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Diversity of species of the genus Ganoderma (Ganodermataceae, Basidiomycota) from the Haut Sassandra region (Central-West; Côte d'Ivoire)

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Abstract

The objective of this study is to identify and promote the higher fungi of the Haut Sassandra region. Numerous surveys were conducted from April to July 2022 in the various vegetation formations of the four departments of the Haut Sassandra region (Vavoua, Daloa, Issia, and Zoukougbeu). Specimen collection began very early in the morning and ended in the late afternoon. It consisted first of locating the fungi, carefully noting the characteristics visible to the naked eye and the substrate on which they grow. Photographs were then taken before harvesting the specimens.

Once collected, the fungal specimens were taken to the laboratory for observation. Macroscopic and microscopic studies were performed on the different samples. Using various identification keys, five species of the genus Ganoderma were identified: *Ganoderma lucidum, Ganoderma praelongum, Ganoderma colossus, Ganoderma tuberculosum* And *Ganoderma boninense.*

Keywords: Ivory Coast; Haut Sassandra; Higher fungi; Ganoderma; Identification.

1. Introduction

Located in western Côte d'Ivoire, the Haut Sassandra region is a forested area. It abounds with a diversity of fungal species that are at risk of disappearing due to population growth, deforestation, and the effects of climate change. Forest fungi contribute to the maintenance, development, balance, and well-being of many households in rural areas. These forest products are rich in fiber, protein, vitamins, and trace elements, and low in lipids (Reis *et al.*, 2012). Several higher fungi have been identified in Europe and Asia (China, Japan, etc.). Furthermore, in some regions of tropical Africa, they play a role in the lean season and in traditional medicine (Boa, 2006; Tiécoura). *et al.,* 2016), this is the case of *Lentinus edodes, Grifolia frondosa, Auricularia auricula-judae, Agaricus bisporus* and *Ganoderma lucidum* (Chene *et al.,* 2023).

Fungi of the genus Ganoderma are wood-decaying and pathogenic species of plants in tropical and temperate regions. They are responsible for certain plant diseases such as stem rot and white rot. They have long been used in traditional Asian medicine due to their therapeutic properties (Luangharn *et al* ., 2012).

No studies have been conducted on the genus Ganoderma in the Haut Sassandra region (Central-West, Ivory Coast). The work of (N' Douba *et al.,* 2021) made it possible to examine the edible wild mushrooms of the region (Daloa).

The overall objective of this study is to identify and promote the higher fungi of the Haut Sassandra region.

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2. Materials and methods

2.1. Study site

The study was carried out in the Haut Sassandra region (Central-West, Ivory Coast).

This region is located between latitude 6°12' and 7°49' North and longitude 5°55' and 7°10' West (Yao *et al.,* 2020). It is bordered to the North by the Worodougou and Béré regions, to the South by the Nawa and Goh regions, to the West by the Guémon region, and to the East by the Marahoué region. It comprises four (4) major departments (Daloa, Issia, Vavoua, and Zoukougbeu) and more than 23 sub-prefectures.

This area features dense forest vegetation that is declining due to extensive and shifting cultivation practices, coupled with uncontrolled exploitation of forest species (Sangaré *et al.,* 2006). It is characterized by a humid tropical climate, with two generally unstable rainy seasons due to the effects of climate change and two dry seasons (Koné *et al.,* 2019). Average annual rainfall is between 1100 and 1230 mm with an average annual temperature of 26.7 °C (Kouassi *et al.*, 2019).

