



Ganoderma tsugae, courtesy D. Work.

Glossy with Grandeur: The Laccate *Ganoderma* of North America

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We get excited when we find the varnish-capped or laccate *Ganoderma* polypore because its red shiny surface makes it one of the most alluring fungi encountered in the forest. The first one Bob found was while hiking in the mountains of New Hampshire many years ago. It was small with a short stipe, but it seemed to be glowing a brilliant dark red as it grew out of the base of an old hemlock tree. This intriguing fruiting body stopped him in his tracks as he admired the surreal characteristics that made it very different from all other fungi. It motivated him to learn more about mushrooms and led to a lifelong study of these extraordinary forest fungi. For Andrew, the illustrious fruiting bodies of *Ganoderma* were first observed in southern Louisiana fruiting from the ground where a water oak tree once stood at his childhood home. Fruiting bodies were seen every year for about 15 years coming up from buried woody roots. This was nature's most beautiful recycler at work, and the annual spectacle inspired Andrew to want to study the diversity of these fungi in the years to come.

The varnished-looking (laccate) *Ganoderma* are downright beautiful and every time we find one it seems special to us. It is no wonder that in the past others have also appreciated the remarkable features of *Ganoderma* fruiting bodies. They have drawn the attention of people across the world throughout the ages. In Asia, where the fungus has been used in traditional medicine for thousands of years, it has been revered for its beauty and purported healing properties. Called *lingzhi* in China or *reishi* in Japan, these names translate to spirit or sacred mushroom and it is commonly referred to as the "mushroom of immortality." The Qianlong Emperor (his reign in China was 1735-1796) describes *lingzhi* in a poem as having rare ageless beauty and as precious as purple sandalwood or white jade. In 1781, William Curtis gave a London collection of the fungus the name *Boletus lucidus*. He appeared to be awestruck by the find calling it a "handsome fungus ... shining as if varnished" and "beautifully polished that I scarcely knew whether I had found a natural or an artificial production." The hand-colored illustration that he published with the description is magnificent and we include the image to show this outstanding artwork. Later, the name was changed to *Ganoderma lucidum*. Historically the fungus has also been associated with more magical and even supernatural properties



The first illustration of *Ganoderma lucidum* by William Curtis in 1781. From *Flora Londinensis* in author's collection. Curtis named the fungus *Boletus lucidus*.



Varnished-capped *Ganoderma* such as *G. tsugae* are a spectacle in the forest. It is found on Hemlock in the Midwest and East and in the mountains of Arizona and New Mexico on Douglas-fir and other conifers. Top photo by Sam Reford.

All species can vary in color depending on their age and environmental conditions. A range of color is seen here with a young *G. sessile* (top, photo by Jason Smith), mature *G. curtisii* (middle) and young *G. tsugae* (bottom).

as reported previously in FUNGI magazine (Summer 2015, Spring 2017, and Fall 2017) with its use in different regions of the world by shamans.

Given the esteem for this group of fungi, you would think classification and naming would be seamless, but unfortunately this has not been the case. In the past century, field guides and keys have used the name *Ganoderma lucidum* for all laccate *Ganoderma* species growing on hardwood trees. Whether in Europe, Asia or the Americas, this same species name was commonly used. Taxonomists have tried to better classify these fungi based mostly on morphology and geography but really messed things up with over 400 species reported. Morphological characteristics often did not provide a reliable way to differentiate this group of fungi since environmental conditions, age and other factors influence their morphology.

With such confusion over species names, it is no wonder most people just call them all *Ganoderma lucidum*. It was long overdue for the shiny-capped *Ganoderma* species to get a “polish” of the taxonomic kind by way of molecular tools.

Molecular analyses and sequencing of multiple genes provides precise information that can be used to differentiate species. In the era of DNA-based taxonomy the laccate *Ganoderma* species found around the world can now be classified and correctly identified. In Asia where laccate *Ganoderma* species have been used for medicinal purposes for centuries, many of the wild-collected and cultivated species commercially available have been mislabeled as *G. lucidum*. It is now recognized that the cultivated *lingzhi* or *reishi* in Asia represent several species, including *G. lingzhi*, *G. multipileum*, and *G. flexipes*. To determine which species exist in North

