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EFFECTS OF CONTROLLED FIRE ON THE ABUNDANCE AND DIVERSITY OF ARTHROPODS AT OBANLA NATURAL FOREST AND TEAK PLANTATION, AKURE, ONDO STATE, NIGERIA

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ABSTRACT

This study was carried out to investigate the effects of controlled fire on the abundance and diversity of arthropods. The controlled fire used was categorized into; Free range burning, Slash and burn, and Teak litter burning. The Free range burning, and Slash and burn were carried out at the Natural forest while the Teak litter burning in the Tectonia grandis (Teak) Plantation. Land areas of 100 m × 100 m were marked out in all the study area (Free range and Slash area of natural forest and Teak plantation). Soil samples were obtained prior to burning, immediately after burning progressively once per month for a period of four months after the burning were carried out. It was observed that Arthropod abundance of the soil was suppressed after burning in the study area. The result for soil mesofauna abundance shows that there was no significant ($p \geq 0.05$) difference between the burning treatments; while the collection period was significantly higher ($p \leq 0.05$) before burning and significantly ($p \leq 0.05$) lower immediately after burning. Arthropod diversity began to significantly ($p \leq 0.05$) increase from three months after burning with migration of new arthropod species into the burnt area. Total recovery of soil mesofauna was not attained during the period of this research.

Key words: Arthropod, controlled fire, slash and burn, soil, recovery.

INTRODUCTION

Fire has long been integral part of the forest environment and has played an important role in shaping the flora and fauna. Fire is an important natural disturbance in most forest ecosystems and can lead to rapid changes in soil and biogeochemical cycling, which, in turn can have important implications for long-term ecosystem dynamics (Neary *et al.*, 2005; Lecomte *et al.*, 2005). It is used as a managing agent in forests, both to regulate vegetative growth and as a means of insect control (Maartje *et al.*, 2016). There are two types of forest fires: prescribed (controlled) fires and wildfires. The use of controlled fire as a tool in forest ecosystem restoration is increasing rapidly (Morgan *et al.*, 2020), from its inception in Louisiana in the 1920s to the present day, prescribed burning for ecological and silvicultural management has grown from a curious experiment to a tool used over 48,000 times a year (Brose & Patrick, 2014). Forest fire has long been used as a means to improve soil chemical properties with little consideration to its implication on the soil biological properties. Mesofauna playing an important part in decomposition processes which cannot be neglected as reduction in species abundance will greatly affect breaking down of soil nutrients.

Arthropods are the most successful member of the Animal Kingdom; more than 80% of the described living Animal species are Arthropods (Thanukos, 2007). Phylum Arthropoda, which includes more than one million species, is the largest in the animal kingdom and is represented by nine classes of segmented animals with paired, jointed append-ages and a hard exoskeleton. They are common throughout marine, freshwater, terrestrial and even aerial environments. Insects are seen to be the most successful of the known terrestrial Arthropods. However, there are several other families in the Phylum Arthropoda, which are important to the Forest ecosystem. Arthropods are of economic and ecological importance in the Forest Eco-system and their abundance and species diversity are of great interest to the Entomologists (Adeduntan, 2012). The role-played by soil and litter arthropods in the decomposition processes and continuous release of nutrient to the forest soil is of great interest, through

experiment, (Schaefer *et al.*, 2009) confirmed the significance of soil fauna in decomposition and litter transformation. However, Arthropods are also responsible for some activities in the Forest Eco-system that are detrimental to the Forest Environment (especially on the tree community) examples of these are: some Arthropods serves as vectors to some tree's diseases and pests and some (especially the insects e.g. defoliators) are directly pests on forest trees. Soil arthropods occurrence outnumbers the arthropods of all other compartments of many biomes (Badejo and Ola-Adams, 2000; Coleman, 2015). Stork (1988) estimated that the number of arthropods in one hectare of rain forest is 42.2 million and the major soil arthropods groups include (Collembola (48%), Acari (18%), Formicidae (16%) followed by Coleopteran, Psocoptera and Hemiptera. Most tropical soil fauna lives in the top 10 cm of mineral soil where organic matter is decomposed and the final products such as water, CO_2 and mineral salt are available for crops through their roots. The aim of this study is therefore, to find out the effects of controlled fire on the abundance and diversity of arthropods at Obanla Natural Forest and Teak Plantation.

