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Agaricomycota (Mushroom) Occurrence Distribution and Species Abundance in Kogi State, Central Nigeria

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Abstract

The diversity and distribution of mushroom-forming fungi of the three senatorial zones of Kogi state was studied. A multi-stage sampling technique was used to assess twelve randomly selected plots mapped out across the study area during the rainy and early dry seasons of 2014, 2015 and 2016. A total of eight-hundred and six (806) mushrooms species were collected and recorded during the three years of investigation of the study area. Three hundred and fifty (350) species were found in the eastern senatorial district, 143 species were found in the central senatorial district and 313 species were found in the western senatorial district of Kogi State. Out of these, 151genera and 32 families were identified. Kogi West had the highest (26) number of families and the lowest (15) number of families was observed in Kogi Central. Sixty eight (68) species and 14 families were common to all the districts. 6 morpho groups (Ascomycetes fungi, Boletoid and Polyporus fungi, Coral fungi, Gilled fungi, Cortinarius fungi, and Non-gilled fungi) occurred across the study area, the gilled-fungi being the most frequent, while the coral fungi had the least occurence. Also 13 stature types (Amanitoid, Armillarioid, Clitocyboid, Collybioid, Galerinoid, Lepiotoid, Mycenoid, Naucoriod, Omphaloid, Pleurotoid, Pluteotoid, Tricholomatoid, and Vaginatoid) were represented across the plots. Inventory of 112 fleshy and 25 hard mushrooms; 191 fleshy and 46 hard mushrooms; 352 fleshy and 80 hard mushrooms was carried out in year 2014, 2015 and 2016 respectively.

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Two hundred and ninety-eight (298) mushrooms species were collected on wood, 471 on soil and 37 on leaves litter/humus. The mushroom compositional species diversity and richness were estimated and compared using Shannon-Weiner Index, Pielou's Evenness Index, Margalef's Index of Species Richness and Simpson Concentration Index. The Shannon diversity index varied from a significantly lower index of 0.93 at Kogi Central to a significantly higher index of 1.75 at Kogi West (p=0.001). The evenness index varied from a significantly minimum 0.29 at Kogi central to a significantly maximum 0.51 at Kogi West (p=0.010). The species richness significantly varied between 4.56 in Kogi Central to 8.74 in Kogi West and 13.42 in Kogi East (p=0.001). The Simpson index significantly varied between 0.25 in Kogi West to 0.60 in Kogi Central which was the highest (p=0.003). Kogi East and Kogi West were the most similar (0.48) as revealed by the similarity index in terms of mushroom assemblage.

Key words: Agaricomycota; Mushroom; Species abundance; Kogi State.

1. Introduction

The occurrence of mushroom species has been reported by several researchers in different parts of the world [3, 4; 5, 6; 7, 8]. In comparison with previous studies [1, 9, 10, 11, 12], variations were observed in the checklist of species observed from each of the studies comparatively with the different districts of the study area. This may be attributed to variations in time of investigation and level of degradation of the ecosystems that were studied which may include climate, physiognomy, synecology, litter fall dynamics and composition, succession and geography. The author in [2] reported that studies on mushroom diversity in many developing countries such as Nigeria were scattered, often times limited to regions, tribes or forests; far between and biased against non-edible, mycorrhizae and hypogenous (underground) types. The authors in [7], in their study on diversity of macrofungi in Oil Palm Agroforests of Edo State, Nigeria reported a total of 49 fruit bodies belonging to 26 different species of mushrooms. The authors in [13], assessed the macrofungi Community in Rubber Plantations and a forest of Edo State, Nigeria. They encountered 93 different species of macrofungi belonging to 28 families. Similarly, a total of 21 species of edible wild mushrooms harvested from 10 states of the federation distributed into 4 Classes (*Agaricomycetes*, *Heterobacidiomycetes*, *Bacidiomycetes*, and *Homobacidiomycetes*), 4 Orders (*Auriculariales*, *Agaricales*, *Polyporales*, *Russulales*), 10 Families (*Auriculaceae*, *Agariceae*, *Corpinaceae*, *Formitopsidaceae*, *Polyporaceae*, *Russulaceae*, *Tricholomataceae*, *Pleurotaceae*, *Lyophyllaceae*, and *Russulaceae*) were reported by [15] in their research investigation titled catalogue and identification of some wild edible macro-fungi in Nigeria.

