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Distribution and Pathogenic Diversity of *Ganoderma* Sp. Affecting Tree Health in the Patharia Forest of Sagar (M.P.)

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ABSTRACT

Sagar is situated north of tropic of cancer on Vindhyan peaks with 23°50′ North latitude and 78°40′ East longitude. The Patharia forest is dry deciduous forest having an undulating topography with low rising hills scattered all around. Forest is dominated by *Tectona grandis, Butea monosprema, Acacia* sp., *Dalbergia sissoo, Santalum album* and *Delonix regia etc.* The fungus *Ganoderma,* which includes several species such as *G. lucidum, G. tsuga* and *G. applanatum*is commonly found in the Patharia forest, including the university campus. The *Ganoderma* sp. are producing thread to plant health and some are so notorious they cause wilting of the host trees, resulting the death of 40-50 yrs old trees. A plant cannot be diagnosed with *Ganoderma* basal rot until the basidiocarp (conk) forms on the trunk or he internal rotting of the trunk. The fungus is spread by spores which are produced and released by the basidiocarp.

Keywords: *Ganoderma, basidiocarp, Delonix regia and Dalbergia sisso.*

INTRODUCTION

Ganoderma is a fungus from the basidiomycetes class and the Polyporales order, part of the Ganodermataceae family. The genus was established by Karsten in 1881, originally based on *Polyporus lucidus*. All species of *Ganoderma* do not possess cystidia, feature echinulate basidiospores and contribute to white rot in their substrates. Understanding of *Ganoderma* species (Ganodermataceae) has been and continues to be, quite disorganized, mainly because of their polymorphism (Ryvarden,1991).*Ganoderma* species utilize wood-based resources both as saprotrophs and as parasites, as they generate specific enzymes that break down soft tissues and affect the xylem, leading to significant risks to the transport of water and nutrients within the plant(Gottlieb and Wright, 1999).In its natural habitat, it thrives in humid, shaded mountainous regions densely populated with trees. It primarily develops on the desiccated trunks of elderly dead trees. Out of every 10,000 aged dead trees, around 2% are likely to have *Ganoderma* growth, making it exceedingly rare (Willard,1990).

The current research was carried out in Sagar and the surrounding vicinity. Sagar is located to the north of the Tropic of Cancer on the Vindhyan hills, positioned at 23°50′ North latitude and 78°40′ East longitude. The region features a dry deciduous forest characterized by an undulating landscape with low hills dispersed throughout. In January, the average monthly minimum and maximum reach 11.1°C and 25°C, while in June, they rise to 40°C and 44°C. The forest is primarily composed of *Tectona grandis, Butea monosperma, Acacia* sp., *Santalum album, Dalbergia sisso* and *Delonix regia* among others. The understory vegetation includes *Albizia procera, Bambusa* sp., *Lantana camara, Parthenium hysterophorus, Euphorbia geniculata, E. hirta, Heteropogoncontortus, Cynodondactylon, Bryophyllum sensitivum* and *Cassia tora*, among others.

The research indicates that the majority of the prevalent tree species, particularly *Mimusops elengi, Santalum album, Albizia procera, Dalbergia sissoo* and *Delonix regia* within the forest, are being affected by a disease called *Ganoderma* basal white rot. This disease is caused by various species of *Ganoderma*, specifically *G. lucidum, G. applanatum* and *G. tsuga.* The illness is more commonly found on the university campus and in the farms located down the valley, where *Mimusops elengi, Butea monosperma* and *Santalum album* grow in significant quantities.

Host and pathogen

The genus *Ganoderma* consists of a variety of wood-decaying fungi that can be found globally on various types of wood, including gymnosperms, woody dicots, and palms. In Sagar, numerous species of this fungus exist, but the pathogen *G. lucidum* has been most commonly observed among the trees. Other *Ganoderma* sp., such as *G. zonatum* have been noted to primarily infest palms, but there are also occasional reports of it affecting non-palm hosts. Nonetheless, these instances are quite rare. Consequently, palms are regarded as the main hosts for *G. zonatum* (Lonsdale, 1999).

The basidiocarp (conk) that appears on a living tree suggests that it is likely *G. lucidum* rather than another species of

Ganoderma G. lucidum species are frequently seen on hardwood trees (like *Dalbergia sisoo, Santalum album* and *Delonix regia)* and they are seldom found on other living plants. Other *Ganoderma* species can be found growing on decaying trunks and stumps, where they function purely as saprobes. Several plants are believed to be vulnerable to this disease. However, not all trees on the University campus of Sagar have been recorded as having *Ganoderma* basal stem rot. Those not recorded with these conditions may be viewed as having escaped. The sole potential exception for such plant species would be the presence of certain natural antagonists that prevent the fungus from thriving.