MATERIALS AND METHODS

The Study Area

The study was carried out at Teak plantation and natural forest in Obanla campus at Federal University of Technology, which is a portion of the forest left behind during land clearing for the establishment of the Federal University of Technology Akure (FUTA), Ondo State, Nigeria. The forest was formerly part of Akure Forest Reserve. The forest is about 9.34 ha in size, translating into 1.5% of total land mass. Generally, the vegetation zone is the tropical humid lowland forest ecosystem. The ecological zone has been described in details by Nwoboshi (1982), Okojie (1996) and Adekunle (2002).

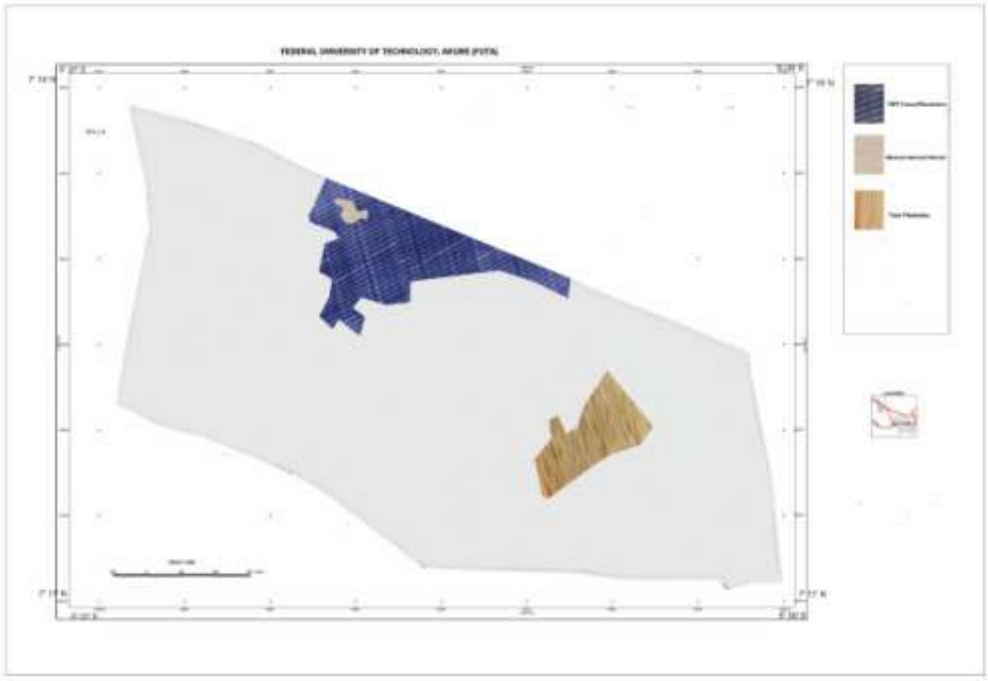


Figure. 1: the map of FUTA showing study Area.

Method of Soil Collection

At each forest habitat (Natural forest and Teak plantation). A 100 m × 100 m land area was demarcated on two different locations in the natural forest and another location in the Teak plantation. The 100 m × 100 m land areas marked was further divided into 25 temporary sample plots of 20 m x 20 m where three plots were randomly selected (12.5% sampling intensity), while 3 m x 3 m dimension was clearly demarcated within each selected plots on both plantation as the project site that were used for burning. The selected plots on each demarcated study area in the Natural forest were subjected to different burning methods, one was subjected to free range burning method while the other to slash and burn method. The selected plots on the demarcated land area in the Teak plantation were subjected to free range burning method. In each of the selected plots, soil samples were collected at a depth of 0 - 10 cm from three points on a diagonally designed pattern within the selected plot. Samples collected in these three points were mixed together, to be able to determine the diversity and abundance of soil mesofauna before burning, and immediately after burning. Soil samples were taken from these selected plots once per month for a period of four

months after the first burning. All the soil samples collected were taken to the laboratory for mesofauna isolation and identification.