Basic Key to the Laccate *Ganoderma* Species of North America

- | | | | |
|--|---|--|--------------------------|
| 1. Typically, stipitate fruiting body with a true stipe (commonly laterally produced) | 2 | 6. Context dark brown | 7 |
| 1. Sessile fruiting body or if a stipe is present less than half the length of the cap diameter | 5 | 6. Context white to cream to light brown | 9 |
| 2. Cream, or buff context with black, shiny melanoid deposits absent | 3 | 7. Found predominately growing on palms, basidiospores twice as long as wide..... | <i>G. zonatum</i> |
| 2. Cream or buff context with black, shiny resinous deposits present..... | 4 | 7. Not as above..... | 8 |
| 3. Concentric zones present in context of cap and stipe, and found in restricted parts of northern Utah and southern California..... | <i>G. lucidum</i> | 8. Sessile, red to orange fruiting bodies limited to deep Southeast | <i>G. tuberculosum</i> |
| 3. Concentric zones absent in context, found in the East, and basidiospores are nearly twice as long as they are wide..... | <i>G. ravenelii</i> | 8. Centrally, pseudostipitate (length of stipe less than the width of the cap) fruiting bodies found throughout the Southeast..... | <i>G. martinicense</i> |
| 4. Found predominately on hardwoods in the East, especially oaks growing from roots | <i>G. curtisii</i> | 9. Context nearly pure white and in temperate locales on conifers..... | 10 |
| 4. Found predominately on pines in the Gulf Coast | <i>G. curtisii</i> f.sp. <i>meredithiae</i> | 9. Not as above..... | 11 |
| 5. Fruiting body yellow and spongy (not woody) with large basidiospores and highly ornamented, pigmented, double-walled chlamydo­spores..... | <i>Tomophagus colossus</i> | 10. Found east of the Rockies and in northern Arizona and northern New Mexico..... | <i>G. tsugae</i> |
| 5. Not as above..... | 6 | 10. Found in the Pacific Northwest | <i>G. oregonense</i> |
| | | 11. Pigmented, round chlamydo­spores found in context and limited to South Florida | <i>G. cf. weberianum</i> |
| | | 11. No pigmented chlamydo­spores in context..... | 12 |
| | | 12. Found east of the Rockies | <i>G. sessile</i> |
| | | 12. Found in the West..... | <i>G. polychromum</i> |

