

Diversity of wild macrofungi found in Gwandu emirate, Kebbi State, Northwestern Nigeria

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Abstract

A survey to determine the diversity of wild macrofungi (mushroom) in Gwandu Emirate area of Kebbi State was carried out. 10 mushroom species from 4 families and 7 genera were identified. The collected mushrooms were found to grow in variety of substrate with different growth habit. Two chlorophyllum sp were found, namely: *Chlorophyllum rachodes* and *Chlorophyllum brunneum*; one specie each of *Coprinus*, *Lycoperdon*, *Bovista* sp, *Agaricus compestris*, *Podaxis* sp, *Termitomyces* sp, *Volvariella* sp and *Auricularia* sp. *Coprinus* sp was found to have the highest frequency and density of 66. 67% and 10.26% respectively. *Auricularia* sp had the lowest frequency of 5.55%; while *Termitomyces* sp recorded the lowest density of 1.21%. This report is the first to be documented for macrofungi diversity in Gwandu Emirate, Kebbi State, Northwestern Nigeria.

Keywords: mushroom, identification, diversity, and gwandu emirate

1. Introduction

Mushrooms are macrofungi with distinct fruiting bodies that can grow on the ground or underground. The fruiting bodies of macrofungi are large enough to be seen with the naked eye and can be picked up by hand (Onchonga *et al.*, 2013) ^[21]. Oyetayo (2011) ^[26], defined mushrooms as fleshy, conspicuous fungi that have been used as food for millennia and are often associated with powers and royalty due to their pleasant taste and flavour. It generally requires an organic substrate (medium) rich in nutrients, especially nitrogen, phosphorus, and potassium (Rogers and Davis, 1972) ^[30]. Lignin and cellulose, which provide nutrition to mushroom mycelium, must also be present in the material (Kimenju *et al.*, 2009) ^[13]. Wild mushrooms appear to have been consumed by men since ancient times, but they were most likely considered a wilderness food that has now become very popular in modern diets due to their nutritional value (Bano, 1976). Pandey (2008) ^[28], suggested that fungus, as well as fleshy species of other fungi, are classified as "Mushrooms," which can either be edible, inedible, poisonous, or non-poisonous.

Mushrooms are diverse as they grow in a wide range of habitats from the Artics to the tropics. Some find preference in a specific area and substrate, while others grow in a geographically dispersed area (Dwiyedi *et al.*, 2017) ^[9]. The number of Fungi present on earth cannot be overemphasized as different works of literature give a different report of fungi species that exist globally. Estimating the number and diversity of fungi globally has always been a topic of debate and recently at the end of the 21st century; this started to gain interest in the scientific literature (Crous *et al.*, 2006) ^[8]. According to Osemwegie (2014) ^[23], the estimation of fungi species diversity in Nigeria is not yet established and no fungal biodiversity

database or inventory of mushrooms currently exists despite a few pace-setting research on mushroom diversity.

Nonetheless, some researchers gave reports of studies that were conducted in certain regions in Nigeria. They include the work of Osemwegie *et al.* (2006) ^[25] and Osemwegie and Okhuoya (2009) ^[24] in Edo State; Ayodele *et al.* (2011) ^[6] in Igala land, Kogi State; Akpaja *et al.* (2014) ^[4], South-South; Kelly *et al.* (2015) ^[11] in Abuja; Adejumo *et al.* (2015) ^[2] in the South-West; Okigbo and Nwatu (2015) ^[20] in Anambra State; Adebisi and Yakubu (2016) ^[1]; Markson *et al.* (2017) ^[17] in cross River State, South-south Nigeria; Adeniyi *et al.* (2018) ^[3]; Buba *et al.* (2018) ^[7] in Bauchi State, North-East; Mani *et al.* (2019) ^[16] in Zaria, Kaduna State; Keta *et al.* (2019) ^[12] in Kebbi State Northwest, and recently the work Apollon *et al.* (2021) ^[5] in Kogi State, North-Central Nigeria. Despite the different studies conducted and publications by various authors on the diversity of wild macrofungi, there are still scanty data on the diversity of wild macrofungi in Nigeria and particularly in Kebbi State. In this work, therefore, a survey of macrofungi has been conducted in Gwandu Emirate, Kebbi State.

