G.J.B.B., VOL.3 (1) 2014: 34-40 ISSN 2278 – 9103

GLOBAL JOURNAL OF BIO-SCIENCE AND BIOTECHNOLOGY

www.scienceandnature.org

DIFFERENTIAL MORPHOMETRIC PATTERNS OF *APIS MELLIFERA* AND ADAPTATION TO CLIMATIC VARIATIONS IN KWARA STATE, NIGERIA

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ABSTRACT

Honey bee is a social insect known as the most economically valuable insect because of its honey production and pollination activities. The morphometric patterns of *Apis mellifera* from two ecological zones of Kwara State, Nigeria and effect of the morphometric patterns on bee adaptation to the ecosystem were investigated. Six hundred (600) worker honeybees were collected from sixty (60) hives in 2 different ecological locations. Three hundred (300) worker bees were dissected and nine morphometric characters were measured in each season: Head Length (HL), Thorax Length (TL), Antenna Length (ANL), Abdomen Length (ABL), Forewing Length (FWL), Hind Wing Length (HWL), Fore-Leg Length (FLL), Mid-Leg Length (MLL), and Hind-Leg Length (HLL). Three hundred (300) bee workers were randomly selected and weighed. The emerging data were analyzed using descriptive statistics. The result of the size of features of bee samples from Guinea savanna revealed that the mean length of (HD) 4.5mm (TH) 4.7mm; (AN) 5.5mm; (AB) 6.1mm; (FW) 9.5mm; (HW) 7.7mm; fore-Leg(FL) 7.9mm; (ML) 8.4mm and (HL) 12.1mm while the bee structures of locations in Derived savanna showed that HD (4.5mm), TH (5.6mm), AT (5.5mm), AB(6.1mm), FW (9.5mm), HW(7.7mm), FL(7.9mm), ML(8.4mm), HL(12.1mm). For the dry and wet seasons in towns in the Guinea savanna showed: HD (3.8mm), AN (5.2mm), TH (4.0mm), AB (4.8mm), FW (8.9mm), HW (8.0mm), FL (6.8mm), ML (6.8mm) and HL (11.9mm); HD (3.7mm), AN(5.3mm), TH (4.1mm), AB (4.8mm), FW (9.6mm), HW (7.9mm), FL (6.8mm), ML (6.9mm) and HL (11.9mm). The results of towns in the Derived savanna: HD (4.5mm), AN(5.5mm), TH (4.6mm), AB (6.0mm), FW (9.5mm), HW (7.5mm), FL (7.8mm), ML (8.4mm) and HL (12.1mm) dry season; the wet season: HD (4.5mm), AN (5.5mm), TH (4.7mm), AB (5.8mm), FW (9.5mm), HW (7.9mm), FL (8.0mm), ML (8.3mm) and HL (12.1mm) respectively. It is imperative from the result of this study that beekeepers should monitor and be conversant with growth, development and adaptive traits so as to check the normal development taking place within the bee's population, such growth index as measurement of characters are pointers to adaptive radiation within the prevailing honeybee species of an area.

KEYWORDS: honey bee, climatic variations, adaptation, morphometrics, bee structure.

INTRODUCTION

The Honeybee, *Apis mellifera,* is social insects noted for providing their nests with large amounts of honey. A colony of honeybees is a highly complex cluster of individuals that functions virtually as a single organism. Honeybee (Hymoneptera: Apidae) is also a social insect known as the most economically valuable insect because of its honey production and pollinating activities (Lawal and Banjo, 2010). *Apis mellifera* otherwise known as western honeybee is naturally spread in Europe, Africa and Western Asia (Howpage, 1991; Miguel *et al*., 2011). *Apis mellifera* is about 1.2 cm (about 0.5 inch) long, the head and thorax, or midsection, are somewhat bristly and vary in colour according to the strain. Two large compound eyes and three simple eyes, or ocelli, are located on top of the head. Keen eyesight is complemented by two sensitive, odour-detecting antennae (Encyclopedia Britannica, 2012). The species has shown great adaptive potential, as it is found almost everywhere in the world and in highly diverse climates. In a context of climate change, the variability of the honey bees life history traits as regards the environment shows that the species possesses such plasticity and genetic variability that this could give rise to the selection of development cycles suited to different environmental conditions (Mazeed, 2004; Rattanawannee *et al., 2010)*. The shape of organisms and their biological structures have been of scientific interest for centuries. This is understandable because biological shape of the most conspicuous aspects of an organism's phenotype provides a link between the genotype and the environment (Ricklefs and Miles, 1994). There is a strong relationship between morphometric structures and climatic data, suggesting that adaptation and natural selection are occurring. Several works with *Apis mellifera* involving morphological characteristics showed that there is a strong influence of the environment in the morphology of the same ones (Eischen *et al.,* 1982; Milne and Friars, 1984; Milne *et al.,* 1986). Various morphometric studies have been reported in literatures most especially on *Apis mellifera* and Apis cerena (Kshirsagar, 1981; Mattu & Verma, 1993, 1984; Ruttner, 1985, 1988; Diniz-Filho *et al., 1993).* Of several techniques used to distinguish European and Africanized bees, discriminant analysis of the morphometric variables has become the standard method for regulatory entomology and morphometric analysis has being a very good tool for identification of honey bee races (Rinderer *et al.*, 1995; Mladenovic *et al.*, 2011).