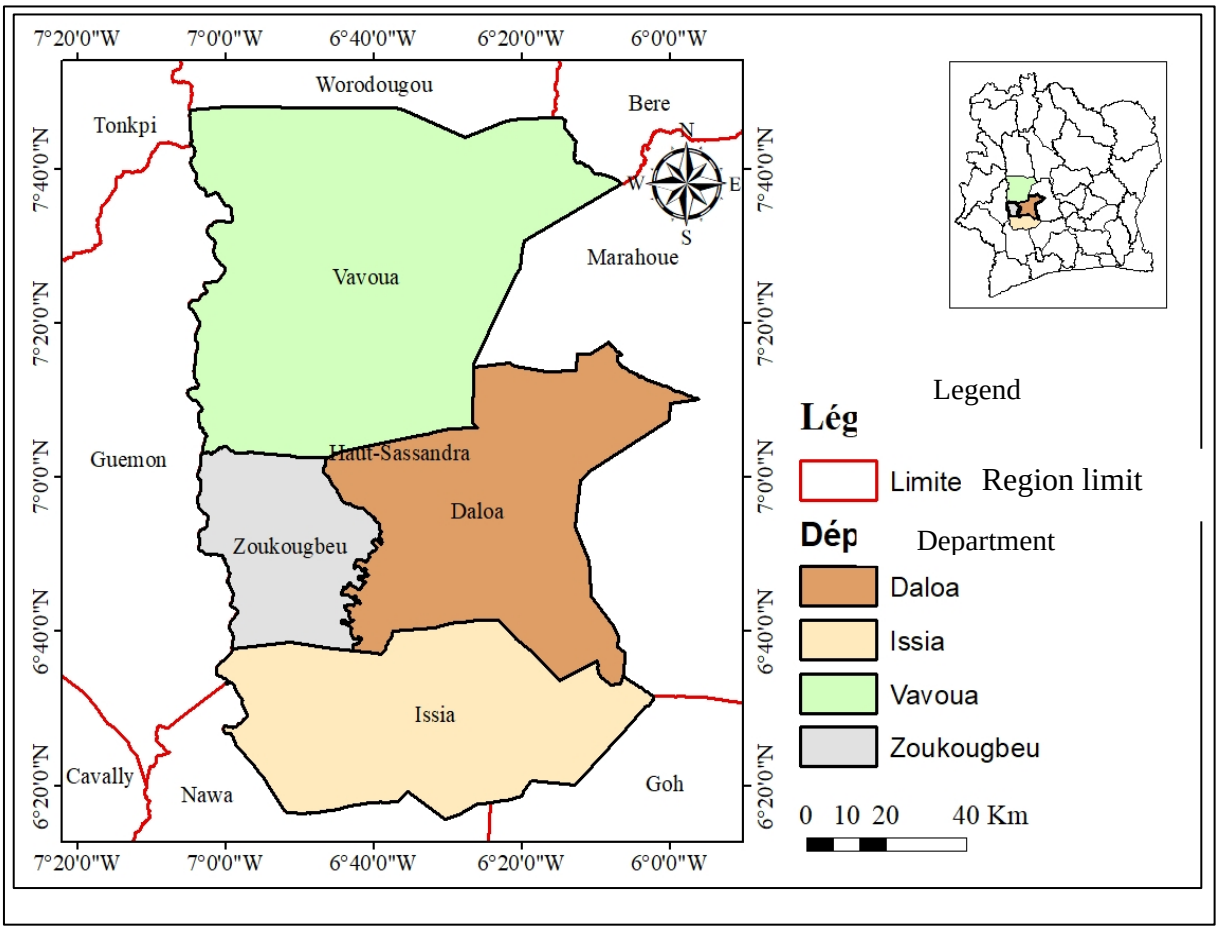

Figure 1 Location of the study area: (A) Haut Sassandra region (B) Map of Ivory Coast

3. Methodology

3.1. The biological material consists of all the higher fungi identified during the various surveys.

Several mycological outings were carried out during the rainy season from April to July 2022. The surveys consisted of observing and collecting fungal species at the different sites. The collection of higher fungi was carried out randomly in different strata or using the so-called opportunistic sampling described by (Mossebo *et al.,* 2002) and adapted by (Metsebing, 2020) . The first step involved identifying the fruiting body. Next, various details about the fruiting body's

collection site were recorded in a notebook, including habitat, ecology, substrate, etc. Finally, the fruiting body was photographed, and its geographic coordinates were recorded using a LUMIX 20X fullHD digital camera.

Macroscopic observation was carried out directly at the mushroom harvesting site. It focused on fresh fruiting bodies and allowed for the description of organs such as: The cap, the flesh, The stipe, ring, volva, and substrate on which the mushroom is harvested were all described. The odor of the species was also noted. Macroscopic description requires meticulous attention for accurate characterization.

