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Traditional Medicinal Uses and Natural Hosts of the Genus *Ganoderma* in North-Eastern Parts of Namibia

Lempie K. Ekandjo and Percy M. Chimwamurombe*

Department of Biological Sciences, University of Namibia, P. Bag 13301, Windhoek, Namibia.

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Ganoderma **is a large complex genus name of polypore fungi, characterized by the presence of pores instead of gills underneath fruiting caps. This genus has very complex taxonomy occasionally resulted in multiple names for some species within this genus. The presence of *Ganoderma* species on hosts is noticed by the appearance of their cap shaped, hard, crusty and shiny varnished appearance of the outer surface of their fruiting bodies. *Ganoderma* species are one of the most commonly used ingredient in Asia's traditional medicine. They are also referred to as a health tonic since they are known to heal a wide range of diseases. The objective of this study was to determine the medicinal uses of *Ganoderma* by local people and also to determine the natural hosts of *Ganoderma* in the north-eastern parts of Namibia. The host identification was done to as species level in the field during sample collection. Open-ended questionnaires were used to gather traditional medicinal uses data. Of all the respondents, 64% did not know any use of *Ganoderma*. *Ganoderma* species are used for three medicinal purposes by local people in the north-eastern parts of Namibia. These are to halt nose bleeding, boost immunity and strengthen infant bones. *Ganoderma* extract can be taken in form of tea, smoke inhalation or ash. Thirteen natural hosts of *Ganoderma* were identified in the north-eastern parts of Namibia. The most common tree host was *Colophospermum mopane* (18%) and the least common were *Ochna pulchra* and *Grewia bicolour* (1%) Lastly *Ganoderma* is also found on soil with high woody debris contents or emerging from a plant root underneath the surface.**

Key words: *Ganoderma*, Medicinal properties, Natural hosts, North-East Namibia.

Ganoderma Karst. (1881) is a large complex genus name of polypore fungi (Buchanan, 2001). Polypore fungi are characterized by the presence of pores instead of the gills on the lowerside of the fruiting body (Englebrecht and Volk, 2005). The genus *Ganoderma* has two subgenus based on variations of its structure, the *Elfvingia* (non laccate species) and subgenus *Ganoderma* (laccate species) (Chang, Yeh, and Lee-Chen, 1996). Laccate defines the shiny upper surface of the *Ganoderma* cap and vice versa (Buchanan, 2001). Genus *Ganoderma* has a very complex taxonomy and consists of about 250 species worldwide (Buchanan, 2001). As a result of this, multiple names for a single species within this genus occasionally exist.

The colonization of *Ganoderma* species on trees is clearly noticed by the appearance of their cap shaped, hard, crusty surface of their fruiting bodies (Appendix 1 to 4) (Schwarze and Ferner, 2003). *Ganoderma* are important plant pathogens and woody decomposer (Mizuno, *et al*., 1995) cited in Buchanan (2001). All *Ganoderma* species degrade woody cell walls of mainly weak or damaged trees (Schwarze, Lonsdale and

* To whom all correspondence should be addressed.
Tel.: +264612063358; +264812744678;
Fax: +264612063791
E-mail: pchimwa@unam.na.

Mattheck, 1995). As a result rated by Campbell and Reece (2005) as the best decomposer of woody lignin polymers and through this they contribute to nutrient cycles in ecosystems. Beside ecological importance, *Ganoderma* have wide range of medicinal importance both traditionally and modern. These properties alternatively led to some of *Ganoderma* species such as *G. lucidum* referred to as a "health tonic" by Lindesquist (1995) cited in Mshigeni and Chang (2001). In China, *Ganoderma* are vital source of raw materials in traditional medicine (Sun *et al.*, 2006). Several researchers indicated important biological activities and high medicinal values of *Ganoderma* extracts such as immunomodulatory action, antitumor, antimicrobial activity, essential amino acids and cardiovascular effects (Sun *et al*., 2006; Chen and Miles, 1996; Chang, 2001; Mshigeni, 2001a).