Various honey bee colonies, races and species were discriminated by employing morphometric analysis (Moradi and Kandemir, 2004; Raina and Kimbu, 2005; Farhoud and Kence, 2005; Shaibi *et al*., 2009; Rattanawannee *et al*., 2010; Nedić *et al*., 2011). Morphometric patterns of Africanized honey bees and their relationship with climatic variation has been studied in various locations (Ruttner, 1988; Sheppard *et al*.; 1997; Engel 1999; Sheppard & Meixner , 2003; Miguel *et al*., 2011). Wing characters were found to be affected by different factors e.g. temperature *(*Tan *et al.*, 2005), season *(*Mattu and Verma, *1984)* and bee age *(*Herbert *et al.*, 1988*;* Moradi and Kandemir, 2004 *and* Abou-Shaara *et al*., *2012)*. The measurement of fore and hind wings of *Apis mellifera* were used in morphometric analysis *(*Nazzi, 1992*;* Andere *et al.,* 2008*;* Uzunov *et al.,* 2009*;* Mladenović *et al.,* 2011 *and* Abou-Shaara *et al.,* 2012*)* while left wings were used by *(*Bouga and Hatjina, 2005 and Tofilski, 2008*)*. The bee body size may be reflected in their body weight which was smaller in both the studied bees. This study was therefore conducted to determine morphometric patterns of *Apis mellifera* in two ecozones of Kwara State and how these morphometric patterns affect the honey bees' adaptation to the ecozones.

MATERIALS & METHODS

The study Area

The study was conducted in Lafiagi, Patigi, Share (Guinea savanna ecozone) and Ajasse, Offa and Erin-ile (Derived savanna ecozone) areas of Kwara State, Nigeria. Kwara State lies between latitude 8°10' and 19° 50'N and between longitudes 3° 10' and 6° 05'E. The area falls within the southern limits of the tropical savannah zone of Nigeria with mean annual rainfall ranges from 800mm to 1500mm, concentrated between the months of April and October with two peaks in July and September (Ibiremo *et al*., 2010). The mean annual temperature is between 31.5°C and 35°C (Oladimeji and Abdulsalam, (2013). February to April are the hottest months while June to September has the lowest maximum temperature which coincides with the peak of the dry and wet seasons respectively (Ogunwale *et al.*, 1999).

The southern guinea savanna zone where Kwara State belongs is one of the four major zones into which Keay (1953) divided the savanna regions of Nigeria. The derived savanna zone extends southwards from the southern guinea zone to the forest zone (Adegbola and Onayinka, 1976). Such is the case for some parts of Kwara State such as from Ajasse towards the south which is now described as part of the derived savanna ecological zone. The State experiences two seasons; the wet season (May-September) and the dry season (October to April). Kwara State lies in two geo-ecological zones; the derived savanna which is characterized by woodland and the Guinea savanna which is characterized by tall grasses growing intermixed with deciduous trees. The vegetation consists largely of a great expanse of arable land and rich fertile soil. The savannah is characterized by tall grasses intermixed with scattered trees. Economic trees found in the area includes *Citrus sinensi,, Parkia biglobosa, Butyrospermum parkii, Azadiracta indica, Mangifera indica, Acacia species Delonix regia* and *Anacardium occidentale.* These species of trees provide forage for the bees (KWADP, 2008).