Arthropod Isolation and Identification

Enumeration of Mesofauna:

Soil samples collected was gently placed in polythene bag to minimize crushing of soil fauna. The soil samples collected were taken to the laboratory immediately after collection. Floatation method was used for the identification of the soil mesofauna, which involves putting the soil sample into a Petri-dish and adding small water quantity so as to help in separating the constituent soil particles into aggregates for easy identification of the mesofauna present. The Petri-dish was then examined under a stereo microscope. Thereafter, species identification, counting and labelling was carried out.

Methods of Data Analysis

Data analysis was carried out using SPSS on results from abundance of soil mesofauna, microbes and organic matter using Randomized complete block design. Descriptive statistics was further used to analyse the data.

RESULTS

Effect of Fire on Soil Mesofauna Abundance and Diversity in the Study Area

The ANOVA Table for soil mesofauna abundance shows that there was significant ($p \leq 0.05$) difference between burning types. Likewise, the sampling period of mesofauna was significantly ($p \leq 0.05$) different (Table 1). Mean separation for soil mesofauna abundance and burning type shows that mesofauna abundance was significantly ($p \leq 0.05$) higher (38.667±1.715) at Free range burning and significantly ($p \leq 0.05$) lower (33.000 ±1.715) at Teak litter burning. However, there were no significant differences in mesofauna abundance between Slash and burn, and Teak litter burning (Table 2). Mean separation for mesofauna abundance and period of collection (Table 3), further reveal that soil samples obtained before burning in all the three burning treatments was significantly ($p \leq 0.05$) higher in mesofauna abundance while mesofauna abundance in the soil samples obtained immediately after burning were significantly ($p \leq 0.05$) lower. There were no significant ($p \leq 0.05$) differences between the third and fourth month after burning were carried out in all the treatment.

The soil mesofauna abundance observed before the burning process in the burnt plots exceeds the observed mesofauna abundance recorded in all the study area (four months after burning) (Fig 1).

Table 1: ANOVA result for Mesofauna abundance in all burnt plots

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Burning type	103.444	2	51.722	2.93	.010*
Collection period	12902.28	5	2580.456	146.155	.000*
Error	176.556	10	17.656		
Total	35725	18			

