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Climatic Variables as Factors Affecting Diversity and Abundance of Butterflies in Okomu National Park, Edo State, Nigeria

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Abstract
The effect of climatic variables on butterflies diversity and abundance in Okomu National Park, Edo State was investigated from July-November, 2012 using baited traps and butterfly nets. A total of 76 species involving 5 families (Papilionidae, Pieridae, Nymphalidae, Lycaenidae, Hesperidae) were captured and identified. Diversity of butterflies in the three ranges was calculated using Shannon-wiener diversity index and the highest diversity was found in Arakhuan (H=3.618) and the lowest in Igwuowan range (H=2.997). The relationship between physical factors and individuals, total species and number of butterflies' per family was determined. Temperature was positively significantly correlated with the total number of individuals (r_s0.418, p=0.05) and species (r_s=0.444, p=0.0001) while Rainfall was negatively correlated with the total number of individuals (r_s=-0.561, p=0.0044) and species (r_s=-0.001, p=0.01), ($p<0.05$). The total abundance of Hesperidae(r_s=0.229, p=0.0010) and Papilionidae(r_s=0.498, p=0.02) increased with humidity, Pieridae(r_s=-0.465, p=0.02) abundance decreased with rainfall while that of the Nymphalidae(r_s=0.384, p=0.04) increased with temperature.

INTRODUCTION

Okomu national park covers a total of 181km^2 which is only 15% of the 1,200km^2 area covered by the Okomu forest reserve. It is situated between longitude 5^0 and 5^0 30' east and between latitude 6^0 and 10' and 6^0 north park. It was originally gazetted as a wildlife sanctuary by the Bendel state government in 1986. It is located in Ovia southwest local government area of Edo state. The park lies 45km west of Benin-city and immediate south of udo town. It derives its name from river okomu which flows southwest to join the Osse River. The rainfall in the area is well above 2,500mm per annum. The area is within 300metres above sea level. (Akinsorotan *et al.,* 2011)

Okomu national park as well as other parks in Nigeria is facing a major problem which is the increasing rate of habitat loss or modification due to human activities. (Ogunjemite *et al.,* 2007). There is no doubt that there has been large-scale destruction and mismanagement of the forest ecosystems of Nigeria. Ecological disasters and climatic change have resulted in loss of soil and greatly reduced biological productivity. (Agbelusi *et al*., 1999). The national park has great species of mammals, aves, reptiles, amphibians, as well as arthropods with the greatest of them as the butterflies.

Butterflies are insect of the order Lepidoptera. They are brightly colored with wings, conspicuous and have fluttering flight. (Hall, 2004). They are present in all terrestrial habitats and sensitive to microclimate heterogeneity and disturbance. They are good agents of pollination and can be easily identified (New, 1997).

Butterflies have been used in most parts of the world in biodiversity assessment programmes (Hill & Hammer, 2004; Aduse-poku & Douku-Marfo, 2007; Barlow et al., 2007; Akite, 2008), in order to understand the biotic impacts of climate change (Parmesan, 2003). They are used because, as poikilothermic organisms, their life-cycle, activity, distribution and abundance are influenced by temperature (Pollard, 1979; Turner *et al*., 1987; Roy & sparks, 2000). Butterflies have a short life cycle with a high dispersal and reproductive capacity. Their basic ecology, evolution, and behavior as well as sensitive micro and macro habitat requirements are well understood by the scientific community and avid amateurs alike. This understanding is invaluable as butterflies demonstrate quick changes in their biological responses to climate (Parmesan *et al.,* 1999; Parmesan, 2003). Quality information on current impacts and future implications of global warming are thus applied in an attempt to prevent a variety of species extinctions (Parmesan, 2006).