There is the need to place high priority on the complex interactions between fungi and terrestrial plants. This stems from the fact that loss of biodiversity may lower the productivity of ecosystems [22], and the diversity of primary producers may be dependent on fungal diversity [23]. Biodiversity indices are generated to bring the diversity and abundance of species in different habitats to similar scale for comparison and the higher the value, the greater the species richness. Such information will also enable integration into the global biodiversity, wider bio-prospecting and downstream application hence the importance of this investigation. . This study assessed all mushrooms irrespective of edibility and other factors. The record and understanding of the diversity, phenology, substrate specificity, and scientific classification of macrofungi is of significant importance to the preparation of

checklists, accession in genbank, management of forests or forest resources

2. Materials and methods

2.1. Study area

The study was carried out in Kogi state located in the North-Central geo-political zone of Nigeria between latitude 6°30' and 8°50'N and longitude 5°51' and 8°00'E (Figure 5). The state is divided into three senatorial districts (Kogi East, Kogi Central and Kogi West) and structured into 21 local government areas. Kogi East comprise of Ankpa, Bassa, Dekina, Ofu, Omala, Olamaboro, Ibaji, Idah and Igalamela-Odolu LGAs; Kogi Central comprise of Ajaokuta, Okene, Okehi, Adavi and Ogori-magongo LGAs; while Kogi West comprise of Kabba-Bunnu, Ijumu, Lokoja, Kogi, Yagba-West, Yagba-East and Mopa-Amuro LGAs [20].

Figure 1: Map of Kogo State, Central Nigeria showing Study area and Sampling Sites.

Map of the Study Area Showing Study Plots

The materials used for the study include wax brown paper bags and aluminum foil for larger specimens, trowel to dig up base of sporocarps, sharp knife, scalpel, specimen field tags, survey data and fungal description forms, collection bottles, Global Positioning System unit (GARMIN GPSmap76Cx), Canon digital camera, permanent marking pens, galvanized iron sheets to tag plot edges and cane basket to carry and dry collected specimens.

2.2. Sampling procedure

A multi-stage sampling technique was adopted for the study. A reconnaissance survey was carried out in the study area. The three senatorial districts (Kogi East, Kogi West and Kogi Central) in the state were selected for the purpose of the study. A total of six (6) LGAs were randomly selected in the three senatorial districts two from each senatorial district; Olamaboro and Ofu LGAs (Kogi East Senatorial) Ijumu and Yagba East LGAs

(Kogi West Senatorial) and Adavi and Okehi LGAs (Kogi Central Senatorial). Thereafter, two sites were randomly selected from each of the selected local government areas in the senatorial districts.

2.3. Laying of plots

Sampling of macrofungi was carried out in 12 plots of 2 x 4km demarcated using Global Positioning System (GARMIN GPSmap76Cx), within which two transects each measuring 0.5 x 2km^2 was forayed 1km away from each other. A total of 24 transects were thus surveyed from the study location.

Study Locations

Table1: Sampling Sites in Senatorial Districts of Kogi State, Central Nigeria

Senetorial Districts	L.G.A	PLOTS	
Kogi East	Olamaboro	ELA	ELB
	Ofu	EFA	EFB
Kogi Central	Okehi	CKA	CKB
	Adavi	CDA	CDB
Kogi West	Ijumu	WIA	WIB
	Yagba East	WYeA	WYeB

Key:

ELA: Eastern Lamaboro Plot A; CDA: Central Davi Plot A

ELB: " " Plot B CDB: " " Plot B

EFA: Eastern Fu Plot A WIA: Western Ijumu Plot A

EFB: " " Plot B WIB: " " Plot B

CKA: Central Kehi Plot A WYeA: Western Yagba East Plot A

CKB: " " Plot B WYeB: " " " Plot B

2.4. Sampling of macrofungi

Marcrofungi were sampled from June to December each year of 2014, 2015 and 2016. This included collection

of every encountered macrofungi within each transects. These were photographed in-situ and tagged digitally with the canon camera. A few sporocarps were carefully dug out and their fertile sides (gill, tubes and spines) were exposed and photographed (Plates 3 to 97). Photographed macrofungi were then collected in separate waxed paper bags in order to avoid spore contamination among the different specimens. The collection bag was correctly labeled.

2.5. Data analysis

The following indices were employed for diversity analysis following [16,21]:

2.5.1. Comparison of Means

Mean values between groups were compared using one way analysis of variance (ANOVA). Where significant difference exists, means were separated using Duncan's multiple range test (DMRT).

2.5.2. Shannon-Wiener Diversity Index (H')

In the Shannon index, p is the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), ln is the natural log, Σ is the sum of the calculations, and s is the number of species [16]. The values of Shannon-Wiener diversity index is usually found to fall between 1.5 and 3.5 and only rarely surpasses 4.5. It is given by (eqn 1):

$$\mathbf{H}^{'} = -\sum \boldsymbol{P_i}\, \boldsymbol{ln}\,(\boldsymbol{P_i}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

2.5.3. Pielou's Evenness Index (E_H)

The ratio of the observed diversity (H') to the maximum diversity (Hmax) is taken as a measure of evenness (E). S represents total number of species. E is constrained between 0 and 1.0 with 1.0 representing a situation in which all species are equally abundant (Equation 2).

$$\boldsymbol{E_H} = \frac{\mathbf{H}^{'}}{\boldsymbol{ln(S)}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

2.5.4. Simpson Concentration Index (λ)

Simpson's Concentration index is weighted towards the abundance of the commonest species (Equation 3).

$$\boldsymbol{\lambda} = \sum \boldsymbol{P_i^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3$$

Pi is the proportional abundance of the ith species. Simpson's index varies from 0 to 1 and gives the probability that two individuals drawn at random from a population belong to the same species. If the probability is high,

then the diversity of the community sample is low. The higher the dominance index the lower the Shannon diversity.