2. Materials and Methods

Collection of the wild macrofungi

A detailed survey was conducted in Gwandu Emirate of Kebbi State, Northwestern Nigeria to ascertain the morphological variability of the mushrooms found in the study area. Mushroom samples seen growing on different substrates were examined, photographed, collected and immediately taken to the laboratory for detailed examination (Musa *et al.*, 2018) ^[18].

Morphological observation and characterization

Macroscopic and microscopic identification

For the macroscopic identification, characteristics features such as type of soil, the diameter of the cap, shape and colour

of cap, surface characterization, cap margin, scale, gill colour, gill attachment, gill spacing, stipe length, width, colour, shape, annuls (position), and volva were noted. Pileus and stipe were bruised to record any colour changes; spore prints were considered and noted (Musa *et al.*, 2019; Tanjim *et al.*, 2019a) [19,31]; while microscopic identification was done by preparing a temporary glass slide from a small tissue of the gills with the aid of a sharp surgical blade. The tissue was stained with cotton blue on a glass slide and covered with cover slips. Furthermore, the spore size was measured using a microscope with a magnification of 40x (Joty *et al.*, 2020) [10]. Colored Mushroom Field Guide Book and various relevant monographs and other publications were used for species identification (Keta *et al.*, 2019) [12].

Spore print

The stipe of the fruit body was cut and the cap was placed on a piece of white paper. For white-spored mushrooms, a black paper was used and for other colour-spored mushrooms. The white paper was used with the gills facing downwards. To keep tissues from drying out, a drop of water was placed on the cap. The material was then placed in a container and incubated for a period ranging from 2 to 12 hours, depending on the nature of the fruit body and finally, the information on the spore prints was now recorded (Kuo, 2006) [15].

Processing and preservation of mushrooms

Mushrooms collected were preserved in two ways, liquid and dry preservation. Liquid preservation was done by cleaning the mushroom with blotting paper and keeping them in 95% ethanol in a sterile container while the dry preservation was done by oven drying at 60°C with constant monitoring and switching off and on the oven. The mushrooms were later stored in cellulose paper bags and closed properly to prevent moisture and insects (Tanjim *et al.*, 2019b) [32].

Frequency, density and diversity analysis

The frequency and density of various species were calculated using the following formula (Zoberi, 1973) [36]:

$$\text{Frequency (\%)} = \frac{\text{Number of sites in which the sp. is present}}{\text{Total number of sites}} \times 100$$

$$\text{Density} = \frac{\text{Total no. of individuals of a particular species}}{\text{Total number of species}} \times 100$$

3. Results

The different mushroom species collected and identified are presented base on the specie name, common name, and family name, macroscopic and microscopic characteristics. The frequencies and densities of the different species of mushroom collected are also presented.

The followings are the description of the biodiversity, distribution, and morphological characterization of the identified mushrooms.

a) *Coprinus* sp

Family name: Agaricaceae

Common name: Shaggy mane, Lawyer's wig

Division: Basidiomycota

Macroscopic characteristic

Pileus

The average fructification size of the pileus (cap) was 5.2cm. The Colour was chocolate to dark brown; broadly conic with an umbonate shape at the top and the margin of the cap is round and lobed or wavy. The surface character and zonation of the cap were fresh, wet, fleshy and soft body fructification. Spore bearing surface under the cap was the gills (lamellae), the gills are regular in shape, spaced, adnate (gills are broadly attached to the stipe) and chocolate in colour.

Stipe

Stipe (Stalk) was present, the shape was equal, cylindrical, centralized, off-white in colour, and the surface characteristic was moist. The stalk posse's distinctive ring (annulus) at the midpoint, no scale and no volva was seen on the lower part of the stipe. The length and width of the stalk were an average of 6.3cm x 1.4cm respectively.

Spore morphology

The colour of the spore was brown, single membrane, thick-walled and smooth. The shape was oval to ellipsoidal and the size of the spore was an average of 5.1µm x 3.9 µm length and width respectively.

Ecology of *Coprinus* sp

Coprinus sp was found growing on loamy soil, cluster and abundant. When counted, they were 102 in number. The frequency of occurrence of its presence was 66.67% and the density was 10.26%.