Butterflies have shown increased sensitivity to thermal conditions. They demonstrate immediate and drastic responses to increased climatic fluctuations, which show a strong and direct influence on their development, reproduction and survival (McLaughlin *et al.,* 2002; Ward & Masters, 2007). It is also important to note that the relationship between butterflies life cycle are intertwined with that of their host and nectar plants that may be affected by climate change in distinct ways. Disruptions of these relationships will also disrupt the development, reproduction and survival of these butterflies.

Climatic variables comprises of rainfall, humidity, and temperature with the major characteristics of climate change being the increasing mean global temperature, which affects many aspects of life-history events including migration and reproduction capabilities. (Memmott *et al.,* 2007). A change in these variables could either affect butterflies diversity and abundance negatively or positively. For example drought, coupled with increased land drainage caused a decline in host plant quality and abundance (Franco *et al.,* 2006). However, it must be noted that climate change may not always be a hindrance to abundance and distribution. Temperature can affect butterfly populations by allowing more time to gather food thereby increasing fitness levels. (Roy & Sparks, 2000).

Changes in climate can limit distributions through effects on host plant food sources and survival (Merrill *et al.,* 2008). The timing of egg hatch and bud-burst in plants is an important determinant of this insect's abundance (Dixon, 2003; Merrill *et al.,* 2008). Eggs that hatch at specific time of their host plants bud-burst tend to have higher fitness levels influenced by variations in climate (Dixon, 2003).

AIM OF THE STUDY

Knowledge on the relation between butterflies and climatic variables in Okomu National Park is scanty. This work however will serve as a baseline data to which further surveys can be related. The aims of this research are

1. To measure the physical/climatic variables (temperature, humidity, and rainfall) in Okomu national park
2. To evaluate the correlation between the variables and butterfly population in the park.

CHAPTER THREE

MATERIALS AND METHODS

3.1: STUDY SITES

The study was conducted on 3 ranges (Arakhuan, Igwuowan, Julius Creek) of the Okomu National Park ($5^0$30'E/ 6^0 10'N) in Edo state, Nigeria.

Arakhuan range is the largest of the three ranges with a size of 66.5sqkm, having great ecolodge facilities such as the accommodation for tourist. This range is made up of an open forest under great threat of logging, human and agricultural activities.

Igwuowan range is close to Arakhuan range having a size of 38.3sqkm, it is made up of secondary forest vegetations as well as savanna vegetations due to the activities of the village dwellers such as the creation of settlements that are illegal and poaching as well as farming activities such as cocoa and rubber farming.

Julius creek is made up of all the layers/ zones of an undisturbed forest due to little or no threat on this range. It has a size of 41.0sqkm and also present here are rivers too.

Permit to use the park was obtained from Nigerian National Park Service, Abuja.