Previous studies on Namibian *Ganoderma* indeed confirmed that these mushrooms are being used in traditional medicine against stress, pain, measles and lung diseases in domesticated ungulates (Kadhila-Muandingi, 2010) in the central northern regions of Namibia. Namibia is one of the countries that import *Ganoderma* products from Asia, beside the fact that there are also indigenous *Ganoderma* mushrooms in Namibia. Mshigeni (2001b) emphasized the need for further research on *Ganoderma* species in Africa to enable exploitation of these medicinally potential mushrooms. *Ganoderma* is believed to have the most promising resources promoting rapid socio-economic development in Africa (Mshigeni, 2001b). It is noted that, the limited knowledge and unrealised wealth of Africa's rich biodiversity by African themselves (Mshigeni, 2001a; Mshigeni. 2001b), had led to African countries spending a lot of money on products that they can produce locally. This study aimed to identify natural hosts of *Ganoderma* species and traditional medicinal used of *Ganoderma* in the north-eastern parts of Namibia. The results of this study could lead to better understanding of *Ganoderma* species which in turn might enhance the local utilization of medicinally important indigenous *Ganoderma* species and lay a foundation for further research on *Ganoderma* in different fields of studies.

MATERIALS AND METHODS

The study area

The north-eastern part of Namibia (Kavango and Caprivi regions) falls within the woodland biome of Namibia (Fig. 1). It is described by ferralic arenosols (Mfune, 2005), which is dominated by 70% sandy soils and little portion of silt and clay soils. These types of soils are known to be rich in iron oxides and aluminum (Singer and Donald, 2002; Foth, 1990) and are usually well drained (Singer & Donald, 2002; Foth, 1990). The north-eastern part of Namibia receives the highest rainfall in Namibia ranging between 450mm to 700mm per annum and temperature ranging from 6^{o}C to 36^{o}C (Mfune, 2005). This area was chosen because of its hot and humid climatic condition which is one of the favourable conditions for *Ganoderma* growth (Sripuan, Tongkao, Yamamoto, and Kumagai, 2005). It was dominated by broad-leaved deciduous trees and shrubs such as; Zambezi teak (*Baikiaea plurijuga*), mopane (*Colophospermum mpane*), wild seringa (*Burkea Africana*) and several *Acacia* species (Mfune, 2005). This area was dominated by hardwoods which are normally natural hosts of *Ganoderma* species.

Ganoderma collection and distribution assessment

In both regions, areas with dense and highly stratified woody vegetation were targeted for *Ganoderma* search. In addition cultivated fields that were densely populated with dead stumps and woody trees were considered. During the field work, the field guide Mushrooms of Southern Africa by Westhuizen and Eicker (1994) was used to differentiate *Ganoderma* species from other similar polyporaceae fungi such as *Pycnoporus sanguineus*. During sample collection GPS points, host identity, dates on which the samples were collected, were noted. Pictures of *Ganoderma* fruiting bodies on their natural hosts were also taken in the field.

Host identification

The host of each collected sample was identified. The Field Guide to Trees of Southern Africa by Van Wyk and Van Wyk (1997) was used to identify tree hosts in the field. Hosts that could not be identified in the field specimens were sharply cut off using secateurs and stored in a plant

presser. These specimens were taken to the National Botanical Research Institute (NBRI) for identification to a species level. For dead stumps, villagers were asked to identify a live tree of the same species, which could be identified. In cases where no live tree could be identified or no one knew what tree it was, the barks of stumps were collected for later identification.