2.5.5. Margalef's Index of Species Richness (M)

The Margalef's index was used to calculate the species richness. The Margalef's index is independent of sample size. It is based on the relationship between total number of species (S) and total number of individuals (N). Margalef's index is given by Equation 4:

$$\mathbf{M} = \frac{S-1}{ln(N)} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.. 4$$

S is the total number of species; N is the total number of individuals and ln' is the natural logarithm (loge).

2.5.6. Sørensen Similarity Index (Cs)

Similarity indices represent variations over three parameters: species composition in each of two sites and the species shared between the two sites [17]. For the purpose of this study the Sørensen similarity index [16] measures similarity in mushroom species composition between two sites, A and B, by equation 5;

$$Cs = \frac{2ab}{a+b} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.. 5$$

Where *a* is the number of species found in site A; b is the number of species in site B and ab is the number of species shared by the two sites.

3. Results

Location/Substrate and Loss of Mushrooms

The result of the mushroom substrate is presented in Table 1. On the overall, majority (199) of the mushrooms grow out from anthill, while 155 grow on wood. Eighty-five (85) and 58 of the mushrooms grow out from soil and dung respectively.

Table 2: Mushroom Location/Substrate in the study area

Location/ Substrate	Adavi	Ijumu	Ofuu	Okehi	Olamaboro	Yagba East	Total
Wood	14	15	11	18	11	16	155
Anthill	18	19	20	16	17	19	199
Dung	4	12	9	3	8	2	58
Soil	7	16	8	6	9	4	85
Total	43	62	48	43	45	41	497

3.1 Mushroom inventory and occurrence in the study area

In the course of the study, 73 fleshy and 15 hard mushrooms (first transects of all plots); and 39 fleshy and 10 hard mushrooms (second transects of all plots) were collected in year 2014; 116 fleshy and 28 hard mushrooms (first transects of all plots); and 75 fleshy and 18 hard mushrooms (second transects of all plots) were collected in year 2015; and 241 fleshy and 49 hard mushrooms (first transect of all plots); 111 fleshy and 31 hard mushrooms (second transect of all plots) were collected in 2016.

In addition, 52 mushrooms were collected on wood, 81 on soil and 4 on leave litter/humus substrates in year 2014; 91 mushrooms were collected on wood, 130 on soil and 16 on leaves litter/humus substrates in year 2015; and 155 mushrooms were collected on wood, 260 on soil and 17 on leaves litter/humus substrates in year 2015.

Tables 2, 3, 4 and 5 show the mean occurrence and distribution of mushrooms substrates across the first and second transects in the study area in 2014.

Table 2 revealed that locations had significant effects ($p \leq 0.05$) on fleshy mushrooms ($p=0.030$) and overall mushrooms ($p=0.041$).

However, in the first transect, the fleshy and hard mushrooms were not significantly different from each other ($p \geq 0.05$). Similarly, hard mushrooms collected in the second transect were not significantly different from each other ($p \geq 0.05$) in the study area.

The result of the mean distribution of mushroom substrates in the selected Local Government Areas (LGAs) of Kogi State in 2014 as shown in Table 10 revealed that the effects of the locations was significant ($p \leq 0.05$) on the emergence of the mushrooms from soil substrate ($p=0.047$), while emergence of the mushrooms on wood ($p=0.105$), leave litter/humus ($p=0.588$) and total emergence on all the substrates ($p=0.266$) were not significantly affected ($p \geq 0.05$) by the variation in the Local Government Areas.

Table 6 showed the result of the mean occurrence of mushrooms across first and second transects in selected local government areas of Kogi state in 2015. It was observed that the senatorial districts and local government areas no significant effects ($p \geq 0.05$) on the fleshy and hard mushrooms collected in the first and second transects of the study area in year 2015.

This is similarly observed for the total fleshy and hard mushrooms occurrence in the first and second transects. Similarly as observed in Table 7, the mean occurrence of mushrooms across first and second transects in the senatorial districts of Kogi State in 2015 had no significant effects ($p \geq 0.05$) on the fleshy and hard mushrooms collected in the first and second transects.

The highest mean occurrence of fleshy and hard mushrooms was observed in Kogi East (25.25 ± 5.27), followed by Kogi West (21.50 ± 1.85) while the lowest was observed in Kogi Central (12.50 ± 4.74).

