Inventory and Sampling of Wild Mushrooms Species in Kogi State, Nigeria

**1**JOHNSON, V.I. and **2FALEMARA, B.C.**

**1**Federal College of Forestry, P.M.B. 2019, Jos, Plateau State, Nigeria
**2**Research Coordinating Unit, Forestry Research Institute of Nigeria, P.M.B. 5054, Jericho Hills, Ibadan, Oyo State, Nigeria.

Corresponding author: vijoshua65@gmail.com; 07039638293

**Abstract:** An inventory was carried out on existing wild mushrooms in Kogi State for a period of three years. A multi-stage sampling procedure was used to randomly select two local government areas each from the three senatorial districts of the state. Two plots were randomly selected from each of the local government areas (12 plots). The mushroom compositional species diversity was determined. Values of the mushroom occurrence over the three-year period of survey were subjected to statistical analysis. The result revealed that Kogi East Senatorial District had the highest (29.2) mushroom occurrence, followed by Kogi West (26.1) and Kogi Central having the least (11.9). Significant difference (p≤0.05) was observed between Kogi East and Kogi Central; and Kogi Central and Kogi West, while no significant difference (p≥0.05) was observed between Kogi East and Kogi West in terms of occurrence of mushroom species across the study area. There were significant differences (p≤0.05) between years 2014 and 2015; and years 2014 and 2016 with respect to occurrence of mushroom species across the study area. Three hundred and fifty species (350), 313 and 143 species of mushrooms were found in Kogi East, Kogi West and Kogi Central respectively. Out of these, 3 classes, 10 orders, 151 genera and 32 families were identified. Kogi East had the highest (29.2) mushroom species across the study area. There were significant differences (p≤0.05) between Kogi East and Kogi West in terms occurrence of mushroom species across the study area. Three hundred and fifty species (350), 313 and 143 species of mushrooms were found in Kogi East, Kogi West and Kogi Central respectively. Out of these, 3 classes, 10 orders, 151 genera and 32 families were identified. Kogi East had the highest species diversity (1.02), in year 2014, while Kogi Central had the lowest species diversity (0.31) in the same year. This study has provided a checklist and emphasized the need to conserve mushrooms diversity in the study area.

**Keywords:** Diversity; Inventory; Kogi State; Macrofungi; Occurrence.

**INTRODUCTION**

Mushrooms constitute one of the most diverse groups of organisms on earth and also form an important part of terrestrial ecosystems (Chang & Miles, 2004). Concomitant varieties of mushrooms i.e. lichenized, mycorrhizal, parasitic and saprotrophic that abound in Nigeria have continued to gain recognition and elicit different interests and questions as potentially resourceful tool in economic modulation pari passu prevailing reliance on leafy plants (Okhuoya et al., 2010).

There is a risk of loss of macrofungi diversity and subsequent loss of knowledge of their existence and uses with continuous deforestation and environmental degradation, which are contributing to loss in global biodiversity and which in many cases are irreversible (Andrew et al., 2013). The tropical region which is undoubtedly hosting the highest mycodiversity has been inadequately sampled and the mycoflora scarcely documented (Hawksworth, 2001). This makes the situation of macrofungi in the tropical forests unclear (Hawksworth, 2004).

As the distributions of all species contract because of habitat fragmentation or other anthropogenic factors, Nigeria fungal species diversity is declining (Staddon et al., 2010; Maltz et al., 2017). Therefore, enriching quantitative databases and monitoring programs for conservation is of great significance. Moreover, since fungal biodiversity is a factor in generating and maintaining biodiversity in other life groups, they have a central role in many ecosystems processes. There is paucity of studies on mushroom diversity and distribution in Nigeria (Nworsu et al., 2013). Based on literature search, there are diverse isolated research studies on the uses, nutritional content, phytochemical assays as well as cultivation of mushrooms (Joshua & Agina 2002; Chang & Miles, 2004; Silva et al., 2010; Ranghoo-Sanmukhiya et al., 2014; Adejumo et al., 2015; Asemota et al., 2015). But research gaps still exist in the inventory, check-listing, cataloguing and monitoring of mushrooms.

In view of the foregoing issues, it will therefore be highly essential to create inventory and provide information on existing wild macrofungi in Kogi State. This is with a view to conserve indigenous mushroom germplasm and arrest fungal biodiversity loss that may lead to extinction. The specific objectives are to create inventory on existing wild macrofungi in Kogi State and determine the mushroom species diversity in Kogi State.

