



Figure 1. Contemporary Tibetan thangka showing Nyamnyi Dorje and Tibetans collecting and trading *yartsa gunbu*.

The Wild Life of *Yartsa Gunbu* (*Cordyceps sinensis*) on the Tibetan Plateau

The beginnings of the *yartsa gunbu* tale lie enshrouded by the mist of time in Tibet's giant snow mountains. It is unclear if it was already thought to be as a powerful medicinal over a thousand years ago, though on the Internet *Cordyceps* merchants allege several thousand years of history and proclaim Tibetan yak herders observing bulls becoming hornier after browsing on *yartsa gunbu*. Yak mating season takes place at the end of summer and *Cordyceps* fruiting starts in early spring, however such details do not derail a potent sales pitch. Anyway, some Tibetan medical scholars

claim to recognize *yartsa gunbu*—the Tibetan appellation for the insect-fungus complex—under the name “tsa daji” in the famous *Gyü Zhi* (composed 8th to 11th century), a name that was later used for a medicinal “snow frog.” Alpine frogs shape shifting to summer worms seems a stretch, but nothing seems impossible at high elevation, where *yartsa gunbu* thrives and thin air can affect the observers’ clarity of thinking. We are talking elevations between 3,000 m to 5,000 m (10,000 to 16,500 ft), though it grows most prolifically between 4,000 m and 4,500 m (13,000 to 15,000 ft), just around and above tree line.

Clear historic documentation shows up in the late 16th century in the writings of Nyamnyi Dorje, a Tibetan doctor and Lama entitled *An Ocean of Excellent Aphrodisiac Qualities*. The text commences thus:

In this world sexual bliss is the most marvellous of all pleasures, the essence of the enjoyment of the all senses.

[...] Concerning this medicinal substance:

It grows in beautiful mountain regions on remote grass-covered slopes.

In the summer it is a blade of grass on a worm similar to the leaf of mountain garlic.

The flower resembles a silken green sedge.

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Figure 5. An alpine meadow seen on Serkyim La in early August at 4,600 m (15,000 ft) altitude in full flower. While the fruiting bodies of *O. sinensis* are long deteriorated, the fungus is still present within these plants. So far, its hyphae have been detected in the roots, stems and leaves of the pinkish-flowering bistort (*Polygonum macrophyllum*), the white *Cyananthus macrocalyx*, a bell flower relative, and also in yellow buttercups (*Ranunculus tanguticus*). However, no report of *O. sinensis* being present in the depicted purple elephant's trunk (*Pedicularis* sp.) or tiny blue gentians.

ghost moth larvae (*Thitarodes* spp.), the hosts of the fungus, but actually present in herbaceous plants growing in *yartsa gunbu* habitat. Common woody plants like rhododendron and creeping willow (*Salix* sp.) have so far tested negative. However, *O. sinensis* hyphae were detected in the tissue of over half of the alpine grasses, forbs and ferns tested! And not just in their roots, but also in their stems and leaves. In addition, the presence of hyphae in surprising quantities was detected within the digestive system of living larvae, indicating that the fungus might



Figure 6. A typical *yartsa gunbu* collectors' camp in Lithang, Garze (Ganzi TAP), Sichuan. They are usually located close to a creek for water access and directly on a mountain road or drivable tracks high up around treeline. The tents have completely changed in the nearly 20 years I have been researching the phenomenon. Traditional black hair tents made from yak wool used by nomads for millennia have been replaced with light-weight and waterproof synthetic tents. Some are even double walled and become warmer than any traditional farmhouse using a stove fueled by wood or yak dung.

infect the insect via the digestive system (Lei et al., 2015). Documenting that *O. sinensis* is present in plants is a total game changer! Practically speaking, it is extremely good news supporting assessments of resource resilience and making sustainable management much more feasible, since even when

yartsa gunbu is intensely collected it seems that *O. sinensis* should persist for extended periods in the ecosystem. The limiting factor would be "supply" of fresh larvae ready to be infected. However, stepping back and looking at the wider picture and having a more theoretical perspective as Lei et al.