Traditional medicinal uses

A questionnaire is one of the best ways to collect qualitative data, most specifically when the information is not documented. A questionnaire was used to study human knowledge or other characters that cannot be observed such as indigenous knowledge (Sheppard, 2004). Indigenous knowledge can be defined as the local knowledge that is unique to a given culture or society (Gaettingen, 2004). Indigenous knowledge is not documented and is mainly found in elderly people in the society (Homann, 2004; Matowanyika, Garibaldi and Msimwa, 1994). To gather information on the traditional use of *Ganoderma* mushrooms by indigenous people in the Kavango and Caprivi regions in this study, an open ended format questionnaires were used. Open ended format was opted for because it can accommodate a variety of responses and more truly reflect the opinions of the respondents. Questionnaires were used in a face-to-face interview to ensure the answering of all questions. The questionnaire was read out to every individual in their vernacular language and the answers were filled in English by the translator. This was done because the targeted people in this study were old individuals who mostly do not have reading skills. The findings were analyzed and summarized later after the survey and presented in a pie chart.

RESULTS

Host identification

In Table 1 are the 12 different tree species that were identified as *Ganoderma* hosts in the Kavango and Caprivi region. Table 1 also consists of host types which vary from dead burned stumps, dead unburned stumps, live trees and debris. The same table also exhibits the proportion of the samples that were collected from each host in regard to the total number of collected samples. Unknown stumps accounted for 37%, *Colophospermum mopane* was the host with the highest number of samples 18% and *Ochna pulchra* and *Grewia bicolour* were the hosts with the lowest number of samples both with 1%.

A total of 89 individuals responded to the questionnaires. Even though most of them did not know any use of *Ganoderma*, they were aware of the existence of this fungi and they knew where they where found in their villages. Of all the respondents, 64% did not know any use of *Ganoderma*. The most common use of *Ganoderma* was the use for hardening infant's forehead bones with 19%, followed by the use to heal nose bleeding with 13% and the last and less common use was

Table 1. Host trees and host types of *Ganoderma* in the Kavango and Caprivi region

Host trees	Host types	Percentages (%)
Unkown	Dead stumps	37
Colophospermum mopane	Dead burned and unburned stumps, sprouting stumps	18
Terminalia sericea	Dead stumps, sprouting stumps, live trees	13
Combretum collinum	Dead stumps	7
humus rich soil	Vegetation debris	4
Baikiaea plurijuga	Dead burned stumps	3
Grewia avellana	Sprouting stumps	3
Acacia erioloba	Dead stumps	3
Combretum imberbe	Dead and sprouting stumps	2
Dialium engleranum	Dead burned stumps	2
Guibourtia coleosperma	Dead burned stumps	2
Peltophorum africanum	Live trees	2
Ochna pulchra	Dead stumps	1
Grewia bicolour	Dead stumps	1

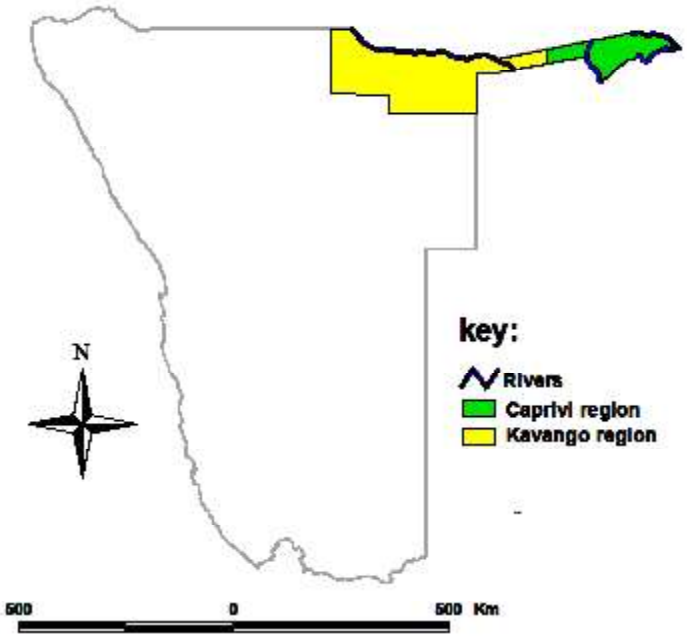

Fig. 1. Two regions in the north-eastern parts of Namibia where *Ganoderma* samples were collected for the study