**MATERIALS AND METHODS**

**Study Area**

The study was carried out in Kogi State located between latitude 6°30' and 8°50"N and longitude 5°51' and 8°00'E. The state has a total landmass of about 30,354.74km². Out of these; about 20% of the land is occupied by people (15,000 km²). Rivers and streams occupy 3,750 km² (5%), while hills and mountains occupy 7% or 3,250km². The remaining 68% are available for cultivation (Ibitoye, 2006). The mean rainfall and temperature pattern during the period of this study

---

**Proceedings of 6th NSCB Biodiversity Conference; Uniuyo 2018 (131 - 137pp)**
(2014-2016) is presented in appendix (NIMET, 2016). The mean annual rainfall ranged from 78.84mm to 114.24mm, while the mean annual temperature ranged from 21.83°C to 31.45°C (Tmin) and 23.18°C to 32.33°C (Tmax).

Materials
The materials used include a GPS for survey, fungi description forms and illustration guides, brown paper bags for specimen collections, trowel to dig up base of mushrooms, specimen field tags, collection jars, digital camera and permanent marking pens, galvanized iron sheets to tag plot edges and cane basket to carry and dry collected specimens.

Sampling Procedure
A multi-stage sampling procedure was carried in this study. This involved a purposive selection of the three Senatorial Districts, out which two (2) Local Government Areas were randomly selected from each and two (2) plots were randomly selected from each of the Local Government Areas. This resulted into 12 plots of 2 x 4km within which two transects each measuring 0.5 x 2km² was forayed 1km away from each other.

The mushrooms were inventoried for a period of three years between 2014, 2015 and 2016. Mushrooms encountered within each transects were photographed in situ, carefully dug out and fertile sides photographed. The mushrooms were then labelled appropriately, recorded and collected in separate paper bags. Voucheried specimens of collected species were collated and identified with description forms, field guides and identification keys.

Data analysis
Values of the mushroom occurrence over a three-year period of survey were subjected to one-way Analysis of Variance (ANOVA). Where significant difference existed, means were separated using Duncan’s multiple range test (DMRT). Data collected were further subjected to Shannon-Wiener Diversity (H’), Pielou’s Evenness (E) and Margalef’s Species Richness indices.

RESULTS
The result of the mean mushroom occurrence revealed that Kogi East had the highest (29.2), followed by Kogi West (26.1) and Kogi Central having the least (11.9). As shown in the result, there was significant difference (p≤0.05) between Kogi East and Kogi Central; and Kogi Central and Kogi West with respect to occurrence of mushroom species in the study area, while no significant difference (p≥0.05) was observed between Kogi East and Kogi West (Figure 1).

Based on the year of survey, year 2016 had the highest (36.0) occurrence of mushrooms, while year 2015 and 2014 had a low mushroom occurrence of 19.8 and 11.4 respectively. The result of the effect of year of survey on the occurrence of mushroom species indicated no significant difference (p≥0.05) between year 2014 and 2015. On the other hand, there were significant differences (p≤0.05) between years 2014 and 2015; and years 2014 and 2016 with respect to occurrence of mushroom species across the study area (Figure 2). The result of the mean occurrence of mushrooms based on senatorial district and year of observation across the study area revealed Kogi East had the highest occurrence of mushroom followed by Kogi West, while Kogi Central had the lowest occurrence of mushroom across the study area (Figure 3).

The findings of this present study revealed that three hundred and fifty species (350), 313 and 143 species of mushrooms were found in the Kogi East, Kogi West and Kogi Central respectively. This comprises of 3 classes (Agaricomycetes, Basidiomycetes and Sordariomycetes), 10 orders (Agaricales, Auriculariales, Boletales, Cantharellales, Geastrales, Gloeophyllales, Hymenochaetales, Polyporales, Russulales, Xylariales), 151 genera and 32 families. The highest genera were recorded in Kogi East (97) followed by Kogi West (72), while Kogi Central had the lowest number of genera (15). The family was distributed across Kogi East, Kogi West and Kogi Central having 22, 26 and 15 families respectively (Figure 4).

The Shannon Wiener mushroom species diversity index between year 2014 and 2016 across the senatorial districts in the study area is presented in Table 1. The diversity index ranged between 0.31 and 1.02. Kogi East showed a decrease in the diversity index from 2014 to 2016, while there were variations in Kogi Central and Kogi West between 2014 and 2016. In Kogi Central, 2015 had the highest (0.58) species diversity, while 2014 had the lowest (0.31) species diversity. In Kogi West, 2016 had the highest (0.92) species diversity, while similar (0.87) species diversity index was observed between 2014 and 2015. In general, Kogi East had the highest species diversity (1.02), in year 2014, while Kogi central had the lowest species diversity (0.31) in the same year.