Table 1: The presence of various *Ganoderma* species across different hosts at various locations within the university campus.

Host	Pathogen	Site/Location
Acacia sp.	*Ganodermatsuga*	Botanicalgarden (arboretum)
Butea monosperma	*Ganoderma lucidum*	Near boys'hostel, University campus
Carica papaya	*Ganoderma lucidum*	Residential quarter, University campus
Dalbergia sisso	*Ganoderma lucidum*	Dept.of law
Delonix regia	*Ganoderma lucidum*	Botanical garden(University campus)
Delonix regia	*Ganoderma lucidum*	Residential quarter, University campus
Mimusopselengi	*Ganoderma aplanatum*	Road side, university campus
Mimusopselengi	*Ganoderma tsuga*	Deptt. of Botany
Murrayakoengii	*Ganoderma lucidum*	Farm house, patharia
Santalum album	*Ganoderma lucidum*	English dept. (University campus)
Tamarindus indica	*Ganoderma tsuga*	Near boys hostel, (University campus)
Terminalia arjuna	*Ganoderma* sp.	Garphera
Dead trunk	*Ganoderma lucidum*	Botanical garden(University campus)
Dead trunk	*Ganoderma* sp.	Residential quarter, University campus
Dead trunk	*Ganoderma* sp.	University ground

Signs, symptoms and diagnosis

G. lucidum is a white rot fungus that generates various enzymes to break down woody materials, mainly lignin and cellulose. As the fungus internally decomposes the wood, the xylem, which is responsible for water transport, is ultimately impacted. The main symptom of *Ganoderma* basal rot disease that can be seen is the wilting (from mild to severe) of all leaves, starting from the spear leaf (Figure 1). Additional symptoms can be characterized as a general decline, which includes slower growth and discoloured foliage.



Figure 1. *Mimusops elengi* exhibits wilted and desiccated leaves as a result of infection by *Ganoderma aplanatum*.

The basidiocarp, commonly referred to as a conk, is the most recognizable structure linked with the fungus. The conk develops from the fungal growth that occurs within the tree trunk. Figure 2 depicts the various phases in the growth of the conk. In the initial stage of conk formation on the side of a trunk or stump, it appears as a solid white mass that feels relatively soft to the touch. Its shape is typically irregular to circular and remains quite flat against the trunk or stump. As the conk develops, a small shelf or bracket begins to appear as the basidiocarp starts to extend or project from the trunk. It will still be white on both the upper and lower surfaces. Ultimately, it develops a distinct shelf-like formation that features a tough, glazed reddish-brown upper surface and a white underside. An adult conk displays a crescent shape with a relatively "straight" side that is directly connected to the trunk. If a conk is visible on the trunk simultaneously, symptoms of wilting or decline will manifest, then it is appropriate to identify *Ganoderma* basal rot. Nonetheless, it is unusual for conks to show up before a tree experiences significant decline and eventual death. In such cases, the only method to identify *Ganoderma* basal rot is to create a cross-section through the lower four feet of the trunk shortly after the tree has been felled.