Table 3: Mean Occurrence of Mushroom across the Plots of the Study Area in 2014 based on Local Government Areas

Senatorial District	LGA	Mean ± SEM				Total
		First Transect		Second Transect		
		Fleshy	Hard	Fleshy	Hard	
Kogi East	Olamaboro	12.00 ± 4.00	2.50 ± 0.50	7.00 ± 1.00[a]	1.50 ± 1.50	23.00 ± 5.00[a]
	Ofu	4.00 ± 1.00	2.50 ± 0.50	4.00 ± 1.00[ab]	2.00 ± 0.00	12.50 ± 2.50[b]
Kogi Central	Okehi	4.50 ± 1.50	1.00 ± 1.00	1.50 ± 0.50[bc]	0.50 ± 0.50	7.50 ± 3.50[bc]
	Adavi	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00[c]	0.00 ± 0.00	0.00 ± 0.00[c]
Kogi West	Ijumu	9.50 ± 4.50	0.50 ± 0.50	3.00 ± 0.00[bc]	0.00 ± 0.00	13.00 ± 5.00[ab]
	Yagba East	6.50 ± 3.50	1.00 ± 1.00	4.00 ± 2.00[ab]	1.00 ± 1.00	12.50 ± 1.50[b]
ANOVA		2.103	2.345	5.544	1.143	4.829
p-value		0.196	0.164	0.030*	0.430	0.041*

Means in the same column having different superscripts are significantly different. Means were separated using Duncan's Multiple Range Test (DMRT) at $p \leq 0.05$.

ANOVA: Analysis of Variance

*: Significant difference exists at $p \leq 0.05$.

SEM: Standard Error of Mean, LGA: Local Government Area

Table 4: Mean Distribution of Mushroom Substrates in the Study Area in 2014 based on Senatorial Districts

LGA	Mean ± SEM			
	Wood	Soil	Leave litter/Humus	Total
Kogi East	6.75 ± 1.25	10.50 ± 3.66[a]	0.50 ± 0.50	44.50 ± 13.90
Kogi Central	2.75 ± 1.70	1.005 ± 1.00[b]	0.00 ± 0.00	19.50 ± 4.72
Kogi West	3.50 ± 0.87	8.75 ± 1.32[a]	0.50 ± 0.50	44.00 ± 4.53
ANOVA	2.604	4.750	0.500	2.598
p-value	0.128	0.039*	0.622	0.129

Means in the same column having different superscripts are significantly different. Means were separated using Duncan's Multiple Range Test (DMRT) at $p \leq 0.05$.

ANOVA: Analysis of Variance

*: Significant difference exists at $p \leq 0.05$.

SEM: Standard Error of Mean, LGA : Local Government Area

Table 5: Mean Occurrence of Mushroom across the Plots of the Study Area in 2015 based on Local Government Areas

Senatorial District	LGA	Mean ± SEM First Transect		Second Transect		Total
		Fleshy	Hard	Fleshy	Hard	
Kogi East	Olamaboro	18.00 ± 3.00	2.50 ± 2.50	8.00 ± 2.00	1.00 ± 1.00	31.50 ± 8.50
	Ofu	7.50 ± 2.50	1.50 ± 0.50	7.50 ± 0.50	2.50 ± 0.50	19.00 ± 4.00
Kogi Central	Okehi	7.50 ± 5.50	2.00 ± 2.00	4.00 ± 2.00	1.50 ± 1.50	15.00 ± 11.00
	Adavi	5.00 ± 1.00	0.50 ± 0.50	3.50 ± 1.50	1.00 ± 1.00	10.00 ± 1.00
Kogi West	Ijumu	11.00 ± 1.00	2.50 ± 0.50	5.50 ± 1.50	1.50 ± 0.50	20.50 ± 2.50
	Yagba East	9.00 ± 1.00	3.00 ± 0.00	9.00 ± 4.00	1.50 ± 0.50	22.50 ± 31.50
ANOVA		2.544	1.018	1.059	0.360	1.387
p-value		0.143	0.481	0.464	0.859	0.347

Means in the same column having different superscripts are significantly different.

Means were separated using Duncan's Multiple Range Test (DMRT) at $p \leq 0.05$.

ANOVA: Analysis of Variance

*: Significant difference exists at $p \leq 0.05$.

SEM: Standard Error of Mean, LGA: Local Government Area

Table 6: Mean Occurrence of Mushroom across the Plots of the Study Area in 2015 based on Senatorial Districts

Senatorial District	Mean ± SEM				
	First Transect		Second Transect		Total
	Fleshy	Hard	Fleshy	Hard	
Kogi East	12.75 ± 3.43	3.00 ± 1.35	7.75 ± 0.85	1.75 ± 0.63	25.25 ± 5.27
Kogi Central	6.25 ± 2.39	1.25 ± 0.95	3.75 ± 1.03	1.25 ± 0.75	12.50 ± 4.74
Kogi West	10.00 ± 0.82	2.75 ± 0.25	7.25 ± 2.02	1.50 ± 0.29	21.50 ± 1.85
ANOVA	1.762	0.963	2.434	0.180	2.405
p-value	0.226	0.418	0.143	0.838	0.146

Means in the same column having different superscripts are significantly different. Means were separated using Duncan's Multiple Range Test (DMRT) at $p \leq 0.05$.