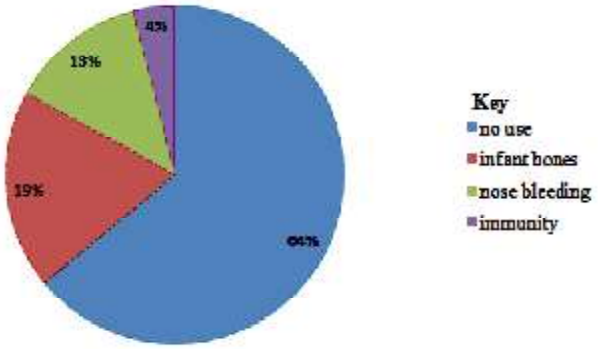

Fig. 2. Different uses of *Ganoderma* in the *north-eastern* parts of Namibia

the use to boost pregnant mother's immunity with 4% (Fig. 2).

DISCUSSION

Ganoderma hosts

Apart from unidentified hosts, trees from which most of the samples were collected were *Colophospermum mopane* (18%), *Terminalia serecia* (13%) *and Combretum collinum* (7%). *Colophospermum mopane* is one of the dominant woody trees of the woodland biome of Namibia of which the Kavango and Caprivi region are part of (Mfune, 2005). Erkel (2009) indicated that *Ganoderma* species prefer hosts with high carbohydrate contents for energy source as well as adequate protein source for formation of fruiting bodies. Erkel (2009) further elaborated that they do not favour hosts with lack of protein, hence there is a need to convert carbon to protein. Carbohydrate is indicated in Erkel (2009) to have a major role in *Ganoderma* as it is the main source of energy and carbon during the growth.

Ganoderma are known to be associated

Fig. 3. *Ganoderma* growing on soil host (1), dead burned woody stumps (2); dead unburned woody stumps (3) and on building post (4)

with solid hosts that have high moisture contents and also prefers very humid places Habijanic and Berovic (2000). Lack of adequate moisture is associated with reduction of polysaccharides production and mycelia growth Habijanic and Berovic (2000). It appears, like beside humid environmental conditions, the moisture holding capacity of a particular woody material also plays a major role in determining the presence or absence of *Ganoderma* on different woody hosts. Polysaccharides have two main roles these are: to fasten the hyphae to the surface of the host as well as protecting the hyphae against evaporation and mechanical disturbances (Habijanic and

Berovic 2000). For this reason, the availability of a few number of *Ganoderma* on some woody trees can be partially explained by little amount of polysaccharides in the host.

Apart from nutrient composition of the hosts, other factors such as sampling techniques, age of the hosts and variation in microhabitats also play a part in the presence or absence of *Ganoderma* on various hosts. For instance, in this study higher number of *Ganoderma* were collected from *Colophospermum mopane* mainly building post (Fig. 3.4) can also be explained by the fact that most of these samples where collected from homesteads especially in the Caprivi region in which *Colophospermum mopane* are the commonly used building materials. Even if the fungi disperse their spores by wind (Elliot and Paschot, 2000) which present equivalent chances of host colonization. Variations in microhabitats temperature and humidity of different habitats, host specificity of different *Ganoderma* species and geographical location of different trees tend to play a major role in the determination of the spores germination. Although this study only focused on the appearance of fruiting bodies as the presence of *Ganoderma* on hosts, the fungi may still be present inside the host as hyphae (Elliot and Paschot, 2000).

It can be seen in Table 1 that 4% of the samples collected in this study were found on soil hosts (Fig. 3.1). Even though in this study analysis of soil samples from which the *Ganoderma* samples were collected were not conducted, Wasser (2005) reported the same findings. Wasser (2005) further reported that *Ganoderma* fungi can be occasionally found on soils either arising from buried roots or stumps and also on soils that have high concentration of decomposing wood debris or wood chips.