The Pielou’s Evenness mushroom species index ranged between 0.14 and 0.34 across the study area from year 2014 to 2016 (Table 2). A progressive decrease in species evenness was observed in Kogi East and Kogi West from 2014 to 2016.

The Margalef’s index of species richness ranged from 2.56 to 8.49 across the study area from year 2014 to 2016 (Table 3). A progressive increase was observed in species evenness in Kogi East and Kogi West between year 2014 and 2016.
DISCUSSION

The occurrence of mushroom species has been reported by several researchers in different parts of the world (Fonseca et al., 2008; Osemwegie & Okhuoya, 2009; Pawlik et al., 2012; Das et al., 2013; Oyetayo 2014; Adejumo et al., 2015). In comparison with previous studies (Hyde et al., 1997; Ayodele et al., 2011; Asemota et al., 2015; Adebiyi & Yakubu, 2016; Adedokun et al., 2016), variations were observed in the checklist of species produced 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.

Boa (2004) 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 hypogeous (underground) types. The present study assessed all mushrooms irrespective of edibility and other factors. It was observed that there were no local names for most inedible mushroom species.

The variations in species assemblage in the different districts observed during this study may also be due to differences in the composition of the vegetation, level of competitiveness amongst biota and the level of human disturbances (Osemwegie & Okhuoya, 2009; Adebiyi & Yakubu, 2016). This observation was affirmed by Cifuentes & Villarruel-Ordaz (2006) who reported that the occurrence, composition and number of species recorded during a study may be a function of the area surveyed coupled with the duration and time of foray. Tilman et al. (1996) and Hooper & Vitousek (1997) 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 (van der Heijden et al., 1998).

The increase in the occurrence of mushroom between year 2014 and 2016 across all the senatorial districts in the study area (Figure 4) and variation in the diversity indices (Table 1 to 3) can be attributed to the rainfall and temperature pattern in the study area (Table Appendix 1). In 2016, the mean rainfall was 114.24mm while the maximum temperature was 23.18°C. The mean rainfall and temperature for 2014 and 2015 were 78.84mm and 32.28°C; and 78.84mm and 32.33°C respectively. The implication of this is that increased amount of rainfall with subsequent decreased environmental temperature led to increased occurrence of the mushrooms in the study area. This gives an indication that there is a relationship between rainfall, temperature and mushroom occurrence. The result of this finding is in collaboration with the assertions of Kauserud et al. (2008); and Jang & Hur, (2014) who reported that climate factors, including temperature, humidity, and precipitation, affected the occurrence of higher fungi.

This study provided a detailed investigation of macrofungi species diversity, evenness and richness over a three-year period in Kogi State, Nigeria. A few research scientists have reported varied macrofungi survey and diversity findings, particularly in Nigeria (Osemwegie & Okhuoya, 2009; Osemwegie et al., 2010; Nwordu et al., 2013). The current study has reported higher number of mushroom species and diversity than those reported previously. Osemwegie & Okhuoya (2009) 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. Osemwegie et al. (2010) 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, Heterobasidionomycetes, Bacidiomycetes, and Homobasidionomycetes), 4 Orders (Auriculariales, Agaricales, Polyporales, Russulales), 10 Families (Auricularaceae, Agaricaeae, Corpinaceae, Formitopsidaceae, Polyporaceae, Russulaceae, Tricholomataceae, Pleurotaceae, Lyophyllaceae, and Russulacea) were reported by Nwordu et al. (2013) in their research investigation on catalogue and identification of some wild edible macro-fungi in Nigeria.

The values of Shannon-Wiener diversity index is usually found to fall between 1.5 and 3.5 and only rarely surpasses 4.5. As the value of the index increases there is more order in the community. A small value would indicate a lack of order in the community (entropy). According to this index, values less than 1 characterize very low diversity, and values in the range of 1 to 2 are characteristics of moderate diversity while the value above 3 signifies stable and high diversity. The diversity index of this study ranged between 0.31 and 1.02 (Table 1). This value is indicated a very low diversity. The Pielou’s evenness index (E), on the other hand expresses how evenly the individuals in a community are distributed among the different species. Evenness index shows whether there is same pattern of distribution of species or it varies. Higher value of evenness index indicates more uniform distribution of species. It is constrained between 0 and 1.0 with 1.0 representing a situation in which all species are equally abundant. The
Pielou’s evenness mushroom species index of this study ranged between 0.14 and 0.34 across the study area from year 2014 to 2016 (Table 2). This connotes less or non-uniform distribution of mushroom species in the study area. The Margalef’s species richness index is a measure for the total number of the species in a community. As indicated from the result of this study, Margalef’s species richness ranged from 2.56 to 8.49 across the study area from year 2014 to 2016 (Table 3).