ANOVA: Analysis of Variance

*: Significant difference exists at $p \leq 0.05$.

SEM: Standard Error of Mean

LGA: Local Government Area.

The mean occurrence and distribution of mushrooms substrates across the first and second transects in Kogi State in the year 2016 are presented in Tables 6 and 7. As shown in Table 6, the senatorial districts and selected local government areas had no significant effects ($p \geq 0.05$) on the fleshy, hard and total mushrooms collected from the first and second transects in year 2016.

The mean distribution of mushroom substrates in the selected Local Government Areas (LGAs) of Kogi State in 2016 was presented in Table 7. As shown in the result, the six Local Government Areas had no significant effects ($p \geq 0.05$) on the mean distribution of the mushroom substrates. On the overall, Yagba East had the highest distribution of mushrooms which popped out of wood (23.50±5.50) and leave litter/humus (2.50±2.50), while Olamaboro had the highest mean distribution of mushroom which popped out of soil (43.00±23.00). Adavi LGA on the other had the lowest distribution of mushrooms which popped out of wood (5.50±1.00), soil (8.00±1.00) and Leave litter/humus (1.00±1.00) substrates.

Table 7: Mean Occurrence of Mushroom across the Plots of the Study Area in 2016 based on Local Government Areas

Senatorial District	LGA	Mean ± SEM First Transect		Second Transect		Total
		Fleshy	Hard	Fleshy	Hard	
Kogi East	Olamaboro	34.00 ± 14.00	3.50 ± 1.50	16.50 ± 11.50	5.00 ± 3.00	59.00 ± 27.00
	Ofu	15.50 ± 3.50	5.50 ± 1.50	6.50 ± 1.50	2.50 ± 0.50	30.00 ± 3.00
Kogi Central	Okehi	15.00 ± 4.00	3.00 ± 1.00	5.50 ± 2.50	1.50 ± 0.50	25.00 ± 8.00
	Adavi	6.50 ± 0.50	1.00 ± 1.00	6.50 ± 2.50	0.00 ± 0.00	14.00 ± 3.00
Kogi West	Ijumu	21.50 ± 5.50	5.00 ± 1.00	11.00 ± 5.00	4.00 ± 1.00	41.50 ± 10.50
	Yagba East	28.00 ± 1.00	6.50 ± 0.50	9.50 ± 1.50	2.50 ± 0.50	46.50 ± 0.50
ANOVA		2.298	3.052	0.585	1.753	1.707
p-value		0.170	0.103	0.714	0.256	0.266

Means in the same column having different superscripts are significantly different. Means were separated using Duncan's Multiple Range Test (DMRT) at $p \leq 0.05$, ANOVA: Analysis of Variance, *: Significant difference exists at $p \leq 0.05$, SEM: Standard Error of Mean, LGA: Local Government Area

Table 8: Mean Distribution of Mushroom Substrates in the Study Area in 2016 based on Local Government Areas

LGA	Mean ± SEM			
	Wood	Soil	Leave litter/Humus	Total
Olamaboro	14.00 ± 2.00	43.00 ± 23.00	2.00 ± 2.00	59.00 ± 27.00
Ofu	10.00 ± 1.00	18.50 ± 0.50	1.50 ± 1.50	30.00 ± 3.00
Okehi	13.50 ± 4.50	11.50 ± 3.50	0.00 ± 0.00	25.00 ± 8.00
Adavi	5.50 ± 1.00	8.00 ± 1.00	1.00 ± 1.00	14.00 ± 3.00
Ijumu	11.50 ± 1.50	28.50 ± 13.50	1.50 ± 1.50	41.50 ± 10.50
Yagba East	23.50 ± 5.50	20.50 ± 3.50	2.50 ± 2.50	46.50 ± 0.50
ANOVA	3.814	1.308	0.283	1.707
p-value	0.067	0.372	0.907	0.266

Means in the same column having different superscripts are significantly different. Means were separated using Duncan's Multiple Range Test (DMRT) at $p \leq 0.05$.

ANOVA: Analysis of Variance

*: Significant difference exists at $p \leq 0.05$.

SEM: Standard Error of Mean

LGA: Local Government Area

Table 9: Pearson Correlation between Rainfall, Temperature and Mushroom occurrence in occurrence in year 2014, 2015 and 2016

Variables	MO2016	MO2015	MO2014
MO	1	1	1
Rainfall (mm)	0.934	0.844	0.955
Tmin (°C)	0.724	-0.749	-0.936
Tmax (°C)	-0.724	-0.948	-0.936

MO: Mushroom occurrence

T_{min}: Minimum temperature (°C)

T_{max}: Maximum temperature (°C)