Data Collection and Sampling Techniques

Six hundred (600) worker honeybee samples were collected from sixty (60) hives in 2 different ecological locations from geographic regions of Kwara State, Nigeria. Honey bee samples were preserved in 70% ethanol and were then dissected to remove body parts according to Ruttner *et al.* (1978). Fifty (50) worker bee samples from each of the six (6) randomly selected study areas in two ecozones were dissected using forceps to separate body parts (head capsules, antenna, thorax, wings, and legs). Nine morphometric characters were measured using dissecting microscope and ruler during the dry and wet season: Head Length (HL), Thorax Length (TL), Antenna Length (ANL), Abdomen Length (ABL), Forewing Length (FWL), Hind Wing Length (HWL), Fore-Leg Length (FLL), Mid-Leg Length (MLL), and Hind-Leg Length (HLL), according to Ruttner *et al*. (1978). The remaining three hundred (300) bee workers were weighed separately using sensitive weighing balance of type Mettler Toledo P. B. 303-5 model. The emerging data were analyzed using descriptive statistics such as mean, percentage, and standard deviation. Using these variables, the morphometric structure and adaptation of honeybees to variation in climate was examined.

RESULTS

The result of the measurements of the of Head Length (HL), Thorax Length (THL), Antenna Length (ANL), Abdomen Length (ABL), Fore-Wing Length (FWl), Hind-Wing Lenght (HWL), Fore-Leg Length (FLL), Middle-Leg Length (MLL) and Hind-Leg Length (HLL), of Lafiagi, Patigi and Share: the three towns constituting the Guinea savanna ecological zone revealed that the mean length of (HD) of bees of Lafiagi stood at 3.7mm; (TH) (4.2mm); (AN) (4.6mm); (AB) (4.8mm); (FW) (8.6mm); (HW) (7.8mm); fore-(FL) (6.7mm); (ML) (6.8mm) and (HL) 11.9mm respectively. The size of honey bee structures of Patigi showed that HD (3.7mm), TH (4.0mm), AT (5.6mm), AB (4.8mm), FW (9.6mm), HW (7.8mm), FL (6.7mm), ML (6.8mm), HL (11.9mm), while for Share result obtained showed that the HD (3.8mm), TH (3.9mm), AT (5.7mm), AB (4.7mm), FW (9.7mm), HW (8.1mm), FL (6.8mm), ML (6.8mm), HL (11.8mm).

The result of the measured structures showed the size of structures of bees of Ajasse for the length of HD to be 4.4mm; (TH) (5.5mm); (AN) (4.8mm); (AB) (6.1mm); (FW) (9.5mm); (HW) (6.7mm); fore-(FL) (7.2mm); (ML) (8.3mm) and (HL) (11.9mm) respectively. For the size of honey bee structures of Offa showed that HD (4.5mm), TH (5.3mm), AT (4.6mm), AB (5.5mm), FW (9.5mm), HW (9.4mm), FL (9.1mm), ML (8.4mm), HL (12.0mm), while for Erin-ile result obtained showed that the HD (4.6mm), TH (5.5mm), AT (4.6mm), AB (6.5mm), FW (9.5mm), HW (7.0mm), FL (7.4mm), ML (8.3mm), HL (12.2mm).The result of the size of hind-leg, fore-wing, hind-wing and mid and fore-legs showed higher values than other bee structures measured in locations at Guinea savanna (Fig. 1), Derived savanna (Fig.2) and both pooled (Fig.3).

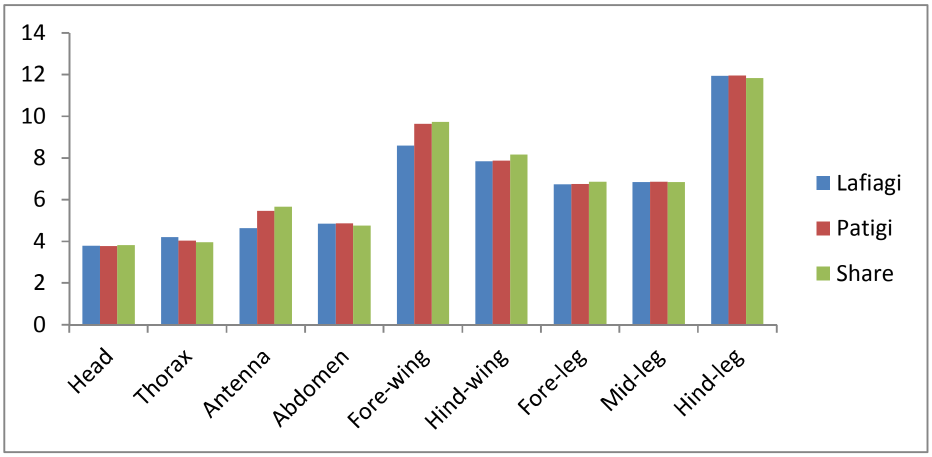

FIGURE 1: The size of honey bee morphological structures in the Guinea savanna ecozone