Microscopic study involves observing the reproductive organs: spores, basidia, and cystidia. This observation is based on size, shape, color, ornamentation, appearance, and the presence or absence of germinal pores in the spores.

Identification was made possible thanks to identification keys and the work of Kesel *et al.* (2002), Verbeken and Walleyn (2010), Eyi-Ndong *et al.* (2011), Heim (2000) and Beeli (1935).

4. Results

4.1. List of recorded fungal species

4.1.1. Ganoderma lucidum (Curtis : Fr.) P. Karst. var. lucidum

The basidiocarp (5-15 cm) is fan-shaped, off-center, stalked, sessile, and dimidiate. The cap surface is shiny and smooth. The color is dark reddish-brown, the margin is thin and yellow, and furrowed with several thick layers. The cuticle cells are thin to thick, with club-shaped terminals. The cap has a spongy to firm, fibrous appearance. The tubes are hard and woody when dried. The stipe is central or lateral, shiny, with a distinct cuticle. The margin is entirely white when fresh, round, soft, and smooth when young, slippery to the touch. At maturity, the margin becomes hard and brittle. The pores on the surface are cream-colored, turning ochre. There are 4-6 pores per mm^2. The stipe is lateral but sometimes absent, vertical, slender, irregular, and the same color as the cap. The flesh is hard and reddish-brown. The basidiospores are 7-8 x 5.5-6 µm, ovoid, truncate, guttulate, light brown to golden brown.

Ecology and habitat: The species is lignicolous, it is harvested from the stumps of hardwoods and tree trunks in forests and plantations.

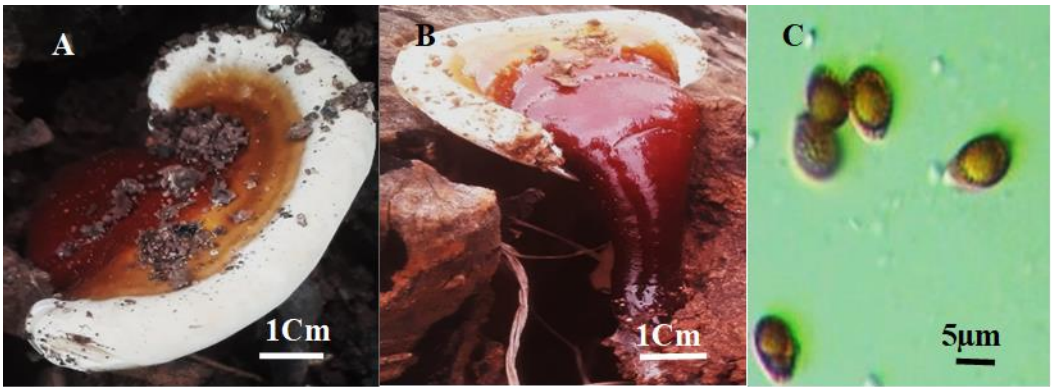

Figure 1 *Ganoderma lucidum*; A et B: Fruiting body; C: Spores

4.1.2. Ganoderma colossus (Fr.) CF Baker

The mushroom has a massive fruiting body.

The cap (25-35 cm in diameter) is large, sessile, generally fleshier than *G. lucidum,* yellowish-white to the margin, often speckled with brownish bands, with a fissured, sometimes lobed surface. The angular pores are creamy white. A longitudinal section of the cap reveals flesh of varying colors (whitish, yellowish), becoming creamy after picking. The flesh has a pleasant odor and a slightly bitter taste.

The basidiospores (3-3.5 x 3.33 µm), ovoid, truncate, guttulate, light brown to golden brown.

The species is harvested from hardwood stumps and tree trunks in forests and plantations.