MAP SHOWING OKOMU NATIONAL PARK LOCATION

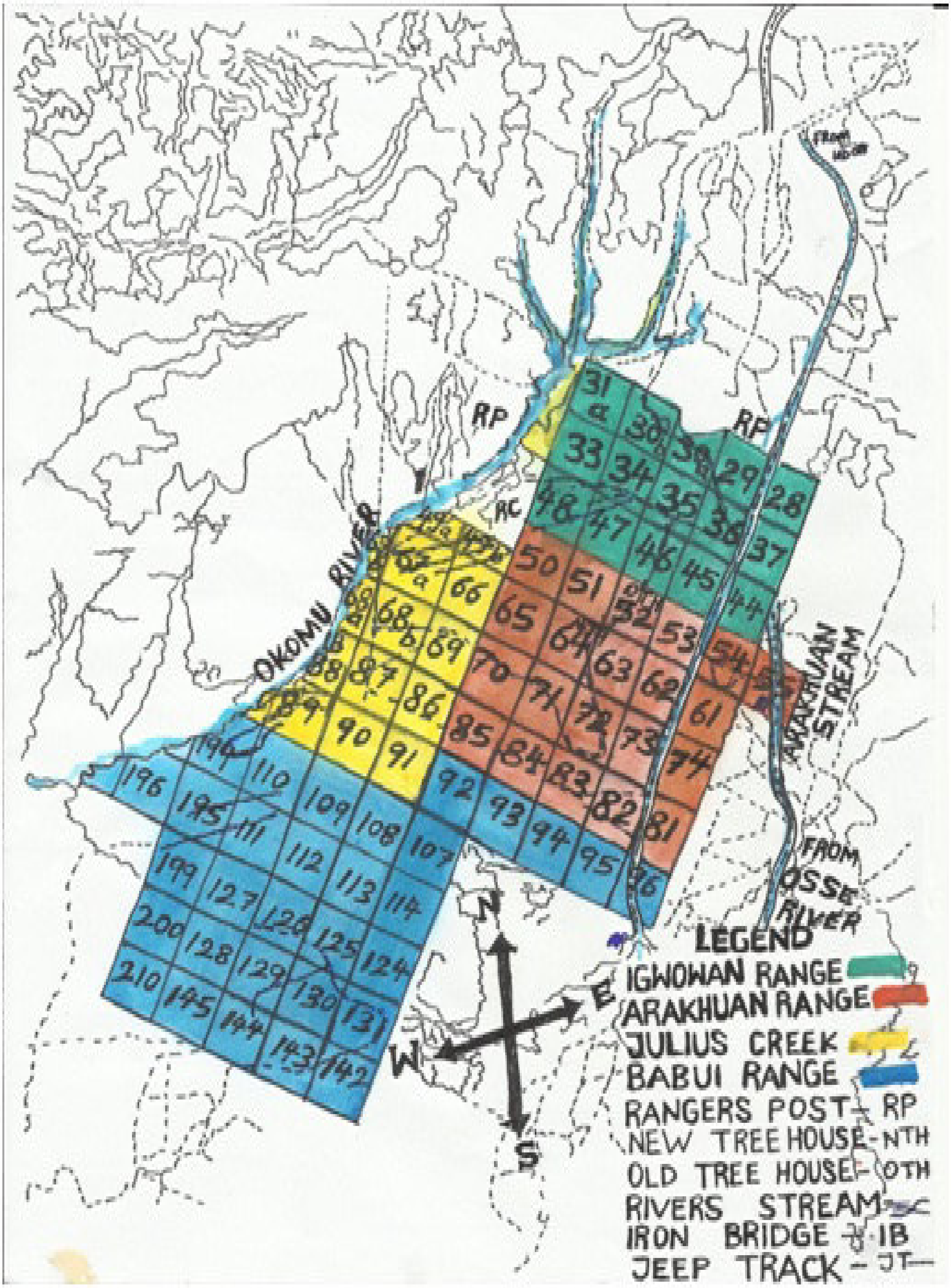

FIG 3.1: MAP OF OKOMU NATIONAL PARK

3.2: FIELD METHODS

Temperature, Humidity and Rainfall Surveys.

Temperature, humidity and rainfall suveys were done using Brooks & Kyker-Snowman (2007) methods with slight modifications.

Sample locations within each range were randomly located either from a central point or a central transect. RH/Temperature Data Logger (Lascor-EL-USB-2) was programmed to record temperature and humidity every 6 hours in each forest floor range. Data logger was installed before noon on the first day of a session and removed 2 days later. By removing and installing the units on consecutive days all 3 sites were sampled within 3 days.

Rainfall was measured using the Rainguage Monsun radio-controlled rainguage. The rainguage was placed at different central points on each range in order to determine the amount of rainfall on the forest floor.

BUTTRFLY SAMPLING AND IDENTIFICATION

Butterfly samples were collected for a period of 5 months between July- November, 2012. The butterflies were collected using baited traps and butterfly nets. The butterfly nets were made using lawn tennis racket and nets of 64cm length sown round the base of the lawn tennis racket. The baited traps were made from a laundry bag of cylinder shape. At the base of the laundry bag, plywood was measured exactly to the size of the base of the laundry bag and a hole for the plate containing the baits (over-riped banana mixed with yeast) was also cut open in the plywood. The butterflies were identified using taxonomical keys (Larsen, 2005) and (Lewis, 1973).