Table 1 also exhibits the state of tree hosts on which samples were collected; which were grouped as either dead burned stumps (Fig. 3.2) and dead unburned (Fig. 3.3). Even though *Ganoderma* is commonly found on dead trees or sprouting stumps, Elliot and Broschat (2000) confirmed that indeed some species of *Ganoderma* can be found on live trees, the same results were obtained in this study. Elliot and Broschat (2000) supported his idea by giving evidence of *G. lucidum* as the common cause of white rot disease in live oak trees in Florida. However, this can not be used as sole identification tools for *G. lucidum* since other species also colonize live trees of different species in different areas. For all tree hosts recorded in this study, *Ganoderma* was only found either on the root or within 1.5m on the trunk from the soil surface. However, it was not found on small branches higher up on the trees.

Ganoderma traditional medicinal uses

Ganoderma uses

About 90% of all the people who filled the questionnaires indicated that only *Ganoderma* collected from the base of stumps or live *Acacia erioloba* and *Combretum imberbe* is used medicinally. Similar findings were reported in Uganda in Opige, Kateyo, and Olila (2006) cited in Kadhila- Muandingi (2010) that only *Ganoderma* from certain tree hosts are used medicinally in traditional practices. *Ganoderma* collected from *A. erioloba* and *C. imberbe* are used to treat nose breeding, boost woman and fetus immunity during pregnancy and also to strengthen infant head bones. The findings of the study carried out by McMeekin (2004) found out that the medicinally important *G. lucidum* is usually found at the base of the stumps or on the roots of a living hardwood. This is similar to the findings of this study.

Beside the indigenous medicinal use of *Ganoderma* by people in the Caprivi region, fungi of the same genus have also been used in folk medicine for health promotion in Asia (Wesser, 2005; Habijanic and Berovic, 2000). Liu (1993) cited in McMeekin (2004) noted that *G. lucidum* medicinal properties have been tested on both mice and several human disease and has indeed showed medicinal properties. McMeekin (2004) stated that eastern scientists had reported that *Ganoderma* extract had in fact prolonged life spans, stimulate and regulate immune systems and affect the endocrine system of mice. In fact this proved the presence of anti-aging agents in *Ganoderma* extract (Xiao, Xing and Wang, 1993 cited in McMeekin, 2004). Accordingly this highlights the need for further detailed study to investigate the nature as well as the mode of action of *Ganoderma* extract in the human body.

Preparation of _Ganoderma_ extract

Different people indicated that *Ganoderma* can be prepared in different ways before use as medicine. *Ganoderma* can be ground

to powder which is then rubbed on infants' forehead in order to strengthen the skull bone. *Ganoderma* cap can also be soaked in boiled water for few minutes until the water has turned reddish. The extracted remedy is called *Ganoderma* tea. This so called *Ganoderma* tea is then taken by pregnant women as an immune booster for both mother and child. This is supported by Arora (1986) cited in McMeekin (2004) who stated that since the mushroom is too tough to be edible in Thailand *G. lucidum* is soaked in water for several months and then the extracted wine is drunk or put in a candy. In addition to this, *G. lucidum* tea is also sold in the markets in Thailand for medicinal purposes. Lastly *Ganoderma* can be burned on a clean surface and then the smoke will be inhaled by a nose bleeding individual in order to prevent nose bleeding.

To this end, beside the medicinal usefulness of *Ganoderma* species many people in the north eastern part of Namibia, still have no knowledge about their uses. The local people in the north-eastern parts of Namibia use *Ganoderma* for three medicinal purposes such as: stopping nose bleeding, strengthening of infant head bones and immune boosting. Preparation of the medicine varies from smoke, powder and tea depending on the illness targeted. Finally, thirteen natural hosts of *Ganoderma* were identified comprising of 12 tree species and soil.

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