Figure 7. Since collectors make good money and do not want to waste time to go down in the valleys to resupply, dealers set up shop supplying warm socks, coats, soft drinks, beer, liquor, instant noodles, crackers, candy, etc.



Figure 8. Checkpoints make sure only locals with collection permits enter *yartsa gunbu* habitat.

(2015) clearly point out, *O. sinensis* is an interkingdom colonizer! It has developed the capacity to overpower the immune systems of insects and plants and seems to need both for successful reproduction. Repeated interkingdom jumping, when acquiring new hosts, e.g. jumping from cicadas to *Elaphomyces* sp. truffles is well documented among other *Cordyceps* species (e.g. Nikoh and Fukatsu, 2000).

Ophiocordyceps sinensis being present in plants and ghost moth larvae in its habitat might also explain why artificial cultivation of *O. sinensis* is still not feasible on a level that allows commercial production. You might think, wait a minute, what about all the *Cordyceps* products I can buy in any supplement store? Well, they are derived from ground-up dried anamorphic mycelium grown predominantly on grains. An anamorph is the asexual form of a fungus, meaning without meiosis or the development of a proper sexual organ; all the mushrooms we are familiar with as food are actually fungal sex organs. And the fruiting body of wild *yartsa gunbu*, which is growing out of the head of the larva, is just such a sexual organ. In mycology this is referred to as sporocarp, or spore-bearing structure. The fruiting body is also referred to as teleomorph when juxtapositioning to the anamorph. However, an anamorph mycelium has the capacity to grow propagules, often conidiospores. These reproductive cells are genetically just a clone of their parent organism (therefore called “asexual”). Thus some fungi can exist predominantly or even solely in this anamorph state. Interestingly, in the past anamorphs were known as *Fungi imperfecti*, but mycological progress has shown that these anamorphs are not their own class of fungi, but an “alternative life form.” Furthermore, the anamorph discussion has gained some steam, since mycologists in 2011 met in Melbourne and adopted an International Code of Nomenclature for algae, fungi, and plants (ICN) concept whereby “1F1N” (= one fungus one name) applies, which has led to the adoption of a multitude of new name combinations, since two genera may have to be combined into one (Hawksworth, 2011). For example, the source of the famous drug cyclosporine, an immuno-suppressor given to a



Figure 9. Tibetan women searching for the elusive caterpillar fungus in the mountains near Gyegu (Yushu TAP), South Qinghai Province. Note how they are bending over to spot the tiny brown fruiting bodies. Collectors may find up to 100 'bu a day, but more common is about 10 to 40. But in a bad year people search for a whole day to find a few or might not find any.

patient receiving an organ transplant to avoid transplant rejection, was derived from *Tolypocladium inflatum*. Many years later Kathy Hodge et al. (1996) realized that *T. inflatum* was the anamorph of *Cordyceps subsessilis*! In 2007 *C. subsessilis* was transferred to the newly erected genus *Elaphocordyceps*, named for *Cordyceps* species parasitizing *Elaphomyces* truffles. Surprisingly the insect parasitizing *C. subsessilis* is closely related, thus it was transferred to *Elaphocordyceps* (Sung et al., 2007). Applying the new 1F1N concept, one of the two generic names (*Elaphocordyceps* and *Tolypocladium*) of this polymorphic species had to be dropped. Thus, anamorph and teleomorph are now both

named *Tolypocladium inflatum* (Quandt et al., 2014). *Tolypocladium* was chosen over *Elaphomyces* due to its economic value as a source of cyclosporine. In this realignment all the truffle *Cordyceps*, such as *Elaphocordyceps capitata* and *E. ophioglossoides* had to be transferred to *Tolypocladium* as well.

So far, artificial *C. sinensis* production has relied on growing the anamorphic mycelium. As it turns out, what is labeled in trade as *C. sinensis* seems not to be the actual anamorph of *O. sinensis*. Still, much of the medical research has been carried out using this mycelium, which also contains many of the active ingredients, the most famous being cordycepin. Growing the teleomorph--the actual fruiting body of *O. sinensis*--on a larva has not been successfully performed on a scale that has resulted in a commercially viable product. However, great progress has been made in recent years, but since successful artificial production of the insect-fungus complex would promise hundreds of millions in revenue, not many details are published on the

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Figure 10. A *yartsa gunbu* collectors' camp snowed in. Snow melts under the intense high altitude sun, usually in a day or two. Here, no one freezes to death; Tibetans are used to the harsh conditions of their mountain environment in Nyachuka/Yajiang County (Ganzi TAP).