PRESERVATION

Butterflies caught were killed by pinching on the thorax, then set on a setting board using number 3 entomological pins and setting strips. They were kept in insect boxes stuffed with naphthalene balls to prevent insect attack for a week. After they were dried, they were then labeled using insect boxes of 450mm by 300mm and preserved using naphthalene balls.

3.3: ANALYSIS

Temperature and relative humidity data were classified by quarter day: night (0.0-6.0h), morning (6.01-12.00h), afternoon (12.01-18.00h), evening (18.01-24.00h). Rainfall data was collected daily.

The effect of temperature, humidity and rainfall on butterflies abundance and diversity was analyzed with repeated measures, analysis of variance (ANOVA) and pearsons correlation.

CHAPTER FOUR

4.0 RESULTS

4.1 TEMPERATURE

The result of the mean monthly temperature measured from the three ranges sampled from July-November, 2012 as shown in table 4.1.1 and figure 4.1.1 as shown below.

FIG 4.1.1: Monthly temperature Distribution at each range

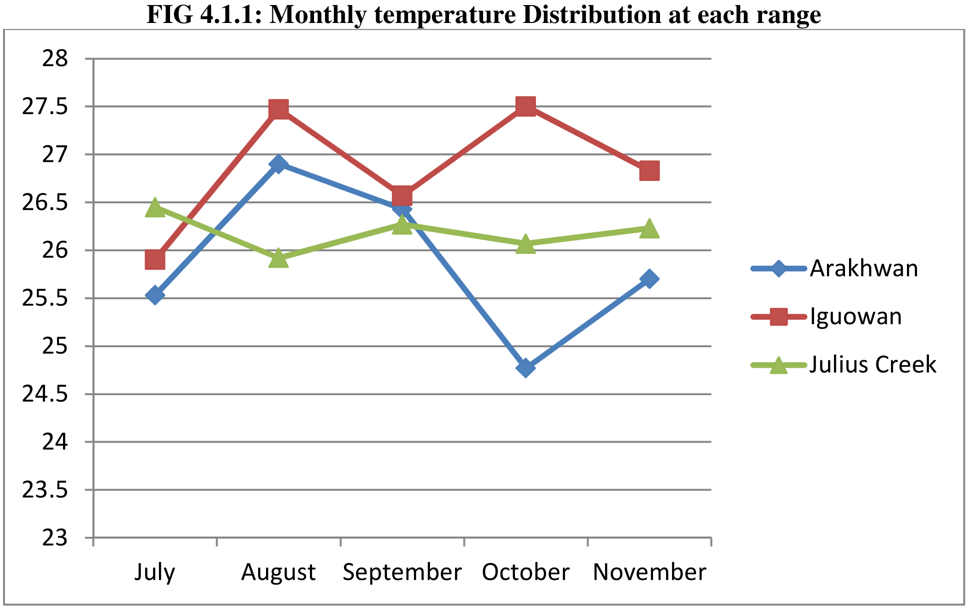

Table 4.1.1 shows ANOVA done on the data collected and it was recorded that there was no significant difference in the mean temperatures of the three ranges(f-cal -3.26, $p<0.05$) as values followed the same trend.

Figure 4.1.1 it shows the graph of the monthly temperatures of the three ranges with Igwuowan having the highest mean temperature, followed by Julius creek and the least was that of Arakhuan.

4.2 HUMIDITY

The result of the monthly humidity of okomu national park was taken generally for a period of 5months (July-November, 2012). Figure 4.2.1 shows August having the highest humidity (89.0) while November had the least (66.5) and the mean humidity was 81.74.