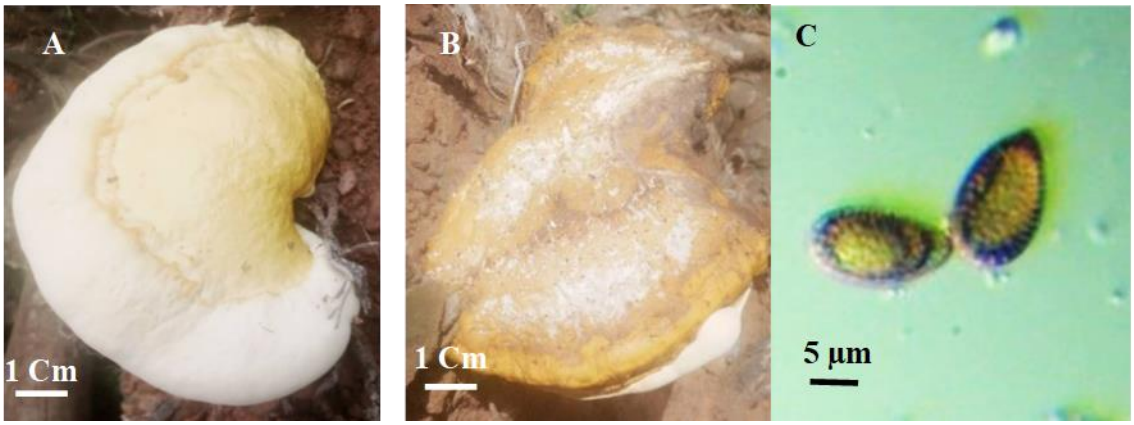

Figure 2 *Ganoderma colosus*; A: Fruiting body in its young state, B: Fruiting body at maturity; C: spores.

4.2. *Ganoderma praelongum* Murrill

The cap measures 10-27.5 cm in diameter, overlapping in a disc, of variable shape, flat, sessile, and less fleshy. The surface is dry, smooth, shiny, and grayish-brown to brown in color. It has 5 pores per mm, and the underside is creamy white. The stipe (10.1-12.5 cm) is cylindrical, swollen, with a smooth, shiny surface the same color as the cap. The flesh is voluminous, firm, and grayish to reddish-brown in color. The flesh has a pleasant odor and a slightly bitter taste. spores (8.32-10 x 6.67 µm) are ovoid, guttulate, truncated in shape with golden brown hues.

This mushroom is harvested from deciduous hardwood stumps and tree trunks in forests and plantations.