Fig 1: (A) The fruiting body of *Coprinus* sp, (B) Gills of *Coprinus* sp, (C) Spore *Coprinus* sp (40 x)

b) *Lycoperdon* sp**Family name:** Agaricaceae**Common name:** Pear-shaped**Division:** Basidiomycota**Macroscopic characteristic**

The average fructification size of the pileus was 3.2cm. The colour was cream colour and the ball-shaped fruiting body. The Pileus (cap) was white to cream in colour with a ball-shaped fruiting body. The margin of the cap was round and smooth. Surface character and zonation, the surface was initially covered in warts, which are easily detached. The surface was wet with a spine. The spore-bearing surface was not seen.

Stipe

The stalk is extremely short and scouts. Scale, annulus and volva were all absent.

Spore morphology

The spore colour was golden yellow, smooth, single membrane and thin-walled. The shape of the spore was globose to subglobose and the size of the spore was an average of 5.9µm x 4.0µm length and width respectively.

Ecology of *Lycoperdon* sp

Lycoperdon sp was found growing on loamy soil, scattered and abundant. When counted, they were 39 in number. The frequency of occurrence of its presence was 50.00% and the density was 3.92%.



Fig 2: (A) The fruiting body of *Lycoperdon* sp, (B) Gills of *Lycoperdon* sp, (C) Spore of *Lycoperdon* sp (40x)

c) *Bovista colorata***Family name:** Agaricaceae**Common name:** Golden puffball**Division:** Basidiomycota**Macroscopic characteristic****Pileus**

The average size of the fruiting body was 3.9cm. The Pileus (cap) was golden yellow. The ball shape was round in shape. The edge of the cap was smooth and round. Gills (lamellae) were absent. The surface character and zonation of the cap were smooth, soft and wet nature.

Stipe

He stalks on the mushroom was extremely short and scouts.

Scale, annulus and volva were not seen.

Spore Morphology

The spore colour was white. Single membrane; thin-walled, smooth and oval to spherical. The length and width of the spore were an average of 6.8µm x 5.8µm respectively.

Ecology of *Bovista colorata*

Bovista sp was found growing on sandy loamy soil, Scattered and scarce. When this mushroom was counted, it gave a total number of 22 individuals. The frequency of occurrence of its presence was 44.44% and the density was 2.21%.



Fig 3: (A) Fruiting body of *Bovista colorata*, (B) Gills of *Bovista colorata*, (C) Spore of *Bovista colorata* (40x)

d) *Chlorophyllum rachodes***Family name:** Agaricaceae**Common name:** Parasol Mushroom**Division:** Basidiomycota**Macroscopic characteristic****Pileus**

The average fructification size of the pileus (cap) was 10cm. The Colour was white and broadly convex in shape, and the margin of the cap was regular and smooth. The surface character and zonation of the cap were dry, fleshy and soft body fructification with brown scales on the body. Spore bearing surface under the cap was the gills (lamellae), the gills are regular in shape, crowded, free (gills do not attach to the stipe) and white.

Stipe

Stipe (Stalk) was present, the shape was equal, centralized,

enlarged at the base white in colour and the surface characteristic was dry. The stalk posse's ring (annulus) at the midpoint, no scale and no volva was seen on the lower part of the stipe. The length and width of the stalk were an average of 4.7cm x 4.3cm, respectively.

Spore morphology

The colour of the spore was white double membrane, thick-walled and smooth. The shape was oval to ellipsoid and the size of the spore was an average of 7.6µm x 6.5µm length and width respectively.

Ecology of *Chlorophyllum rachodes*

Chlorophyllum rachodes were found growing on loamy soil, Scattered and scarce. When counted, they were 17 in number. The frequency of occurrence of its presence was 27.78% and the density was 1.71%.