The diversity indices values as obtained in this present study are comparably low. Richard et al. (2004) posited that fungal diversity is closely related with forest structure and composition. This study collected more mushrooms within transects that had closely populated trees than sparsely populated or mainly grassy areas. This compares with the study of Sysouphanthong et al. (2010) who reported higher macrofungi diversity in forests having higher canopy closure. As such the environment, forest structure and composition have contributed to the low species diversity in the study area which if unchecked may begin extinction process of its macro-fungi composition. The result also showed that regions of the districts closer to the derived rain forests had higher diversity values than areas farther. The low values recorded confirmed the loss of forest cover, thinning out of vegetation in general (plant density) and variety of plants (diversity) in particular attributable to uncontrolled trees felling over exploitation.

CONCLUSION
Kogi state is substantially endowed with a diverse variety of macrofungi whose contribution to the ecosystem cannot be overemphasized. A total of eight hundred and six (806) mushrooms species consisting of 151 genera and 32 families were collected and identified over the three years period (2014 to 2016) of investigation of this study. These were distributed between Kogi East which had the highest occurrence, Kogi West and Kogi Central having the lowest occurrence of mushrooms species. Kogi state macrofungi have been considerably inventoried. This has provided a checklist and emphasized the need to conserve mushrooms diversity in the study area. Since threats to fungal diversity are by and large, the same processes that threaten the diversity of all living things.

Overexploitation of our forest flora results in loss of fungal diversity. This should be curbed to preserve our forests. The low Shannon diversity index values recorded confirmed a decline in mushrooms both in species diversity and richness attributed to loss of forest cover, thinning out of vegetation in general (plant density) and variety of plants (diversity) in particular. As such, it is recommended that the government should look into establishment of forest reserves in the study area so as to preserve the macrofungi community.

Figure 1: Mean occurrence of mushrooms based on senatorial district across the Study Area.
Means in bars having the same superscripts/ letters are not significantly different (p≤0.05)

Figure 3: Mean occurrence of mushrooms based on senatorial district and year of observation across the Study Area.
Figure 2: Mean occurrence of mushrooms based on year of observation across the Study Area

Means in bars having the same superscripts are not significantly different (p≤0.05)

Table 1: Shannon-Weiner Index (H’)

<table>
<thead>
<tr>
<th>Senatorial District</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kogi East</td>
<td>1.02</td>
<td>0.93</td>
<td>0.88</td>
</tr>
<tr>
<td>Kogi Central</td>
<td>0.31</td>
<td>0.58</td>
<td>0.54</td>
</tr>
<tr>
<td>Kogi West</td>
<td>0.87</td>
<td>0.87</td>
<td>0.92</td>
</tr>
</tbody>
</table>

Table 2: Pielou’s Evenness Index (E)

<table>
<thead>
<tr>
<th>Senatorial District</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kogi East</td>
<td>0.34</td>
<td>0.27</td>
<td>0.23</td>
</tr>
<tr>
<td>Kogi Central</td>
<td>0.14</td>
<td>0.24</td>
<td>0.16</td>
</tr>
<tr>
<td>Kogi West</td>
<td>0.33</td>
<td>0.28</td>
<td>0.26</td>
</tr>
</tbody>
</table>

Table 3: Margalef’s Index of Species Richness (M)

<table>
<thead>
<tr>
<th>Senatorial District</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kogi East</td>
<td>4.69</td>
<td>6.50</td>
<td>8.49</td>
</tr>
<tr>
<td>Kogi Central</td>
<td>2.95</td>
<td>2.56</td>
<td>6.20</td>
</tr>
<tr>
<td>Kogi West</td>
<td>3.31</td>
<td>4.94</td>
<td>6.58</td>
</tr>
</tbody>
</table>

REFERENCES
Cifuentes, J.B. & Villarruel-Ordaz, L.J. (2006, July). Macrophungi diversity pattern in a Suburban forest in