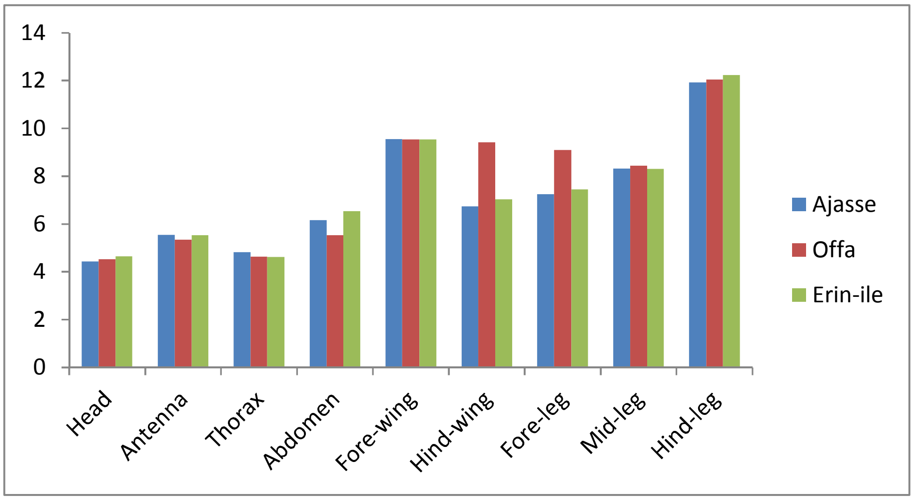

FIGURE 2: The size of honey bee morphological structures in the Derived savanna ecozone

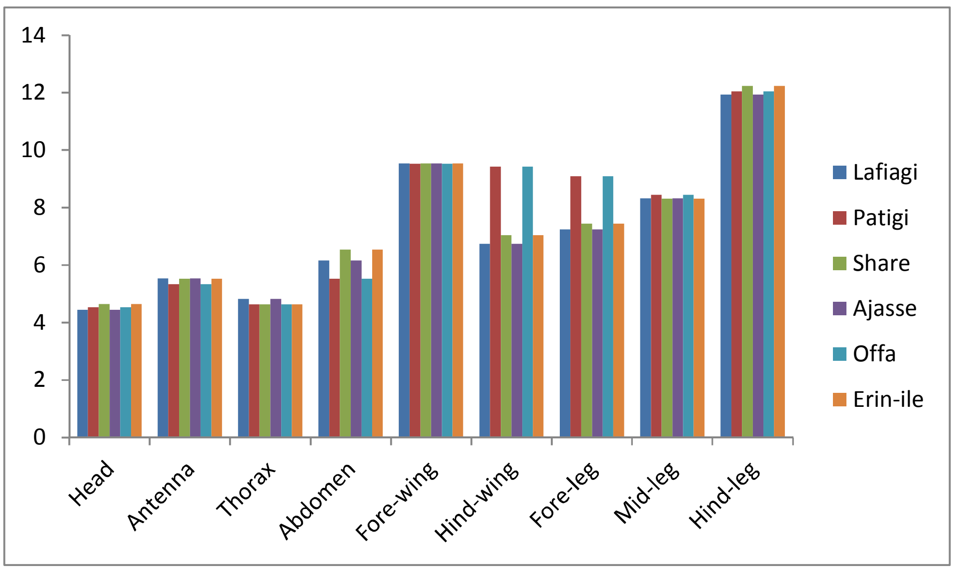

FIGURE 3: Differential size of morphological structures for both Guinea and Derived savanna ecozones