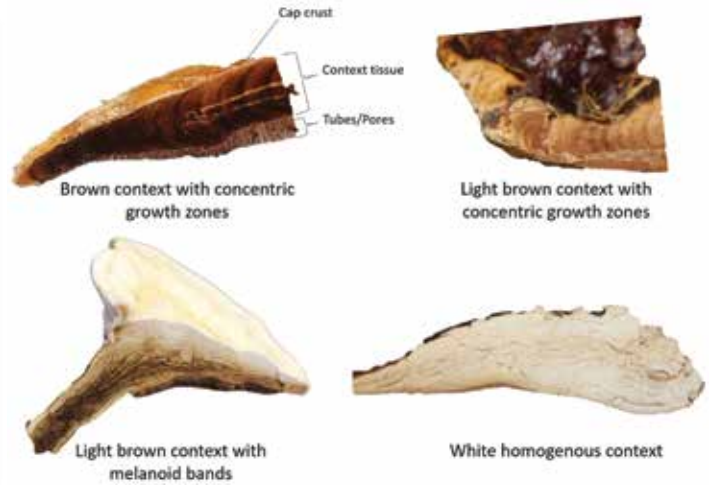
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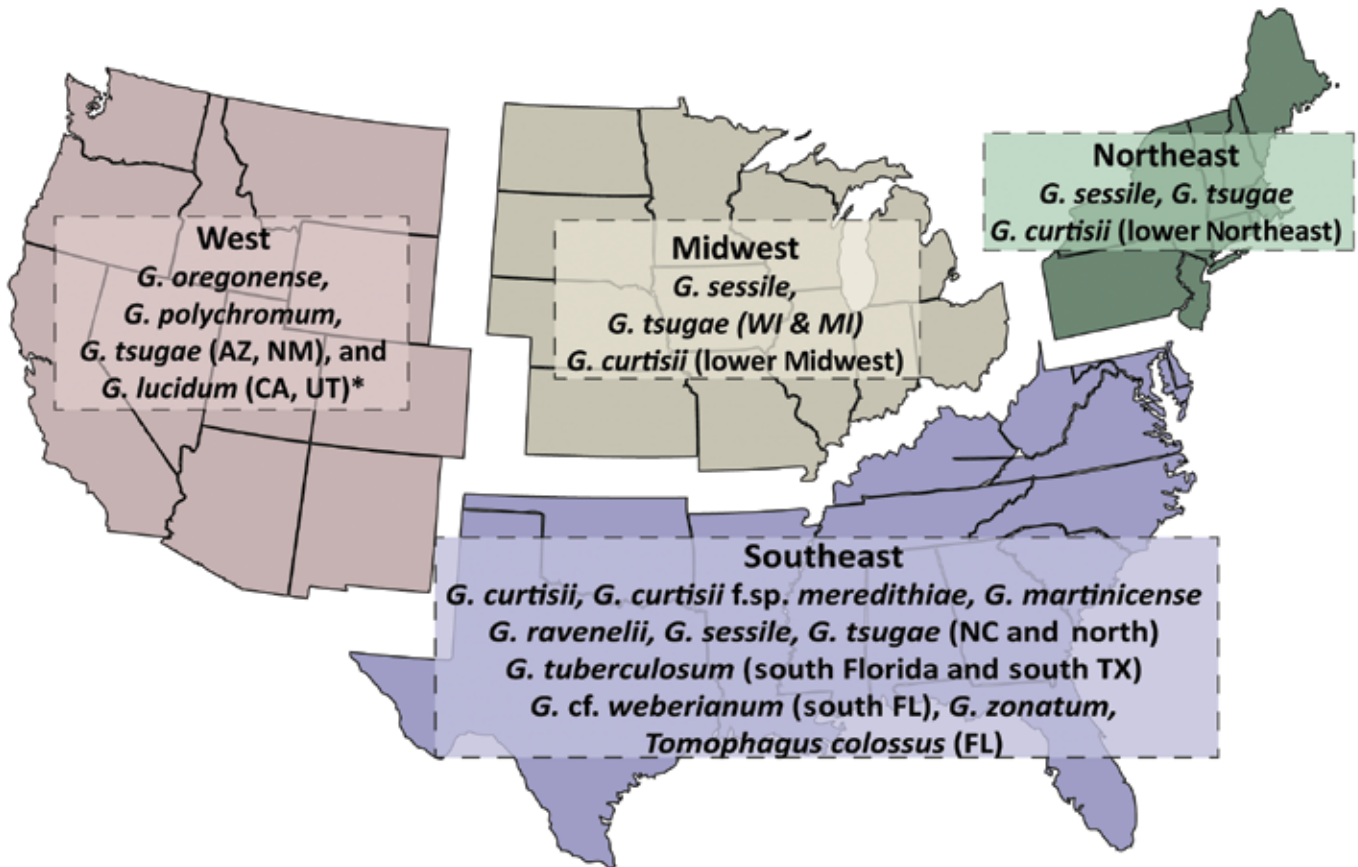
Ganoderma species such as this *G. tuberculosum*, can colonize the roots and trunks of live trees causing a root and butt rot. For more information on decay by *Ganoderma* see the Fall 2018 issue of FUNGI magazine.

America, we made over 500 collections and examined their morphology and DNA sequences.

In the United States it turns out that the species once called *Ganoderma lucidum* is actually many species, and there is quite a bit of diversity among varnished-capped *Ganoderma*. We have found there are 13 laccate *Ganoderma* taxonomic