Figure 11. *Khukhu shamo*, the “cuckoo” mushroom as Tibetans know morels (*Morchella* spp.). The famous cuckoo bird returns at the same time morels fruit in the forests and caterpillar fungus emerges high above on the alpine grasslands.

process and progress of cultivation. The fact that artificial production of a regular fruiting body (though attempted for many decades now) has been elusive, while the closely related bright yellow-orange fruiting bodies of *Cordyceps militaris* are successfully cultivated on grand scale, is quite perplexing. (See article on cultivating *Cordyceps militaris*

elsewhere in this edition of FUNGI.) But this may not be too surprising, taking into account that many years were spent on using the misidentified anamorph and that the reproductive cycle seems to include a stage in a plant.

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The incredible value of *yartsa gunbu* has transformed rural Tibet, and not just Tibet Autonomous Region (TAR), which encompasses about a third of the Tibetan cultural area, but also the other 2/3 of the Tibetan Plateau administrated as Tibetan Autonomous Prefectures (TAP) in Qinghai, Sichuan, Yunnan, and Gansu Provinces. For 2006, I had calculated that nearly 10% of the GDP of TAR was derived from *yartsa gunbu* and I had looked into these numbers again in 2014 and the increase in value of the fungus kept up with the growth of the Tibetan GDP. However, the recent slump in economic growth in China has also affected the value of *yartsa gunbu* and prices are down by around 20% in recent years. Still, in vast rural areas of Tibet the collection of caterpillar fungus is the main source of cash, it is no exaggeration to state that rural Tibet has a fungally fueled economy! And life in the valleys comes to a halt when in spring every able body is camping high up in the summer grazing grounds searching daily for the elusive precious fungus. Most collection

is done by families or parties of friends, so besides the hardships of being a bit early up on the summer pastures, most Tibetans, nomadic or sedentary, enjoy the social aspect of 'bu camps. Most people are only allowed to collect within their home district or county, and even when collecting in a bordering district within the same county there can be high collection fees, some collected by government agencies, but some also by the families holding grazing rights. Since China has divided the Tibetan cultural area among five provinces, which all have *yartsa gunbu* habitat, there is a krummholz of regulations. However at this point, nearly every 'bu collector, as Tibetans refer colloquially to *yartsa gunbu*, needs to have a permit, which can range in price from CN¥35-5000 and above (US\$5-750) whether issued by a government agency or local people who have full control over grassland uses, the latter is more commonly practiced in the highly productive areas of Golok and Gyegu TAPs in South Qinghai.

In these areas one can easily run into road blocks or rather *yartsa gunbu* checkpoints and unless you are a local or you have a collection permit, one will not be allowed to pass. These areas were heavily impacted from collecting by outsiders, often Hui people, northwest Chinese Muslims who would come in droves that outnumbered local residents. Locals, to put it mildly, were not happy that their officials were selling off their resources for a fortune to outsiders without disbursing a good amount of the funds to the community. By popular demand these practices were faded out in the last decade.

The high collection fees have triggered interesting business models. (Disclaimer: I have not investigated these myself, but was told about them by collectors.) In counties that have rich 'bu resources, local teachers are not paid a salary, but compensated by guaranteeing them collection rights and thus enabling them to make much more money than they would be receiving on a regular teacher's salary (and all schools are closed during collection season anyway). In some places an entrepreneurial Tibetan will hire a crew of collectors and pay a guaranteed daily salary and provide housing and food. The daily wages are surprisingly low at CN¥100-200 (US\$15-30) taking the value of 'bu collected into



Figure 12. Lhamo ready to dig (left) and Pema digging *yartsa gunbu*. You have to be very careful not to break the larva from the fungal fruiting body when lifting it out of the ground for two reasons. Firstly, it is not clear in which direction the larva might project underground and secondly, in some habitats the ground is covered by extremely dense *Kobresia* sedge mats, which need a lot of force to be broken. The sedge roots are so dense that they are also cut into pieces and used as “bricks” for walling.