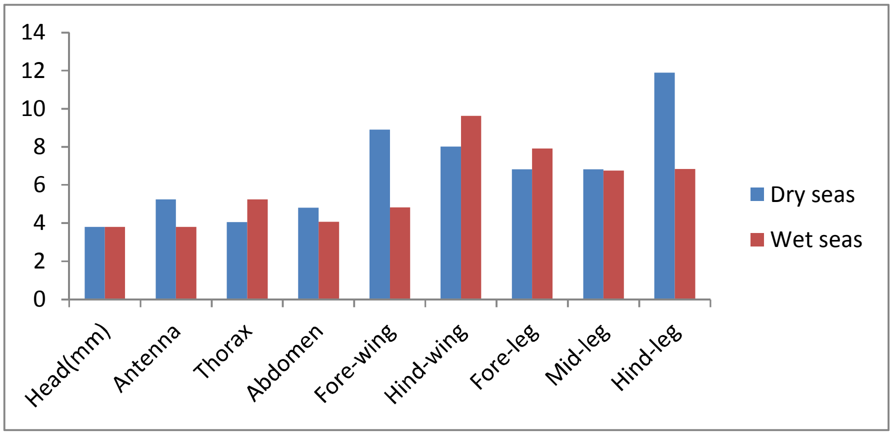

FIGURE 4: The size of bee structures per season in Guinea savanna

The result of the size of structures of honey bee for the dry and wet seasons in towns in each of the ecological zone revealed mean size of structures for the dry season in the Guinea savanna were: HD (3.8mm), AN (5.2mm), TH (4.0mm), AB (4.8mm), FW (8.9mm), HW (8.0mm), FL (6.8mm), ML (6.8mm) and HL (11.9mm) while for the wet season HD (3.7mm), AN (5.3mm), TH (4.1mm), AB (4.8mm), FW (9.6mm), HW (7.9mm), FL (6.8mm), ML (6.9mm) and HL (11.9mm). The morphological size of structures between the dry and wet seasons showed a differential, and higher value of growth and development were obtained for almost all the structures. The result further revealed an increase in size during wet season than dry season in the study locations across the ecological zones.

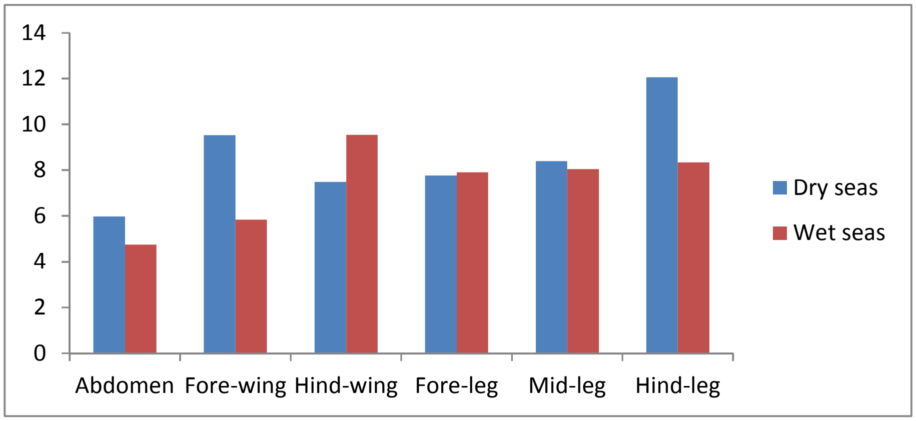

FIGURE 5: Differential size of structures per season in Derived savanna in the study area

