *Apis mellifera adansonii* has a range of colony cluster temperatures that inconsistently fluctuate with the ambient temperatures. However, frequent swarming is a behavioural mechanism of the bee species to ease the dense colony population and cluster temperature. Therefore, the commonly used top bar hives made of hard wood that insulates colony heat require modifications such as introduction of vents to dissipate cluster heat.

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