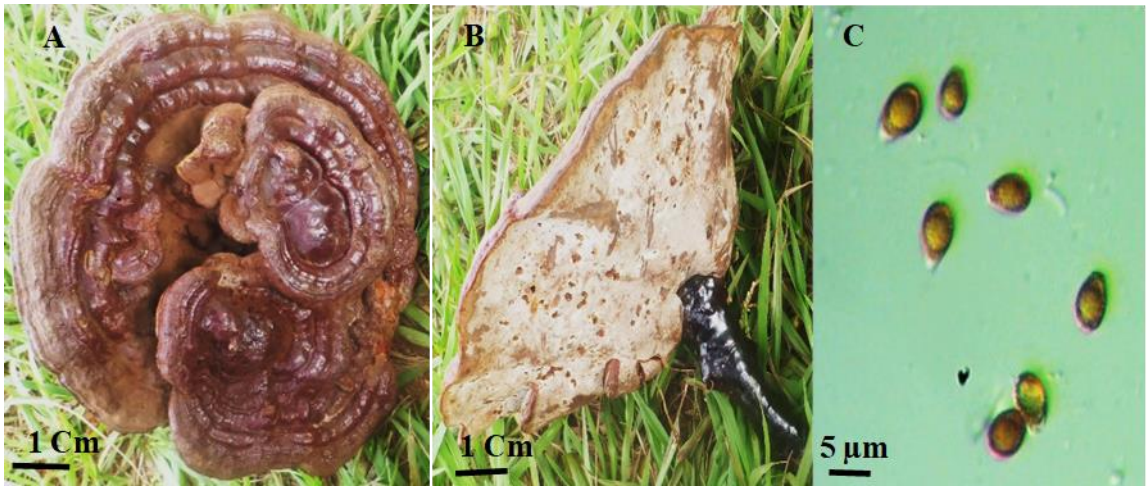

Figure 3 *Ganoderma praelongum* ; A et B: Fruiting body; C: Spores

4.3. *Ganoderma tuberculosum* Murrill

The cap is semicircular, sometimes circular in young shoots, sessile, flat, overlapping, and of variable size. The color is orange-brown, cinnamon-brown, sometimes chocolate-brown, and the size varies from 10 to 18 cm in diameter. The texture is not very flexible, and the surface yields to finger pressure. The surface is smooth, glossy, varnished, and hairless. It has shallow, concentric bumps. The margin is obtuse to thick, slightly wavy, rounded, white in young specimens, then ochre-orange. The stipe is absent. The spores (3-3.5 x 1-2 µm) are ovoid, guttulate, truncate, golden-brown in color, and measure widths of

The species is harvested from the stumps of hardwood trees and the trunks of dead, decomposing trees, in forests and plantations.

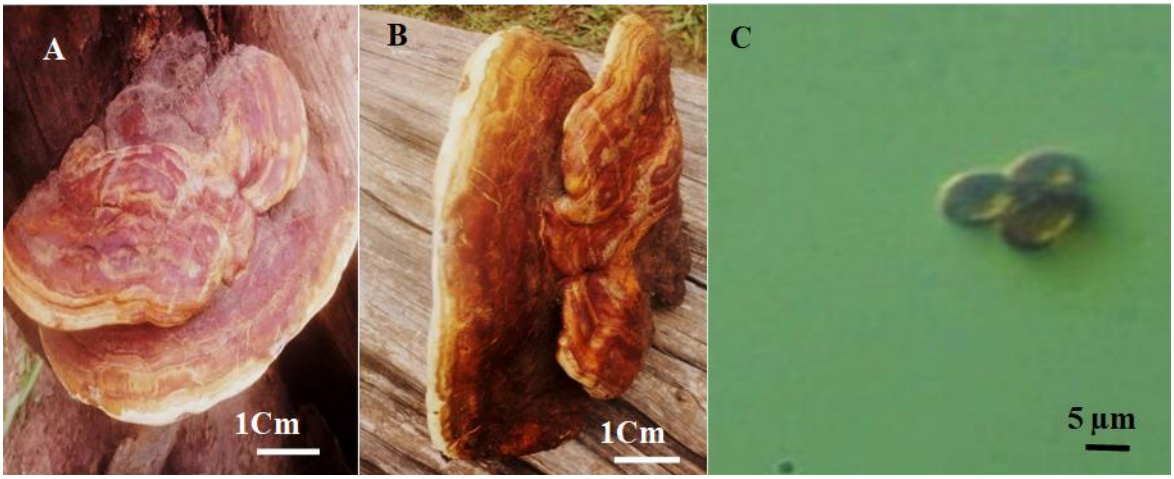

Figure 4 *Ganoderma tuberculosum*; A : Fruiting body; B : Spores

4.3.1. Ganoderma Boninense Pat.

The cap (10-27.5 cm in diameter) is a disc of varying shape, smooth, flat, sessile, less fleshy, and firm with a dry, smooth, slightly elastic, glossy or shiny surface, ranging in color from grayish-brown to glossy-brown to the margin. The pores are small and creamy white. The stem (10.1-12.5 cm) is cylindrical, swollen, and has a smooth, shiny surface the same color as the cap. The flesh is voluminous, firm, and grayish to reddish-brown. It has a pleasant odor and a slightly bitter taste.

Ecology and habitat: Saprophytic species is harvested on hardwood stumps and tree trunks in forests and plantations.

Microscopic description: Spores are ovoid, guttulate, truncated, and golden brown in color, measuring (4-5) µm in length and (2-3.5) µm in width.