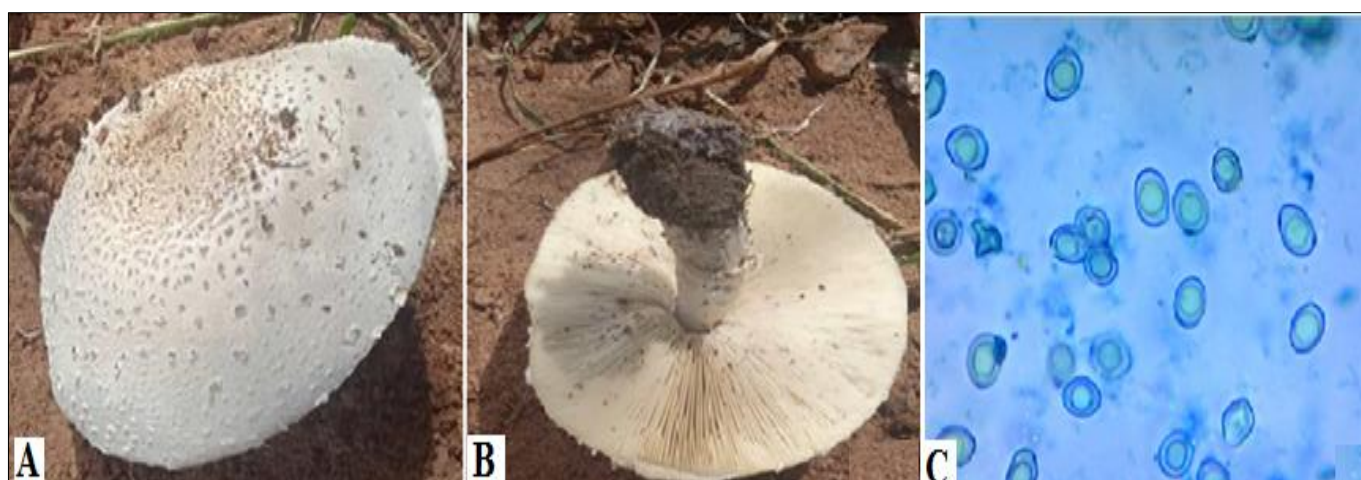


Fig 4: (A) Fruiting body of *Chlorophyllum rachodes*, (B) Gills of *Chlorophyllum rachodes*, (C) Spore of *Chlorophyllum rachodes* (40x)

e) *Chlorophyllum brunneum***Family name:** Agaricaceae**Common name:** True mushroom**Division:** Basidiomycota**Macroscopic characteristic****Pileus**

The average fructification size of the pileus (cap) was 8.9cm. Cap colour was white, smooth at first, covered with brown scales on a white background, which breaks up as it expands. The cap was wine in colour or brown in the middle. The shape was convex to flat. The margin of the cap was regular and smooth. The surface character and zonation of the cap were dry and fleshy and the body was soft body fructification. Spore bearing surface under the cap was the gills (lamellae), the gills are regular in shape, crowded, free and white to cream in colour, stains pinkish which later turns reddish brown.

Stipe

Stipe (Stalk) was present; the shape was equal slightly bulbous

at the base, centralized, and pale white colour. The surface characteristic was dry and smooth. The stalk posse a distinctive movable double-lipped ring (annulus), no scale or snakeskin pattern; no volva was seen on the lower part of the stipe. The length and width of the stalk were an average of 6.2cm x 2.7cm, respectively.

Spore morphology

The colour of the spore was white, double membrane, thick-walled and smooth. The shape was ellipsoidal with tiny pores and the size of the spore was an average of 8.4µm x 5.7µm length and width respectively.

Ecology of *Chlorophyllum brunneum*

Chlorophyllum brunneum was found growing on sandy loamy soil, Scattered and scarce. When counted, they were 17 in number. The frequency of occurrence of its presence was 27.78% and the density was 1.71%.