3.2. Mushroom species diversity and richness

A total of eight hundred and six (806) mushrooms species were collected and recorded during the three years of investigation in the study area. This was composed of a total of three hundred and seventy-four (374), and four hundred and thirty-two (432) mushrooms collected in year 2014and 2015 respectively. In general, three hundred and fifty (350) species were found in the eastern senatorial district, one hundred and forty-three (143) species in the central senatorial district and three hundred and thirteen (313) species in the western senatorial district of Kogi State (Figure 1). Out of these, 151genera and 32 families were identified. Kogi west had the highest (26) number of families, followed by Kogi East having 22 number of families, while the lowest (15) number of families was observed in Kogi Central (Figure 2). Kogi East recorded the highest (97) number of genera while Kogi Central had the lowest (48) number of mushroom genera. A total of 72 mushroom genera were collected from Kogi West (Figure 3). 68 species and 14 families were common to all the districts. The most abundant family was Russulaceae (*Russula* sp). This was followed by Pleurotaceae (*Pleurotus* sp, *Lentinus* sp), Ganodermataceae (*Ganoderma* sp), Agaricaceae (*Agaricus* sp), and Tricholomataceae (*Tricholoma* sp) families. Bolbitaceae (*Bolbitius* sp), Inocybaceae (*Inocybe* sp), Entolomatacea (*Entoloma* sp), Tapinellaceae (*Tapinella* sp), Phanerochaetaceae (*Phlebiopsis* sp) and Schizophyllaceae (*Schizophyllum sp*) were among the least

abundant families collected from the study area (Figure 4). Six morpho groups occurred across the study area with the gilled-fungi being the most frequent. Also thirteen stature types were represented across the plots.