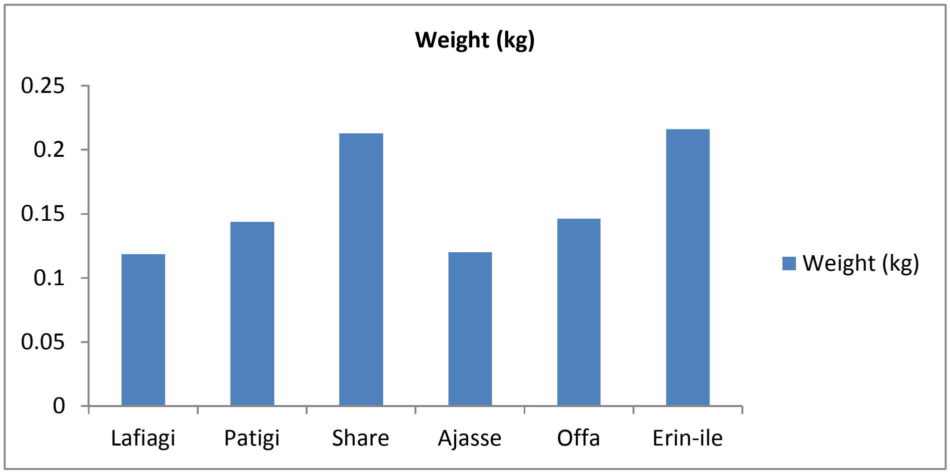

FIGURE 6: The weight of honey bees in towns in the two ecozones

For the towns in the Derived savanna ecozones, the result of the mean size of honey bee structures obtained for dry season period are: HD (4.5mm), AN (5.5mm), TH (4.6mm), AB (6.0mm), FW (9.5mm), HW (7.5mm), FL (7.8mm), ML (8.4mm) and HL (12.1mm) while for the wet season: HD (4.5mm), AN (5.5mm), TH (4.7mm), AB (5.8mm), FW (9.5mm), HW (7.9mm), FL (8.0mm), ML (8.3mm) and HL (12.1mm) respectively. The result of the weight of the honey bees in the Guinea savanna ecozone of Kwara State, Nigeria showed Lafiagi (mean 0.1185kg)(std 0.016561), Patigi (mean 0.1437kg)(std 0.002417) and Share (mean 0.213kg)(Std 0.0088) while for the towns in the Derived savanna, Ajasse had (mean 0.12025) (Std 0.0168), Offa (mean 0.14625kg) (Std 0.00205) and Erin-ile (mean 0.21616kg)(0.00836) respectively. For the weight of honeybee across the season of the year per ecozones, the result revealed that during the dry season in Guinea savanna the bees weighed mean 0.1531kg, std 0.0017, while for the wet season mean weight obtained was 0.1621kg, std 0.0021. The result of weight of the bees of Derived savanna across the season revealed mean for dry season was 0.1556kg, std 0.0021 while for wet season mean obtained was 0.164, std 0.0023 respectively (Table 1).

TABLE 1: The weight of honey bee per ecozone per season in the study area

Ecozone	Guinea savanna		Derived savanna	
	Dry season	Wet season	Dry season	Wet season
Mean	0.1531	0.1621	0.1556	0.164
Std.	0.0017	0.0021	0.0021	0.0023
Min.	0.149	0.15	0.0021	0.1523
Max.	0.1693	0.1673	0.1703	0.1696

Source: Data Analysis, 2012

DISCUSSION

The result of the study revealed that size of hind-leg; fore-wing and hind-wing were generally high when compared with other structures in study locations in Guinea savanna ecological zone. These structures were found to play prominent roles in the activities of the bees. Hind-leg bears the pollen basket and pollen brushes, an adaptation for efficiency in pollen collection and transportation. The wings are important for flight during foraging and thermal regulation of comb. These features are regularly used irrespective of period and season of the year and are thus developed as a result of constant use and adaptation to the environment. This finding is indicative of the fact that constant use of certain biological features of organisms aids growth, development and adaptation to the environment. This findings is in line with those of Rattanawannee *et al.,* 2010; Eischen *et al.,* 1982; Milne and Friars, 1984; Milne *et al.,* 1986. During wet season, honey bee of the study area has abundant food, high physiological activity which culminates in high growth and development of bee body and parts. This finding is in line with those of Hubert *et al*., 1989; Ominde and Juna, 1991; Bricquet *et al*., 1997; Servat *et al*., 1999 and FAO, 2007 a & b. The study confirmed that environmental change have a direct influence on honey bee growth and development. Therefore, a change in climatic conditions is bound to have an impact on the survival of the bee species in each ecological zone. Climate change constitutes one of the most serious threats which affect the sustainability of natural resources and development of organisms including honey bees whose growth are seriously affected by climatic variations. The result of this study showed that the honeybee in both ecozones of the State were profound in weight during the wet season when there is abundant resources for growth and development. This observation was in line with those of (Ricklefs and Miles, 1994) that stated that the shape of organisms and their biological structures have been of scientific interest for centuries. This is understandable because biological shape of the most conspicuous aspects of an organism's phenotype provides a link between the genotype and the environment. There is a strong relationship between morphometric structures and climatic data, suggesting that adaptation and natural selection are occurring.

CONCLUSION

The results obtained from the measurement of external characteristics and weight of honey bees of the Guinea and Derived ecological zones of Kwara State, Nigeria, showed a strong relationship between morphometric structures and climatic data, suggesting that adaptation and natural selection are occurring. The result of this study also showed that the honeybee in both ecozones of the State were profound in weight during the wet season when there is abundant resources for growth and development. It is imperative from the result of this study that beekeepers should monitor and be conversant with growth, development and adaptive traits so as to check the normal development taking place within the bee's population, such growth index as measurement of characters are pointers to adaptive radiation within the prevailing honeybee species of any area.

ACKNOWLEDGEMENT

The researchers are appreciative of logistics provided by Beekeeping Training and Research Centre (BTRC) Amberi, Offa road Ajasse-ipo, Kwara state, Nigeria (www.ajaocbtr.com).

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