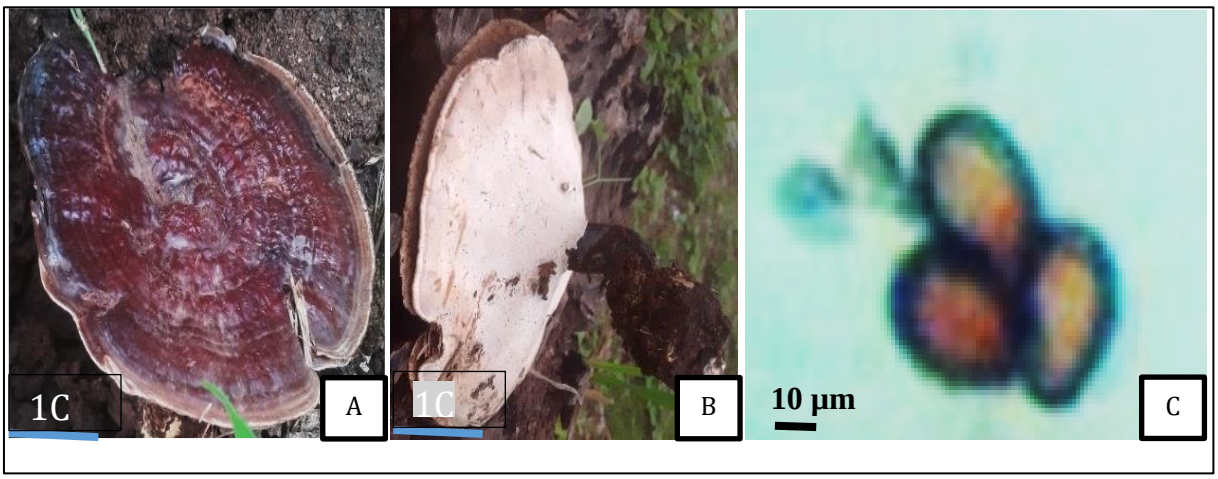

Figure 5 A; External view of the entire Fruiting body fixed to its substrate, B; Internal view of the Fruiting body showing pores and the stipe, C; Microscopic observations of the spores.

5. Discussion

Species of the genus Ganoderma are fungi cosmopolitan and rich in species that cause root, branch, and stem rot in plants. This attack leads to significant agricultural losses. They induce molecular responses in the host plant, including alterations in gene expression related to defense mechanisms and competition for resources (Luangharn *et al* ., 2012).

Mushrooms of the genus *Ganoderma* have long been used in Asia, especially in Chinese medicine, to support health and longevity (El Sheikha, 2022). Ganoderma species are the subject of much research due to their high medicinal value, as

they contain numerous chemical compounds with potential nutritional and therapeutic properties (Hapuarachchi *et al.,* 2018).

In Côte d'Ivoire, no studies have been conducted on the genus Ganoderma. In total, five Ganoderma species were identified in this study. These species were collected from trees in plantations and forests in the Daloa region.

The species are well distributed across the different surveyed locations. According to Bhosle *et al.* (2010), nine Ganoderma species have been reported and described in India; these are: *G. lucidum, G. applanatum, G. philippi, G. multiplicatum, G. resinaceum, G. perzonatum, G. sessili formae, G. praelongum,* and *G. multicornum.* Only the species *G. perzonatum, G. sessili, G. formae* and *G. multicornum* which are restricted to specific locations.

There is considerable morphological variation within the genus Ganoderma. The taxonomics of the genus Ganoderma remains unclear (Hapuarachchi *et al*., 2018), morphologically similar individuals are found in the genera Fomes, Polyporus, and Tomophagus (Paterson, 2006). Mycochemical studies have identified several species within the genus Ganoderma (Li *et al* ., 2013; Yan *et al*., 2013; Peng *et al.*, 2014). The Index Fungorum (2018) lists 445 species of Ganoderma, although Kirk *et al.* (2008) estimate the number of species worldwide at 80, several of which are synonyms. However, most Ganoderma species have not been systematically studied (Baby *et al.*, 2015).

6. Conclusion

The collection of Macromycetes in Côte d'Ivoire reveals a diversity of species of considerable ecological, economic, nutritional, and therapeutic importance. Investigations carried out in the upper Sassandra region have allowed us to identify species of the genus Ganoderma. As a result of this study, five species of the genus Ganoderma have been identified and described for the first time in the upper Sassandra. These are: *Ganoderma lucidum, Ganoderma praelongum, Ganoderma colossus, Ganoderma tuberculosum* And *Ganoderma boninense.*

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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