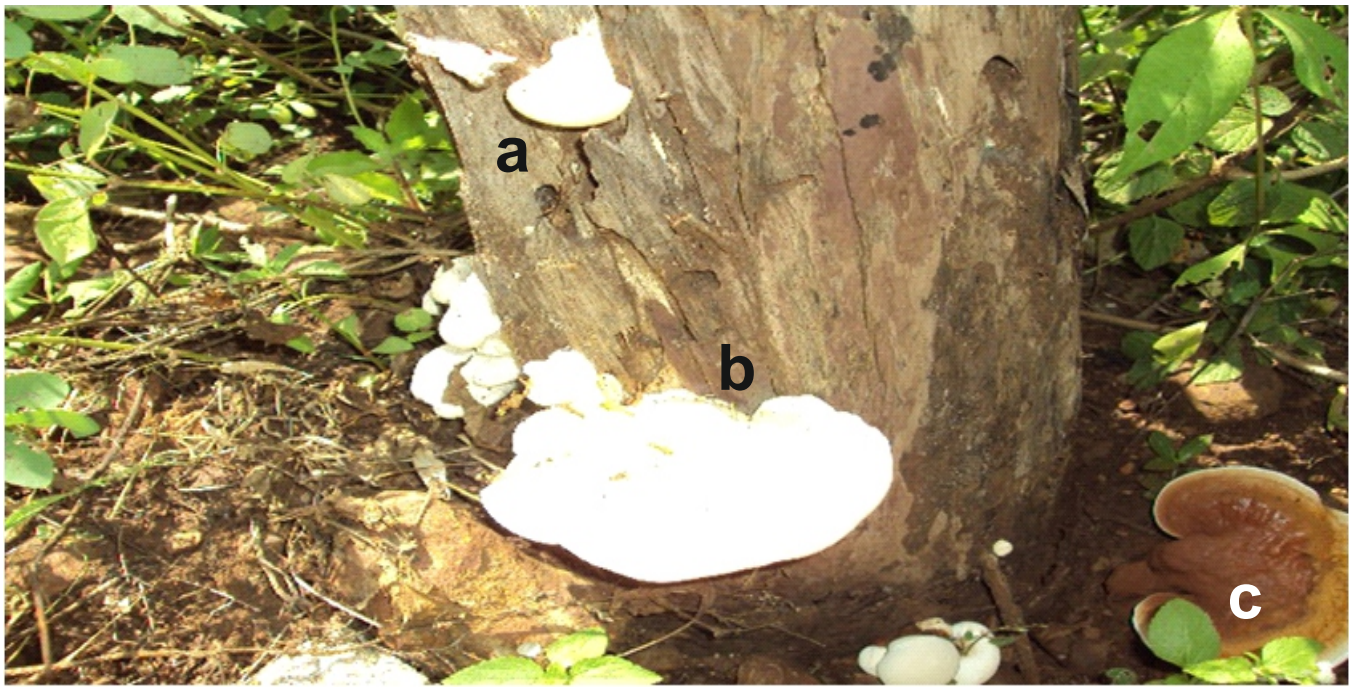


Figure 2.The three stages of Basidiocarp (Conk) development of *G. lucidum*. The structure (a) initial stage of the conk. The structure (b) represents a fully matured conk, while the structure (c) depicts an aged conk.



Figure 3. The basidiocarp (conk) of *Ganoderma* sp. did not reveal a “stem” or “stalk” connecting the conk to the trunk.

The conk of *G. zonatum* can reach widths of up to 8 inches and can be 2 inches thick. Nevertheless, the shape and size of conks are influenced by their growth environment. The "pores" located on the underside of the conk are where microscopic basidiospores are generated. When a large quantity of basidiospores is deposited on a white surface, they take on a brownish-red hue. Surrounding objects near a conk that has released its spores may look as if they are coated with rusty-colored powder. A single conk has the potential to generate a minimum of 3 cups of spores simultaneously.

Diseases and life Cycle

The fungus primarily propagates through the spores that originate from the basidiocarp (conk). These spores integrate into the soil, where they germinate and the hyphae (fungal threads) subsequently extend over the roots of the tree.The fungus does not decay the roots; it merely utilizes them as a conduit to access the woody trunk tissues. Once a tree becomes infected with *Ganoderma*, the fungus spreads to nearby areas where other plants are present and reaches the soil linked with other trees, leading to its rapid infectious spread.



Figure 4. Numerous basidiocarps (conks) of *Ganoderma*sp.on cut stamp.

It remains unclear how many months or years elapse from the initial infection of trees to the formation of the conk. Until now, there has been no specific method to identify and confirm *Ganoderma* infection in a tree prior to the emergence of the conk.Consequently, it cannot be assured that plants are devoid of *Ganoderma* when initially introduced into the landscape (Schwarze, 2000).Figures 3 and 4 illustrate the patterns of wood decay and disease advancement that have been documented. The fungus first invades and decomposes the tree trunk tissue near the soil line, then it grows in width at the base and ascends either through the centre or close to the centre of the trunk. As a result, the pattern of disease advancement in the trunk can be characterized as cone-shaped, being broadest at the soil level and tapering to a sharp point.



Figure 5. The release of spores from mature conks led to a reddish-brown coloration of the conks and the nearby area.