*Key: * = significant*

Table 2: Influence of burning type on Mesofauna Abundance

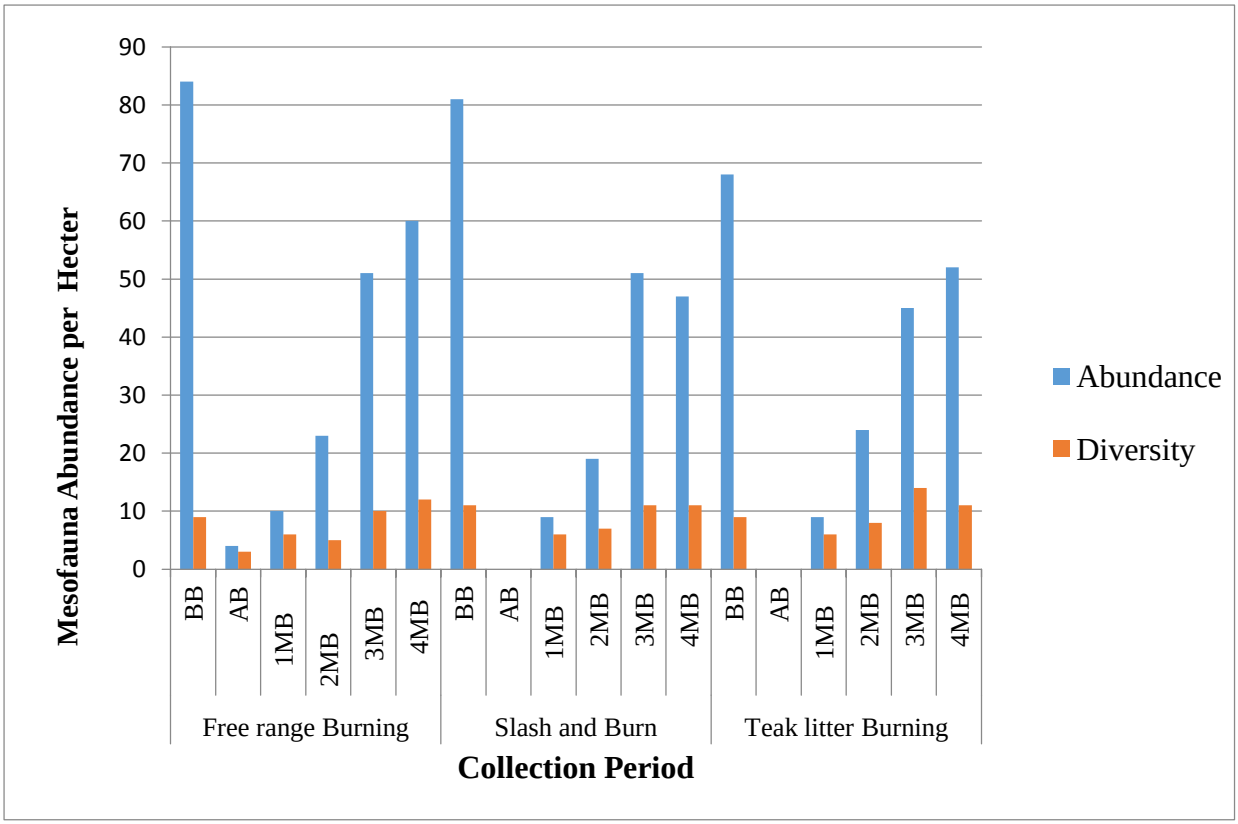
Burning type	Mean± Std Error
Free range burning	38.667^{a}±1.715
Slash and burn	34.500^{ab}±1.715
Teak litter burning	33.000^{b} ±1.715

Means followed with the same alphabet in the same column are not significantly different at P ≤ 0.05

Table 3: Influence of burning on Mesofauna Abundance and period of collection

Collection period	Mean± Std Error		
	Free litter Burning	Slash and Burn	Teak litter burning
Before burning	84.0000^{a}±2.425	81.0000^{a}±2.425	68.0000^{a}±2.425
After burning	4.0000^{d}±2.425	0.0000^{d}±2.425	0.0000^{d}±2.425
One month after burning	10.0000^{d}±2.425	9.0000^{d}±2.425	9.0000^{d}±2.425
Two months after burning	23.0000^{c}±2.425	19.0000^{c}±2.425	24.0000^{c}±2.425
Three months after burning	51.0000^{b}±2.425	51.0000^{b}±2.425	45.0000^{b}±2.425
Four months after burning	60.0000^{b}±2.425	47.000^{b}±2.425	52.0000^{b}±2.425

Means followed with the same alphabet in the same column are not significantly different at P ≤ 0.05



Key: *BB – Before Burning; AB – After Burning; 1MB – One Month After Burning; 2MB – Two Months After Burning; 3MB – Three Months After Burning; 4MB – Four Months After Burning*

Fig 1: Mesofauna Abundance and Diversity in relation to the collection periods

Table 4: Abundance and Diversity of soil mesofauna in Free, Slash and Teak burning in the study area