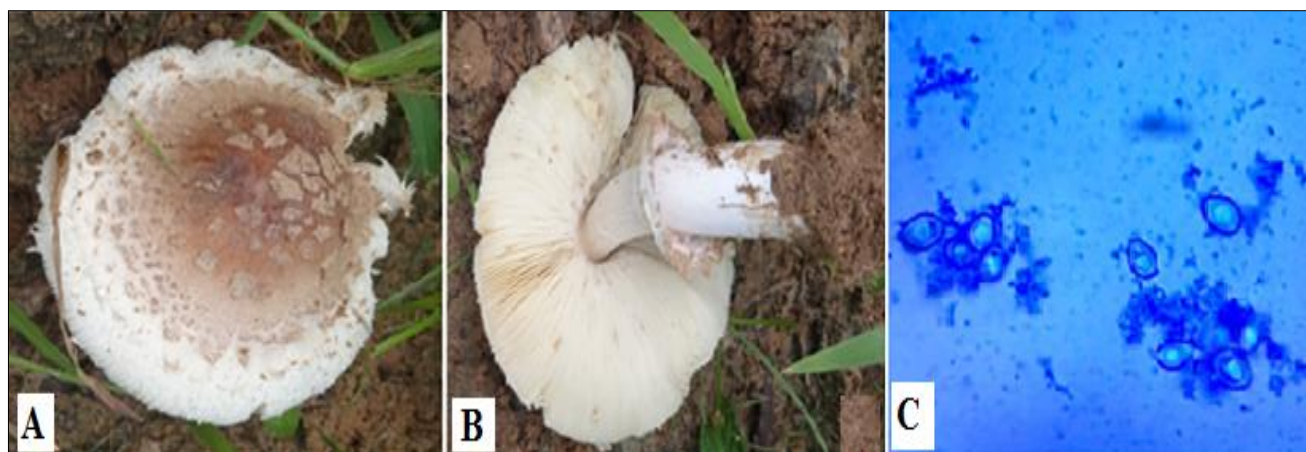


Fig 5: (A) Fruiting body of *Chlorophyllum brunneum*, (B) Gills of *Chlorophyllum brunneum* (C) Spore of *Chlorophyllum brunneum* (40x)

f) *Agaricus campestris*

Family name: Agaricaceae

Common name: Field mushroom

Division: Basidiomycota

Macroscopic characteristic

Pileus

The average fructification size of the pileus (cap) was 8.3cm. The Colour was white and the shape was convex and flattened out with maturity. The margin of the cap is regular and smooth. The surface character and zonation of the cap were dry, fleshy and soft body fructification. Spore bearing surface under the cap was the gills (lamellae), the gills were regular in shape, crowded, and free and the colour was initially pink then pinkish brown and finally dark brown.

Stipe

Stipe (Stalk) was present; the shape was equaled (cylindrical) with no bulbous at the bottom, white in colour, becomes darker

t maturity and the surface characteristic of the stalk was smooth, dry and tough. The stalk possesses a ring that usually goes away, no scale and no volva were seen on the lower part of the stipe. The length and width of the stalk were an average of 6.1cm x 4.5cm respectively.

Spore morphology

The colour of the spore was brown, double membrane, thick-walled and smooth. The shape was finely ellipsoidal to globose with an average size of 5.8 μm x 5.9 μm length and width respectively.

Ecology of *Agaricus campestris*

Agaricus campestris was found growing on loamy soil, Solitary and scarce. A total of 25 individual of *Agaricus campestris* was found during the collection. The Frequency of occurrence was 44.44% and the density was 2.52%.



Fig 6: (A) The fruiting body of *Agaricus campestris*, (B) Gills of *Agaricus campestris*, (C) Spore of *Agaricus campestris* (40x)

g) *Podaxis* sp

Family name: Agaricaceae

Common name: Desert shaggy mane

Division: Basidiomycota

Macroscopic characteristic

Pileus

The average fructification size of the peridium was 4.2cm. The

Colour was whitish silver to golden yellow; Fruiting bodies have the shape of an unopened *Cosprinus cosmatus*, campanulate (Bell-shaped) shape. The margin of the cap is round and smooth. The surface character and zonation of the cap were dry, and shining, with shaggy scales and brown patches. Spore bearing surface was inside the fruiting body. At maturity, it splits and a brown-black spore mass is dispersed by the wind.

Stipe

Stipe (Stalk) was present, the shape was straight, but becomes bulbous at the base, centralized, pale brown, and surface characteristic was dry, smooth and golden yellow and woody. The stalk was not annulated, the scale was present and no volva was seen on the lower part of the stipe. The length and width of the stalk were an average of 9.0cm x 4.8cm, respectively.

Spore morphology

The colour of the spore was brownish yellow, double

membrane, thick-walled and smooth. The shape was oval to sub-global and the size of the spore was an average of 8.6 μ m x 5.0 μ m length and width respectively.

Ecology of *Podaxis* sp

Podaxis sp was found growing on Clay loamy, Scattered and scarce. When counted, they were 19 individuals. The frequency of occurrence of its presence was 27.78% and the density was 1.91%.