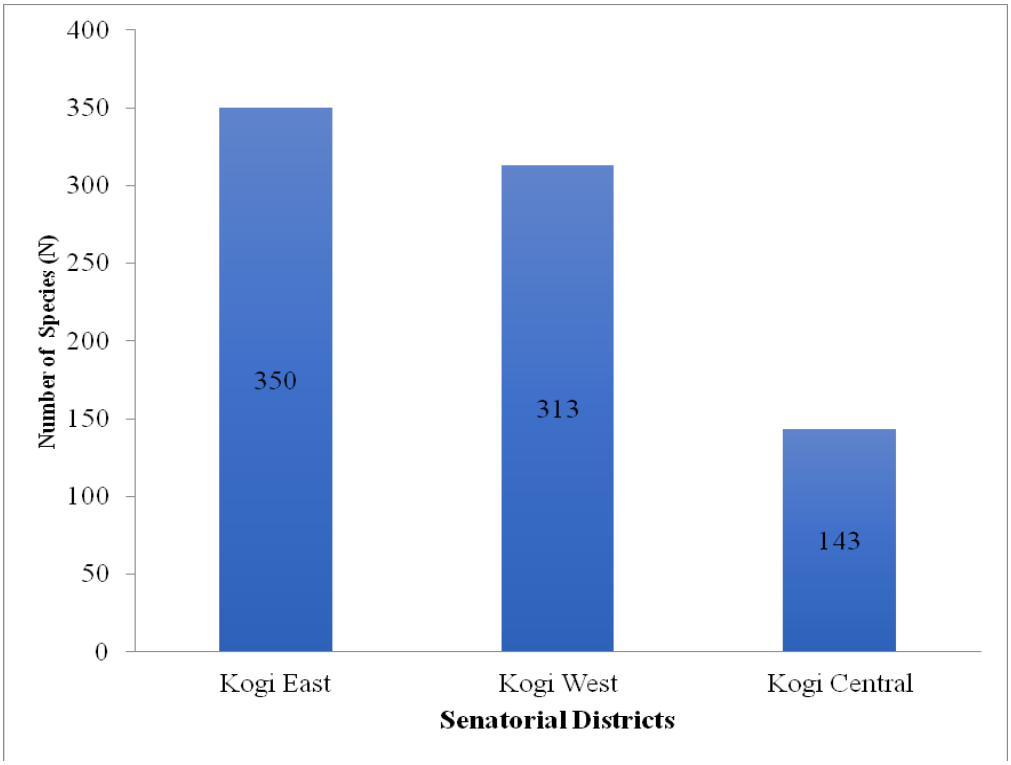

Figure 2: Number of Species Recorded in Kogi State

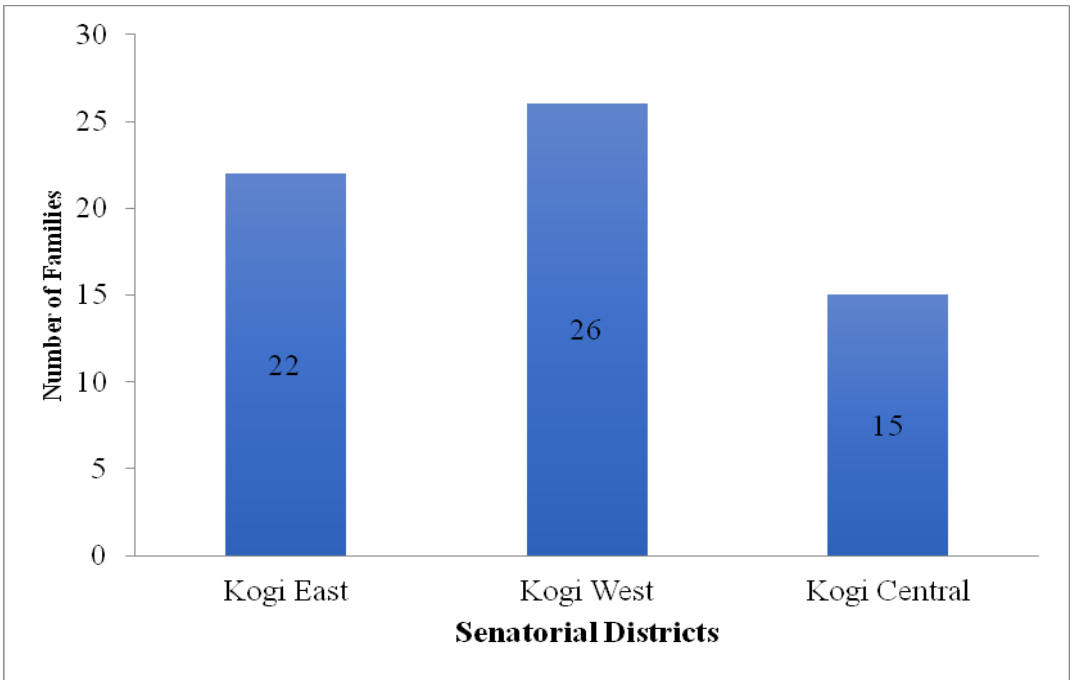

Figure 3: Number of Mushroom families Recorded in Kogi State

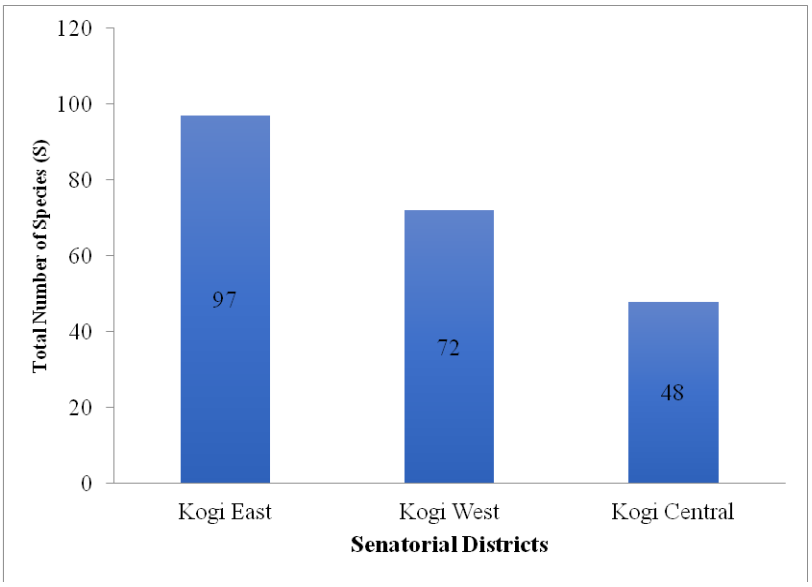

Figure 4: Number of Mushroom genera Recorded in Kogi State

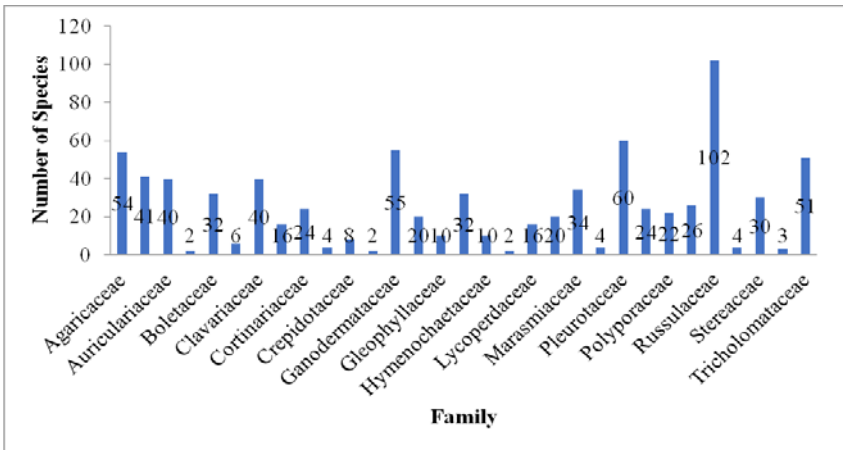

Figure 5: Families of Mushroom Species Recorded in Kogi State

3.3. Diversity and Richness Indices

Diversity indices provide important information about rarity and commonness of species in a community. The mushroom compositional species diversity and richness between the various sampled senatorial districts were estimated using the Shannon-Weiner Index (H'), Pielou's Evenness Index (E), Margalef's Index of Species Richness (M) and Simpson Concentration Index (λ) as shown in Table 10. Shannon Wiener index of the mushroom collected from the study location ranged from 1.75 in Kogi West to 0.93 in Kogi Central. Kogi East had 1.55 diversity index. The highest diversity index as obtained in Kogi West was significantly different from the lowest significant diversity index recorded in Kogi Central (Table 10). The Pielou's Evenness Index (E) of the mushroom species (Table 21) varied from a minimum of 0.29 at Kogi Central to a maximum of 0.41 at Kogi East. The evenness index obtained in Kogi East and Kogi West were not significantly different ($p \geq 0.05$). Conversely, the Evenness index as revealed in Kogi Central was significantly lower that the values obtained in