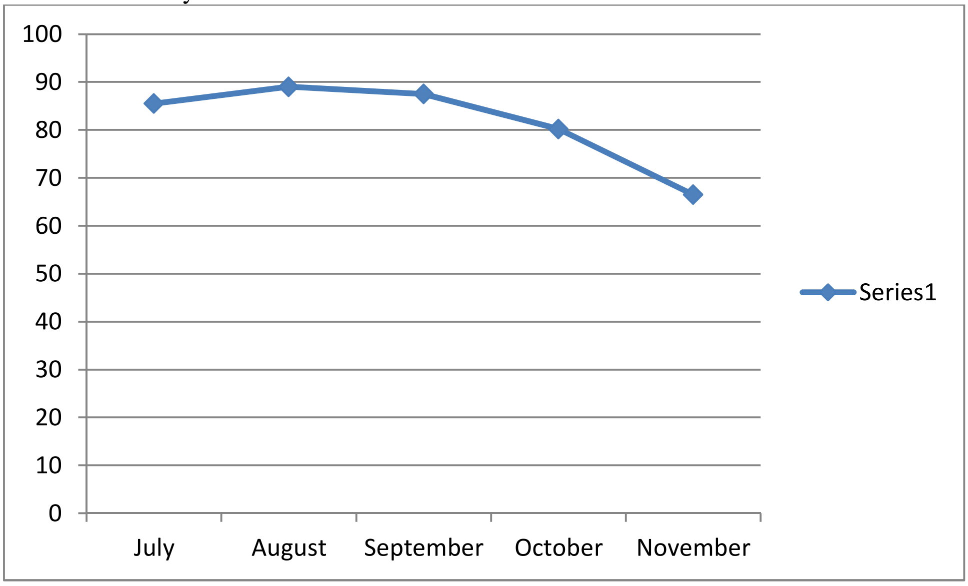

FIG 4.2.1: Monthly Humidity in all sampling Sites

4.3 RAINFALL

The result of the monthly rainfall of the park was measured from July – November, 2012. From figure 4.3.1 as seen above July had the highest amount of rainfall (785mm) while November had the least amount of rainfall (126mm) and the mean amount of rainfall was 470.2mm.

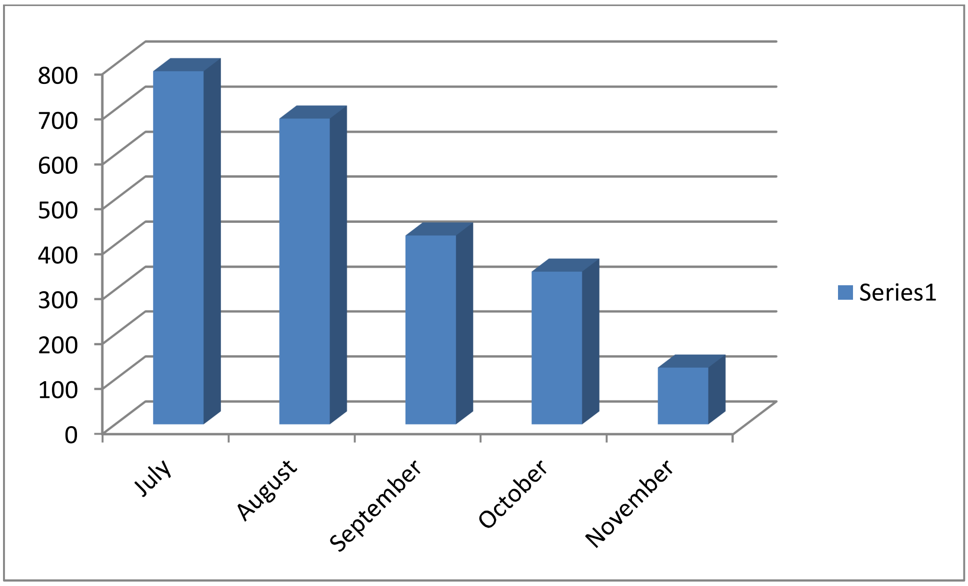

Fig 4.3.1: Monthly Rainfall In all Sampling Sites

4.4 SPECIES DIVERSITY FOR THE THREE RANGES

Regular transect counts on Arakhuan, Igwuowan and Julius creek were used to establish diversity indicesfor the ranges. Table 4.4.1 showed that the maximum diversity was observed in Arakhuan (H=3.618) and the lowest in Igwuowan (2.997).