Fig 7: (A) The fruiting body of *Podaxis* sp, (B) Gills of *Podaxis* sp, (C) Spore of *Podaxis* sp (40x)

h) *Termitomyces* sp

Family name: *Lyophyllaceae*

Common name: Termit nest mushroom

Division: Basidiomycota

Macroscopic characteristic**Pileus**

The average fructification size of the pileus (cap) was 4.2cm; cream was white to light grey with a creamy dark colouration in the middle. The margin was smooth, unequal and irregular in shape. At maturity, the margin of the fruiting body splits, looking like a flower petal. Spore bearing surface under the cap was the gills (lamellae), the gills are regular in shape, crowded narrowly attached to the stipe (adenexed). The surface character and zonation of the cap were dry with soft body fructification.

Stipe

Stipe (Stalk) was present, long and unequal in shape (tapering

at the bottom), centralized, white and the surface characteristic was dry. The stipe also narrows down the base (tapered). No scale and volva were seen on the lower part of the stipe. The length and width of the stalk are an average of 11.3cm x 2.4cm, respectively.

Spore morphology

Spore colour was white to cream, ellipsoidal to ovoid, hyaline (smooth and transparent), double membrane, thin-walled with an average length and width of 7.3 μ m x 5.3 μ m respectively.

Ecology of *Termitomyces* sp

Termitomyces sp was found growing on sandy loamy soil, Scattered and scarce. When counted, they were 12 in number. The frequency of occurrence of its presence was 33.33 % and the density was 1.21%.



Fig 8: (A) The fruiting body of *Termitomyces* sp, (B) Gills of *Termitomyces* sp, (C) Spore of *Termitomyces* sp (40x)

i) *Volvariella* sp**Family name:** Pluteaceae**Common name:** Straw mushroom**Division:** Basidiomycota**Macroscopic characteristic****Pileus**

The average fructification size of the pileus (cap) was 6.1cm. The Colour was white at the surface but pink toward the margin, flat in shape and the margin of the cap was regular and smooth. The surface character and zonation of the cap were fresh, silky, wet, fleshy and soft body fructification. Spore bearing surface under the cap was the gills (lamellae), the gills are regular in shape, spaced, emarginated (Gills are notched abruptly before attaching to the stipe.) and pink in colour.

Stipe

Stipe (Stalk) was present, the shape was equal and bulbous at

the base of the stipe, centralized, white and the surface characteristic was dry. No annulus on the stock, no scale and no volva were seen on the lower part of the stipe. The length and width of the stalk were an average of 5.7cm x 3.3cm, respectively.

Spore morphology

The spore colour was light brown, double membrane, thick-walled and smooth. The shape was ellipsoidal and the size of the spore was an average of 8.3µm x 5.9µm length and width respectively.

Ecology of *Volvariella* sp

Volvariella sp was found growing on sandy loamy soil, Scattered and scarce. When counted, they were 15 in number. The frequency of occurrence of its presence was 33.33% and the density was 1.59%.



Fig 9: (A) Fruiting body *Volvariella* sp, (B) Gills of *Volvariella* sp, (C) Spore of *Volvariella* sp (40x)

j) *Auricularia* sp**Family name:** Auriculariaceae**Common name:** Jelly ear mushroom**Division:** Basidiomycota**Macroscopic characteristic**

The average fructification size of the pileus (cap) was 6.4cm. Basidiocarp's surface frequently has a strongly convex dorsal, densely pileus. The outer surface was light grey while the inner part was reddish chocolate to dark brown, the shape of the fruiting body was wrinkled in shape and the margin of the cap was wavy, like the ear of a cat, irregular typical year-shaped to irregularly disc-shaped and sometimes fused. The surface character and zonation of the cap were dry, rubbery and gelatinous. The spore-bearing surface was the upper, fertile part of the mushroom, which was reddish brown.

Stipe

Stipe (Stalk) was absent and less stem directly joined to woods.

Spore morphology

The colour of the spore was chocolate brown, a single membrane, thick-walled and smooth. The shape was kidney-like and the size of the spore was an average of 7.0µm x 5.2µm length and width respectively.

Ecology of *Auricularia* sp

Auricularia sp was found growing on dead wood, Scattered and scarce. When counted, were 27 in number. The frequency of occurrence of its presence was 5.55% and the density was 2.72%.