other districts ($p \leq 0.05$). Margalef's Index of Species Richness (M) was used to calculate the species richness and is independent of sample size. It is a measure for the total number of the species in a community. The species richness significantly varied between 4.56 in Kogi Central to 8.74 in Kogi West and 13.42 in Kogi East (Table 11). As obtained in this study, the Simpson Concentration index varied between 0.25 in Kogi West to 0.32 in Kogi East and 0.60 in Kogi Central. The Simpson concentration index obtained from Kogi Central was significantly higher ($p \leq 0.05$) than values obtained from other districts (Table 11).

3.4. Sorenson's Similarity Matrix

The mushroom compositional similarities or distinctiveness between the various sampled senatorial districts were estimated using the Soresen index as represented in Table 12. The matrices revealed that sites in Kogi East and Kogi West were the most similar (0.48), while a weak similarity was observed between sites in Kogi West and Kogi Central (0.19) in species composition.

Table 10: Diversity Indices of Mushrooms collected from the Study Area

Diversity Indices	**Kogi East**	**Kogi West**	**Kogi Central**
Shannon-Weiner Index (H')	1.55[a]	1.75[a]	0.93[b]
Pielou's Evenness Index (E)	0.41[a]	0.51[a]	0.29[b]
Margalef's Index of Species Richness (M)	13.42[a]	8.74[b]	4.56[c]
Simpson Concentration Index (λ)	0.32[b]	0.25[b]	0.60[a]

means in the same columns having similar superscripts are not significantly different at 5% probability level according to DMRT

Table 11: Diversity Indices of Mushrooms collected from the Study Area

Diversity Indices	**Kogi East**	**Kogi West**	**Kogi Central**
Shannon-Weiner Index (H')	1.55[a]	1.75[a]	0.93[b]
Pielou's Evenness Index (E)	0.41[a]	0.51[a]	0.29[b]
Margalef's Index of Species Richness (M)	13.42[a]	8.74[b]	4.56[c]
Simpson Concentration Index (λ)	0.32[b]	0.25[b]	0.60[a]

means in the same columns having similar superscripts are not significantly different at 5% probability level

according to DMRT

Table 12: Sorenson's Similarity Matrices for the Study Area

Districts	Kogi East	Kogi West	Kogi Central
Kogi East	1		
Kogi West	0.48	1	
Kogi Central	0.35	0.19	1

4. Conclusion

The variations in species assemblage in the different senatorial districts observed during this study may also be due to differences in the composition of the biota, level of competitiveness amongst biota and the level of human disturbances observed elsewhere by other researchers [18, 7, 1]. The authors in [22] and [19] opined that the composition and type of plant species in a terrestrial ecosystem is a primary determinant of ecosystem productivity and sustainability. The biodiversity of plant has been revealed to be predominantly controlled by the diversity of mycorrhizal fungi. Consequently, fungal diversity may indirectly control both ecosystem productivity and variability [23]. As revealed in the result of the mean occurrence of mushrooms, the locations (districts and local government areas) had significant effects ($p \leq 0.05$) on the nature (fleshy and hard) of mushrooms collected in the first and second transects of the plots (Kogi state) between year 2014 and 2016. As similarly shown in the result of the mean distribution of mushroom substrates, the locations (districts and local government areas) had significant effects ($p \leq 0.05$) on mushrooms collected between year 2014 and 2016 in Kogi state on wood and soil substrates, while no significant effects were observed for mushrooms collected on leaves litter/humus. The significant variation of the mushrooms in terms of nature (fleshy and hard) structure and habitats is in agreement with the findings of similar and related studies [15, 5, 1]. This study provided a detailed investigation of macrofungal species diversity and richness in districts of Kogi State, Nigeria. A few research scientists have reported varied macrofungi survey and diversity findings, particularly in Nigeria [7, 14, 15]. But this limited reportage has not been sufficient for current and national representation of Nigeria mycoflora diversity. This is because they are bedeviled with taxonomic inconsistencies and contradiction due mainly to the use of phenotypic features without actual genetic confirmation. Knowledge of mushroom ecology and distribution are not only important for the successful conservation and management of the ecosystem but also for the optimum exploitation of the many benefits to mankind. The dearth of such information on Nigeria's rich mycoflora contributed in some part to the poor status of the mushroom industries in the country [13]. This study reported a total of 151different species belonging to 32 families. The result of this finding is higher than mushroom inventory and diversity results reported by previous research scientists.

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