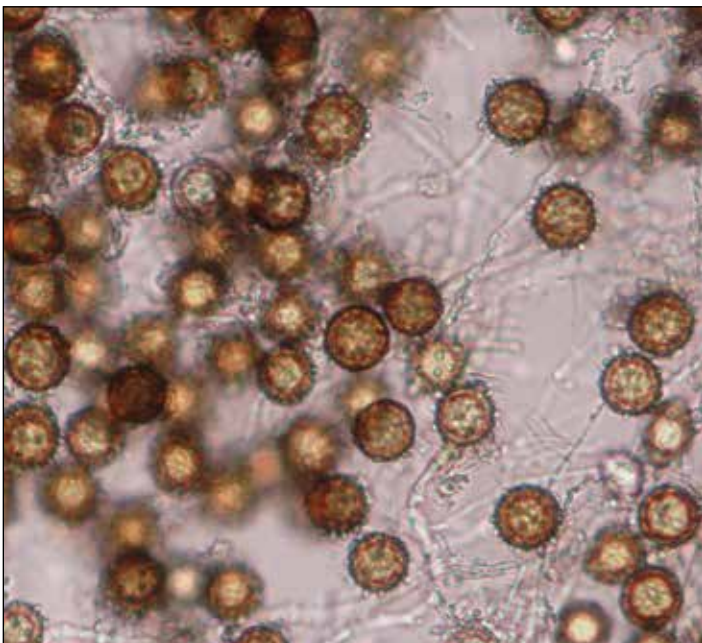
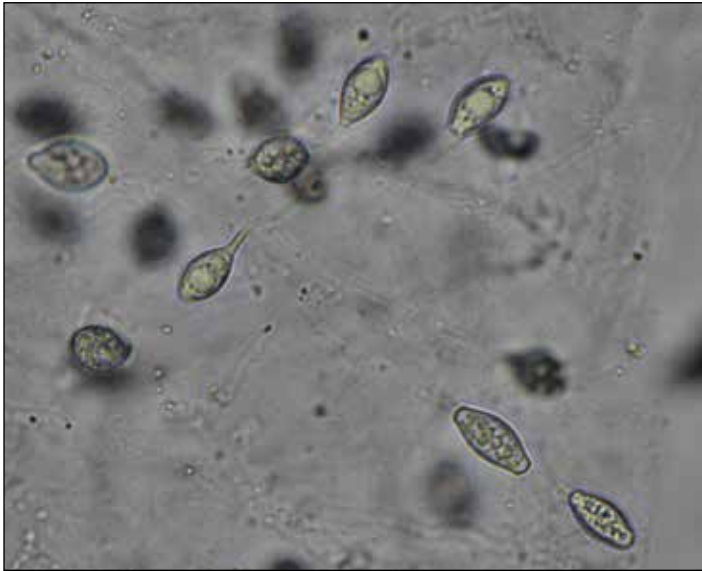
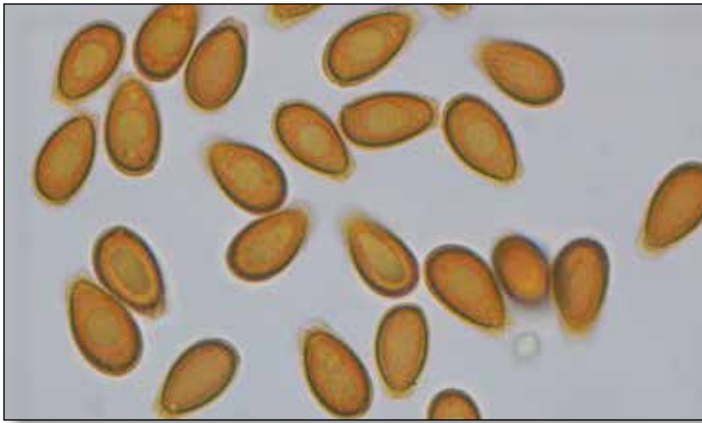
Characteristics of the inner context of the fruiting body that help determine the species.

groups recognized in the United States. These are *G. curtisii*, *G. curtisii* f.sp. *meredithiae*, *G. lucidum*, *G. martinicense*, *G. oregonense*, *G. polychromum*, *G. ravenelii*, *G. sessile*, *G. tsugae*, *G. tuberculosum*, *G. cf. weberianum*, *G. zonatum*, and *Tomophagus colossus* (formerly known as *G. colossus*). All of these species have shiny caps and can be difficult to identify because of overlapping morphological features. Now that we know the taxonomic groups from molecular studies, we



* very localized in California and Utah. Assumed to be introduced.

What species are in your region? This map shows the distribution for the varnished-capped *Ganoderma* species in the United States. Although we did not study collections from Canada and Mexico, there is undoubtedly an overlap of species that exist between these countries and the United States. In addition, there may be additional species in tropical areas of Mexico that are not included.



Basidiospores (top photo) showing their pigmentation and double wall, and chlamydospores of *Ganoderma sessile* (middle photo) and *Tomophagus colossus* (bottom photo) which are asexual survival spores produced by the mycelium that allow the fungus to stay alive under adverse conditions.

can examine differences among them. This article provides a key to separate these species based on morphology, host-group preference, and geography of each molecularly defined taxonomic group.

Generally, all laccate *Ganoderma* species have woody to spongy fruiting bodies that grow on the lower portions of trees (i.e. lower trunk, root flare, roots, etc.). Typically, these fruiting bodies are produced annually in warm, wet conditions of late spring through summer and fall. Occasionally, in tropical locations or under unusual environmental conditions some laccate *Ganoderma* species can produce perennial fruiting bodies (new fruiting bodies forming from old fruiting body tissue).