TABLE 4.4.1: Diversity Calculation for the three Ranges

	Arakhuan	Iguwuowan	Julius Creek
No of Individuals	791	870	993
No of Species	67	58	75
Taxa richness (Margalef's Index(d)	9.89	8.42	10.72
Shannon Diversity Index	3.618	2.997	3.207

4.5 COMPOSITION OF BUTTERFLIES IN ALL THE FAMILIES

The composition of butterflies in all the families recorded all through the sampling period as shown in figure 4.5.1. The Lycaenidae had the highest composition of butterflies 1174(44.2%) while the Hesperidae had the least 33(1.2%).

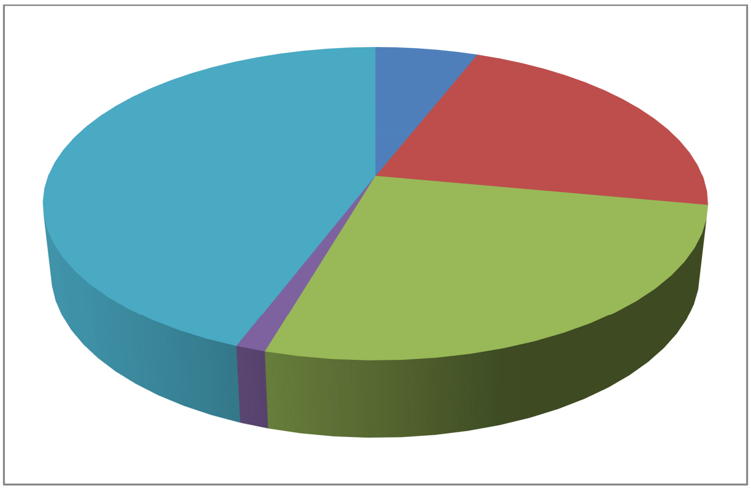

Fig 4.5.1: Composition of Butterflies in All the families

4.6 EFFECTS OF PHYSICAL FACTORS ON NUMBERS OF INDIVIDUALS AND SPECIES.

Table 4.6.1.: Correlation coefficient (r_s) of pearsons rank correlation and probability (p) between physical factors and total number of individuals, species and individual numbers in each family.

Physical factors	**Humidity**	**rainfall**	**temperature**
Total individuals	-0.541 (p=0.08)	-0.561 (p=0.0044)	0.418 (p=0.05)
Total species	0.291 (p=0.51)	-0.001 (p=0.01)	0.444 (p=0.0001)
Individual numbers in			
Papilionidae	0.498 (p=0.02)	0.298 (p=0.006)	0.771 (p=0.51)
Pieridae	-0.565 (p=0.41)	-0.465(p=0.02)	-0.920 (p=0.122)
Nymphalidae	0.626 (p=0.335)	0.425 (p=0.06)	0.384 (p=0.04)
Hesperidae	0.229 (p=0.0010)	-0.211 (p=0.01)	0.210 (p=0.09)
lycaenidae	0.339 (p=0.42)	-0.123 (p=0.44)	0.212 (p=0.40)

$P<0.05$

The pearsons rank correlation between physical factors (humidity, rainfall, temperature)and total individual number as seen in table 4.3 shows that rainfall was negatively correlated significantly to the total individuals (^{r}s =-0.561, p=0.0044) as well as temperature which was positively correlated to the total individuals number (^{r}s=0.418, p=0.05). The correlation between physical factors and species showed that rainfall was negatively correlated to the number of species (r_s=0.001, p=0.01) while temperature was positively significantly correlated to the number of species (r_s=0.444, p=0.0001) humidity was not significantly correlated to the number of species.