## Appendix 1: Mean Rainfall and Temperature Pattern from 2014 to 2016 in Kogi State

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>7.3</td>
<td>21.2</td>
<td>35.3</td>
<td>9.5</td>
<td>19.1</td>
<td>34.6</td>
<td>0.0</td>
<td>35.2</td>
<td>19.7</td>
</tr>
<tr>
<td>Feb</td>
<td>3.5</td>
<td>22.7</td>
<td>36.2</td>
<td>0.0</td>
<td>23.4</td>
<td>31.7</td>
<td>0.0</td>
<td>37.9</td>
<td>22.3</td>
</tr>
<tr>
<td>Mar</td>
<td>41.3</td>
<td>23.4</td>
<td>36.0</td>
<td>85.3</td>
<td>23.4</td>
<td>36.5</td>
<td>113.2</td>
<td>36.7</td>
<td>24.0</td>
</tr>
<tr>
<td>Apr</td>
<td>133.1</td>
<td>23.0</td>
<td>34.1</td>
<td>49.5</td>
<td>23.9</td>
<td>35.3</td>
<td>167.8</td>
<td>33.5</td>
<td>23.5</td>
</tr>
<tr>
<td>May</td>
<td>57.7</td>
<td>22.8</td>
<td>32.0</td>
<td>54.3</td>
<td>23.3</td>
<td>33.6</td>
<td>186.1</td>
<td>32.6</td>
<td>23.0</td>
</tr>
<tr>
<td>Jun</td>
<td>113.9</td>
<td>22.5</td>
<td>30.9</td>
<td>208.6</td>
<td>22.3</td>
<td>30.2</td>
<td>204.2</td>
<td>29.7</td>
<td>21.8</td>
</tr>
<tr>
<td>Jul</td>
<td>120.0</td>
<td>21.8</td>
<td>29.2</td>
<td>85.2</td>
<td>21.7</td>
<td>29.0</td>
<td>208.0</td>
<td>28.4</td>
<td>21.9</td>
</tr>
<tr>
<td>Aug</td>
<td>184.2</td>
<td>21.0</td>
<td>27.2</td>
<td>144.1</td>
<td>21.4</td>
<td>28.5</td>
<td>162.7</td>
<td>27.9</td>
<td>21.6</td>
</tr>
<tr>
<td>Sep</td>
<td>237.7</td>
<td>21.4</td>
<td>29.0</td>
<td>270.1</td>
<td>21.6</td>
<td>29.0</td>
<td>259.9</td>
<td>29.8</td>
<td>21.8</td>
</tr>
<tr>
<td>Oct</td>
<td>164.8</td>
<td>21.6</td>
<td>30.7</td>
<td>39.5</td>
<td>22.1</td>
<td>31.1</td>
<td>68.0</td>
<td>31.5</td>
<td>21.9</td>
</tr>
<tr>
<td>Nov</td>
<td>9.0</td>
<td>22.3</td>
<td>32.3</td>
<td>0.0</td>
<td>22.2</td>
<td>34.5</td>
<td>1.0</td>
<td>35.1</td>
<td>22.5</td>
</tr>
<tr>
<td>Dec</td>
<td>0.0</td>
<td>20.6</td>
<td>34.4</td>
<td>0.0</td>
<td>17.6</td>
<td>34.0</td>
<td>0.0</td>
<td>19.1</td>
<td>34.2</td>
</tr>
<tr>
<td>Total</td>
<td>1072.50</td>
<td>264.30</td>
<td>387.30</td>
<td>946.10</td>
<td>262.00</td>
<td>388.00</td>
<td>1370.90</td>
<td>377.40</td>
<td>278.20</td>
</tr>
<tr>
<td>Mean</td>
<td>89.38</td>
<td>22.03</td>
<td>32.28</td>
<td>78.84</td>
<td>21.83</td>
<td>32.33</td>
<td>114.24</td>
<td>31.45</td>
<td>23.18</td>
</tr>
<tr>
<td>STD.DEV</td>
<td>80.91</td>
<td>0.88</td>
<td>2.96</td>
<td>87.50</td>
<td>1.84</td>
<td>2.76</td>
<td>96.58</td>
<td>5.07</td>
<td>3.63</td>
</tr>
<tr>
<td>STD.ERROR</td>
<td>23.36</td>
<td>0.25</td>
<td>0.86</td>
<td>25.26</td>
<td>0.53</td>
<td>0.80</td>
<td>27.88</td>
<td>1.46</td>
<td>1.05</td>
</tr>
</tbody>
</table>

*Source: Nigeria Meteorological Agency (NIMET) 2016.*