Management of disease

No environmental factors or landscape management techniques have been noted that hinder the progression of *Ganoderma* basal stem rot.The disease is commonly found in natural environments and is effectively sustained(Lonsdale,1999).It affects well-nourished woody trees that are free from nutrient deficiencies. The fungus has been known to kill both trees that show no visible mechanical injuries and those that have been significantly harmed by weed trimmers. The type of soil seems to have no connection to the disease, as infected plants have been seen growing on limestone formations. There is no identifiable pattern that offers insights into why certain trees become infected and succumb to *Ganoderma* while others remain unaffected. Typically, the fungus can be found within the lower 4-5 feet of the trunk, which has three implications. Firstly, the fungus does not disseminate via pruning tools since it is not linked to leaves. The lower segment of the trunk can be chipped and repurposed as mulch in landscaping. Additionally, it is essential to shield only the bottom 4-5 feet of the trunk from the fungus. However, standard xylem-limited and systemic fungicides are ineffective unless they can disseminate beyond the vascular tissue and safeguard all the wood in the lower trunk area. No fungicide can effectively treat the tree once conks have developed, as a significant portion of the trunk's cross-sectional area has already been compromised. Since we currently lack methods to predict or identify which trees are infected with *Ganoderma*, this renders the use of fungicides ineffective as a control strategy, both for prevention and treatment. As a result, there are no fungicide recommendations available for managing this disease.

Given that basidiospores from the basidiocarps (conks) are likely the main way the fungus disseminates, it is essential to keep a close watch on trees, particularly after one has died or been cut down for any reason. The fungus can easily inhabit and break down tree stumps. Once the fungus takes hold in the decayed wood, it typically generates conks that release millions of basidiospores, which can be easily dispersed by wind and water. As a result, it is crucial to inspect trees and their stumps for conks, remove them, and dispose of them in a trash container that will be incinerated or sent to a landfill. Removing conk early minimizes spore dispersal. It is crucial to consistently inspect trees, as any signs of disease must be addressed promptly. Because spores can travel on the wind, it is essential for the community to collaborate in limiting the spread of this harmful fungus's spores.

Once a conk is spotted on a tree, it should be taken down mainly for safety concerns. This is particularly crucial during the season. As mentioned earlier, if conks are developing on a living tree, it indicates that a large part of the trunk is already decayed. These trees are probably the most susceptible to being uprooted in strong winds. Completely eliminate the plant, including its decayed parts. Any remaining plant material will serve as a breeding ground for the fungus, as its spores can survive well in the soil. It has been noted that new trees planted in the same location where one succumbed to *Ganoderma* basal stem rot also fell ill and perished. Consequently, replanting with a different tree poses a risk. Various other plant species, including hardwood trees and shrubs, are also impacted by *Ganoderma* sp. (Elliott and Broschat, 2006).

When replanting a tree, it's essential to adhere to the proper guidelines. Eliminate the stump and all roots from the area and have the soil treated by a licensed professional who is legally registered as a fumigator for landscaping. An example is the product dazomet, also known as Basamid. If a tree is situated in an area surrounded by concrete materials, it is advisable to remove all the old soil, replace it with fresh soil, and then proceed with fumigation (Lonsdale,1999). Nevertheless, this process does not ensure that the new tree will be protected from *Ganoderma* basal stem rot, as the fungus may already be present with the new tree, and spores can easily be carried into the freshly fumigated area by the wind (Elliott and Broschat, 2001).

RESULTS AND DISCUSSION

Ganoderma Karst. species (Ganodermataceae and Aphyllophorales) are a class of wood-decaying basidiomycetes that are found all over the world but are most common in tropical regions. The genus has been thoroughly examined from two very different angles-losses of significant commercial trees and extremely powerful therapeutic qualities against numerous human ailments. *Ganoderma* is essentially in a taxonomic disarray and is the most morphologically complicated genus of polypores. Expanded the genus created by the laccate and stipitate white-rot fungus *Polyporus lucidus* W. Curt. to encompass all polypores with double-walled basidiospores.

Since then, pleomorphic features have been used to characterize approximately 290 *Ganoderma* species worldwide, the majority of which are found in tropical regions. However, this has been a common and obvious example of variability and overlapping characters (Moncalvo and Ryvarden, 1997).The two most significant characteristics of the genus are the size and form of the cuticle cells and the basidiospores. Every species of *Ganoderma* has echinucleate basidiospores, lacks cystidia and frequently causes white rot in the host or substrate (Steyaert, 1972).

Key to Ganodermataceae: Basidiocarp stipitate or sessile; pilear surface with or without material resembling lacca, Trimitic hyphal system: arboriform and aciculiform skeletal hyphae, generative hyphae with clamp connections and thin, branching binding hyphae and contorting. Basidiospores with a typical ganodermoid-type wall structure, globose to sub globose, occasionally oblong, or ovate to cylindric ovate, rounded or truncate at the apex; additional hymenial microstructures lacking; basidium globose to clavate, four spored, collapsing in dried basidiocarps.

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