Regarding each family of Lepidoptera, humidity and temperature were the only physical factors that were positively significantly correlated with the numbers of butterflies. Papilionidae (r_s0.498, p=0.02) and Hesperidae (r_s=0.229, p=0.0010) were positively significantly correlated with humidity while Nymphalidae (r_s=0.384, p=0.04) was positively correlated with temperature. Rainfall was also significantly negatively correlated with the individual numbers of the Pieridae (r_s=-0.465, p=0.02) and the Hesperidae (r_s=-0.211, p=0.01).

CHAPTER 5
DISCUSSION AND CONCLUSION
DIVERSITY OF BUTTERFLIES AT OKOMU NATIONAL PARK

The diversity of butterflies found at Okomu national park during June-November, 2012 was high. A total of 2,654 individuals of 76 species collected using butterfly nets and baited traps can be classified into 5 families. The butterfly family with the highest number of species was the Nymphalidae. The Nymphalidae are large groups of Lepidoptera and they include many common species which can be seen nearly everywhere in the park. *Acraea bonasia bonasia* was the most abundant of this family and it was found at all sites but majorly in Julius creek range. Although it was frequent more in august when the rain was high due to the presence of more host plants.

SPECIES DIVERSITY INDEX

The monthly species diversity index for the three ranges was maximum in Arakhuan(H=3.618). From observations this may be due to the largeness of the range as well as the presence of trees and host plants for this butterflies and also timing of the flowering in some trees species. On the other hand the species diversity was minimum in Igwuowan(H=2.997). This may be due to the high rate of village dwellers activities such as creation of settlements and bush burning for farming activities of cocoa and rubber which led to the destruction of some of this species host plants.

EFFECTS OF PHYSICAL FACTORS ON NUMBERS OF INDIVIDUALS AND SPECIES

The physical factors measured (humidity, rainfall and temperature) was both positively and negatively significantly related to the total number of individuals and species numbers of butterflies. This result is in line with pollard *et al.,* (1993) and pollard (1993). They reported significant effects of weather: rainfall and humidity which was negatively correlated with the numbers of individuals and species. Although the physical factors measured in this study indicated that rainfall was the only physical factor negatively correlated with total number of individuals and species while temperature was positively correlated with the total number of individuals and species. This may reflect the difference between the tropical and temperate climate patterns.

Some field studies of tropical butterflies indicate that periods of very heavy rainfall may result in increased mortality of adults thus causing their numbers to decrease. This study showed a similar pattern in the family's Hesperidae and Pieridae. In contrast individual numbers of Hesperidae increased with high humidity as well as the Papilionidae. It is possible that the immature stages of the Papilionidae and Hesperidae usually reside in blotch mines and that the leaf often folded and becomes a shelter from the rain. Thus the Hesperidae and the Papilionidae showed a positive correlation with rainfall. Also the Nymphalidae were positively correlated with temperature which followed similar patterns that butterfly populations increased significantly during the period of high temperature and low precipitation. Temperature effects the growth of food and plants and therefore should be positively correlated with the total individuals and species as seen in this study (Kantamaht *et al.,* 2000).

Temperature may affect butterfly populations in several ways. High temperature may enhance courtship behavior, oviposition and larval development.

CONCLUSION AND RECOMMENDATIONS

Generally, climatic variables may affect butterflies adversely or positively if there is an increase or decrease in them hence activities that tends to cause this variables to increase or decrease such as bush burning, logging e.t.c. beyond suitable conditions should be controlled in order to prevent adverse effects on this unique species which serves as bioindicators of our environment.

Also long term monitoring is needed to identify significant changes in biological diversity, permitting the timely adjustments of management activities to reverse or prevent undesired trends.