Fig 10: (A) The fruiting body of *Auricularia* sp, (B) Gills of *Auricularia* sp, (C) Spore of *Auricularia* sp (40x)

4. Discussion

Coprinus sp were found growing on loamy soil with a frequency of 66.67% and density of 10.26%, with a cluster and abundant growth habit. These genera were reported by Rahaman *et al.* (2016) ^[29] in Bangladesh. *Lycoperdon* sp was found growing on Loamy soil with a frequency of 50.00% and density of 3.92%, with a scattered and abundant growth habit. Species of this kind were reported by Panda *et al.* (2019) ^[27] in India. *Bovista* sp was found growing on sandy loamy soil with a frequency of 44.44% and density of 2.21%, with a scattered and scarce growth habit. *Bovista* sp was reported by Buba *et al.* (2018) ^[7] in Bauchi State. Two species of *Chlorophyllum rachodes* and *Chlorophyllum brunneum* were found growing on loamy soil and Sandy soil, with the same frequencies and densities of 27.78% and 1.71%; respectively. Their growth habit for the two species were scattered and scarce. The species of this genera were also reported by Ullah *et al.* (2022) ^[33] in Western Himalayas in India.

Agaricus compestris was found growing on loamy soil with a frequency of 44.44% and density was 2.52%, with solitary and scarce growth habit. *Agaricus compestris* was also reported by Kinge *et al.* (2020) ^[14] in South Africa.

Podaxis sp was found growing on clay loamy with a frequency of 27.78% and density of 1.91% with a scattered and scarce growth habit. *Podaxis* sp was reported by Venkatesan and Arun (2019) ^[34] in Cauvery delta region, in India

Termitomyces sp was found growing on sandy loamy soil with a frequency of 33.33% and density of 1.21% with a scattered and scarce growth habit. Species of this genera were reported by Ye *et al.* (2019) ^[35] in China.

Volvariella sp was found growing on sandy loamy soil with a frequency of 33.33% and density was 1.59% and with a scattered and scarce growth habit. *Volvariella* sp was reported by Rahaman *et al.* (2016) ^[29] in Bangladesh. And *Auricularia* sp was found growing on dead wood with a frequency of 5.55% and density of 2.72% and a scattered and scarce growth habit. *Auricularia* sp was reported by Onyango *et al.* (2016) ^[22] in Kenya.

Several species of wild mushrooms were reported in different parts; Keta *et al.* (2019) ^[12] in Kebbi State, Northwestern Nigeria, Adejumo *et al.* (2015) ^[2] in Akoko area, Ondo State, Nigeria. However, Joty *et al.* (2020) ^[10] reported similar specie in Bangladesh. When compared to earlier research on diversity, variations were observed. The variation seen could be a result of variations in the ecosystems under study, which may differ due to variations in the biota's composition, level of competition and degree of human disturbances. This is in agreement with the work of Mani *et al.* (2019) ^[16] who claimed that variations in mushrooms in a biota may be caused by dense vegetation and human waste, which may increase the nutrients for fungi to grow saprophytically.

The highest frequency of the mushroom collected was observed in *Coprinus* sp with 66.67%, while *Auricularia* sp had the lowest frequency of 5.55%. The highest density was observed in *Coprinus* sp with 10.26 % and the lowest was 1.21% in *Termitomyces* sp.

5. Conclusion

In the course of the study, 10 species of mushrooms from 7 genera and 4 families were collected and identified. The most abundant family was that of the Agaricaceae. The identified species include *Coprinus* sp, *Lycoperdon* sp, *Bovista* sp, *Chlorophyllum rachodes*, *Chlorophyllum brunneum*, *Agaricus compestris*, *Podaxis* sp, *Termitomyces* sp, *Volvariella* sp and *Auricularia* sp. The highest frequency was observed in *Coprinus* sp at 66.67% while the lowest was *Auricularia* sp at 5.55%. The specie with the highest density was *Coprinus* sp at 10.26% and the lowest was *Volvariella* sp at 1.21%. The findings in this study shows that there is a wide diversity of wild macrofungi in Gwandu Emirate of Kebbi State and has the potential to create a global recognition for Kebbi State and Nigeria. This work is expected to create more awareness on the abundant mushroom resources in the study area, encourage its consumption, and also serve as baseline data for future research on mushroom diversity in Kebbi State in particular and Nigeria at large.

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