Morphological characteristics of the fruiting bodies most helpful for species identification are the color of the cap, stipitate vs. sessile anatomy (presence or absence of a stalk), context characters (tissues between cap crust and tubes and throughout stem), basidiospore measurements and presence or absence of chlamydospores. Fruiting bodies range in color from yellow to brown to reddish-brown, and are mostly “shiny” on the top of the cap. Stipes can be present or absent and when present can range from short and stocky, referred to as pseudostipes, to lengths that are equal or greater than the diameter of the cap. The context ranges from white to cream to dark brown in color, and corky to felt-like in texture. Black and shiny melanoid deposits throughout the length of the stipe and/or concentric growth zones in the context are features that are important characteristics for some taxa.

Microscopically, basidiospore size and shape can distinguish some species, but in most species the spores are quite similar. All *Ganoderma* species have double-walled basidiospores that are pigmented, appearing golden-brown under a microscope. The inner wall is pigmented and extends through the non-pigmented outer wall giving the appearance of small pillars making the spores appear spiny. Some species have spores that appear “rough,” while others have spores that appear “smooth.” The distinction between “rough” and “smooth” can be subjective and is only a relative distinction among the taxa that characterizes the thickness and abundance of pillars found in the spore wall. This distinction can only be made when basidiospores are fully mature.

Lastly, there are some species of *Ganoderma* that produce chlamydospores in the fruiting body or in culture. Chlamydospores are thick-walled asexual spores that function as survival structures, which can persist under extreme conditions (e.g. high/low temperatures, drought conditions). These structures are variable among taxa and can be clear to pigmented, round to obovate, and smooth or ornamented depending on the species. Similar to the basidiospores, chlamydospores can be an important morphological feature and they require the aid of a light microscope to see them since they are very small.

In addition to morphology, geography and host-group preference can help with identification of some *Ganoderma* species. Based on surveys from the United States, some species have geographic boundaries where they are more or less common. Some species are strictly observed in the East or in the West while others only in parts of the South or in narrow distributions in specific regions. Host-group preference is also an important feature. This is likely due to

adaptations of *Ganoderma* species' ability to only colonize and decay particular types of trees (e.g. hardwoods, conifers, palms). Host-group preference is likely an adaptation of niche specialization for the various *Ganoderma* species.

Although all laccate *Ganoderma* were historically lumped under the name *G. lucidum* in North America, we found no *G. lucidum* to be native here after studying hundreds of collections. Our species are genetically distant from this European species. However, the real *G. lucidum* has been found in localized areas of Salt Lake City and southern California where *G. lucidum* has apparently been naturalized after being introduced, most likely from outdoor cultivation of the European species.

The next time you find an illustrious fruiting body of a varnish-capped *Ganoderma*, try using the key provided to

assign its name. With the exception of a few small geographic locations in Utah and California where *G. lucidum* is present (likely from at least two introductions), *G. lucidum* has not been found in the North America. In the East, *G. sessile* and *G. curtisii* will be the most common species found on hardwoods and in the West, *G. polychromum* is the most common species. With a growing interest in using the fungus for medicinal purposes, the new taxonomy suggests that more research is needed to discover which of these species has the greatest medicinal benefits.

No matter the name, the laccate or varnish-capped *Ganoderma* species will continue to delight the collector and be admired for their beauty and cultural significance. They have fascinated emperors, empowered shamans and changed the lives of both of us. Finding *Ganoderma* can be a magical experience. 🍄

Every Season Catches Me

Every season catches me by surprise.

Will the snow ever melt?

Then suddenly leaves unfurl, trees blossom
and volunteer lettuce from last year's seed
patches the palest celadon on the bare brown earth.

With worry I watch the squash seedlings.

Will they ever grow?

Then suddenly leaves the size
of dinner plates spread three rows over,
and hide zucchini big as baseball bats.
Bindweed and purslane blanket all the beds.
Trees then bowls and jars full of cherries,
peas by the gallon and then gone,
morning grazing on raspberries and then gone—

Will the days always be this hot?

Garlic uncurls graceful scapes; basil blooms.
The garden is a patchwork quilt
of white buckwheat flowers, purple cosmos,
yellow calendula, blue and white potato flowers,

accented among nineteen—count 'em—

nineteen shades of green.

Mushrooms fruit from the duff.

Beans bloom and pod;

plums and peaches ripen, then apples.

Suddenly, a few leaves turn gold—

then whole forests.

I am as shocked by the first freeze of autumn
as I was by my first gray hairs. It's all white now,
my hair, as white as the snow
that will soon cover the ground and stay.

As many years as I've spiraled this sun,
still, it catches me by surprise.

Tara Edna Miller

Colorado