	Free range Burning						Slash and Burn						Teak litter Burning					
Mesofauna	**BB**	**AB**	**1MB**	**2MB**	**3MB**	**4MB**	**BB**	**AB**	**1MB**	**2MB**	**3MB**	**4MB**	**BB**	**AB**	**1MB**	**2MB**	**3MB**	**4MB**
Ancistrotermes cavithorax	7	-	2	-	4	2	4	-	1	3	5	4	14	-	-	2	3	3
Dorylus fumbriatus	5	1	2	3	2	3	7	-	-	-	2	4	-	-	3	4	2	-
Microtermitinae	10	1	-	-	3	-	8	-	2	2	4	-	7	-	-	-	2	5
Spirostreptus spp	21	2	1	8	16	8	7	-	-	-	12	11	-	-	-	4	11	13
Chilopoda spp	12	-	2	4	3	14	4	-	-	3	4	6	4	-	-	3	4	8
Spider	4	-	-	-	-	2	1	-	-	-	2	5	1	-	-	2	1	1
Colpoda stenii	-	-	-	-	4	-	14	-	3	-	5	-	10	-	1	-	2	3
Opilions	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-
Aporrectodea trapezoides	19	-	2	6	10	9	11	-	1	-	9	7	14	-	1	4	6	8
Myrmicaria striata	-	-	-	-	-	5	-	-	-	2	3	1	7	-	2	3	3	-
Earwig	3	-	1	2	-	5	12	-	1	-	3	4	10	-	1	-	2	4
Isopod	-	-	-	-	2	6	7	-	-	5	2	3	-	-	-	3	-	2
Mollusca	3	-	-	-	-	1	6	-	-	-	-	1	1	-	-	-	-	1
Octolasion lecteum	-	-	-	-	5	3	-	-	-	-	-	-	-	-	1	-	4	4
Porcellio	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Endrillus engenine	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
Oniscus asellus	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Coleoptera scaber	-	-	-	-	2	2	-	-	-	1	-	1	-	-	-	-	-	-
Hyperiodrilus atriceunus	-	-	-	-	2	-	-	-	-	-	2	-	-	-	-	-	2	-
Abundance	84	4	10	23	51	60	81	0	9	19	51	47	68	0	9	24	45	52
Diversity	9	3	6	5	10	12	11	0	6	7	11	11	9	0	6	8	14	11

KEY: - Not present

BB – Before Burning; AB – After Burning; 1MB – One Month After Burning; 2MB – Two Months After Burning; 3MB – Three Months After Burning; 4MB – Four Months After Burning

DISCUSSION

Influence of Forest fire on Mesofauna Abundance and Diversity

This result revealed that the use of controlled fire significantly affects the forest floor arthropod community. Soil-dwelling arthropods may be directly affected by increase in soil temperature and exposure during combustion (Swengel, 2001). The result of this study clearly revealed that controlled fire causes reduction in arthropod abundance and diversity immediately after burning which is related to the findings of Moretti *et al.*, (2006); Mataix-Solera *et al*., (2009) who reported that forest fire causes immediate reductions in arthropod abundance, whereas others have shown that arthropod populations can demonstrate some resilience (Moretti *et al.,* 2004). The free range burning type had more mesofauna species diversity and abundance after burning compared to slash and burn, and Teak litter burning type which could be due to the ability of some mesofauna species to burrow down into soil of the root of some growing tree seedlings during burning, this observation is similar to the findings of Moretti *et al.,* (2006) who reported that soil mesofauna survives fire under burnt forest stands. Forest fires known for its destructive nature decreases soil mesofauna abundance in the forest which makes it a major disturbance in an ecosystem. Post burnt sample recorded low mesofauna abundance compared to the samples taken before burning. The three burning treatment had similar significant effect on mesofauna abundance and diversity in the study. Total recovery of litter mesofauna in forests did not occur over the duration of the study. The direct effects of fire which includes reduced litter depth appear to prolong the increase in arthropod abundance for a longer period. Litter arthropod abundance also differed between pre-burned and post-burned samples, but did not differ between the burning treatments used.

CONCLUSIONS AND RECOMMENDATIONS

i. Mesofauna abundance was highly suppressed by burning as a result of the high level of heat generated during burning
ii. Burning process had an immediate effect on mesofauna species diversity which led to low recovery in species abundance but gradual increase in diversity.
iii. Forest exploiters should be educated on the importance of biodiversity conservation and the terrible consequences of reckless burning of forest.
iv. Community involvement and education about forest and land fires should be promoted.

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