Figure 13. In the vastness of the Tibetan Highlands spotting the *yartsa gunbu* collectors is nearly as hard as finding the elusive fungus fruiting body itself. How many did you spot? (Answer is at the end of the article.) Some of them are bent over or lying on the ground here at 4,400 m (14,000 ft) near Amnye Machen Mountain in South Qinghai.



Figure 14. “Bu” searching women returning to their tents after a day of collecting on their high altitude *Cordyceps* hunting grounds near Lithang at 4,300 m (13,300 ft).

account, but hired collectors have very little financial risk, need no starting capital for high collection fees, and have hardly any expenses. The whole crew will search collectively a slope and whenever a ‘*bu*’ is found; it goes straight into the pockets of the boss. As a safety precaution collectors are asked to swear by the Three Jewels (Buddha, Dharma and Sangha) to not pocket any of the ‘*bu*’ collected. Some of the entrepreneurs might buy collecting rights for a mountain that is auctioned off by the community that has grazing



Figure 15. *Yartsa gunbu* being carefully cleaned and dried at home.

and hence foraging rights. They might pay tens of thousands of yuan for exclusive collection rights and that must be paid before they know how the season will turn out! And of course there are

nastier stories of ‘*bu*’ robbers, tying up herders for several days while plundering their slope. However, all in all, it is quite surprising how the collection is peacefully taking place every year,

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taking into account that people living in remote areas in tents with stashes of caterpillar fungus worth thousands of dollars and others traveling around with wads of cash in this all-cash economy. And yes, in very few places someone gets killed over caterpillar fungus collection disputes. The saddest story probably took place the day before we visited collection grounds in Naqu County, TAR in 2009. Two Tibetans fought over picking *yartsa gunbu*, one insisted no collection should take place around a sacred lake, while the other probably told him to get over it, knives were drawn, and one lay dead, his blood soaking into the sacred grounds. As sad as such events are, I am convinced if the same money was generated in any other industry on the Tibetan highlands, e.g. mining or logging, many more people would suffer and the ecological impact might be much worse.

And the stories from the Indian or Nepali Himalayas where lowlanders

try their luck, coming up from the subtropics with no mountain experience in thin cotton clothing and fall or freeze to death is not a Tibetan issue. Tibetans collect on their home turf, in areas they would graze their yaks a month later anyways. And some people stay behind in the valleys to take care of their elderly and the household livestock. Where possible, some of these people search the forests for morels (*Morchella* spp.), another valuable spring fungus, collected for export to European connoisseurs.

What about sustainability?

The incredible value and its importance for the economy of the Tibetan areas naturally trigger the question: What about sustainability? The current extreme pressure on natural populations of *O. sinensis* seems to reduce production in some areas, especially in marginal areas that are already plagued by grassland

destruction and soil erosion or other forms of degradation. However, the frantic collection has not endangered the resource to the point of production collapse yet, though some people like to suggest so. It is still growing plentiful in many areas where it has been collected for centuries. It is true, collectors find much less *bu* since so many people are collecting nowadays. In addition, climate change seems to wreak havoc; several *Cordyceps* seasons in recent years were impacted by lack of winter or spring snow showers (which usually guarantee a good harvest), or by temperatures that were unseasonably warm—two conditions reducing productivity. And there is basically no progress in China regarding implementing sustainable harvest practices. Everything is structured by the administrations to maximize collection. Meanwhile, the Chinese research community is spending millions annually on molecular and



Figure 16. Collectors with camping gear from several families on their way home from the collection camp. The season is usually over in mid-June in Eastern Tibet, but can last a month longer in Central Tibet.



Figure 17. At the end of the season *'bu* is dealt in all towns. It is cleaned for the market by removing the mycelium that covers the larva. This is much easier after *yartsa gunbu* is dried. Yet to be cleaned caterpillar fungi are lying on a field bed. Fresh *yartsa gunbu* is priced by piece, weighing does not work due to water content and soil in the mycelial coating. In addition, during the process of drying the larva and stroma will continue to shrink. Since the price is mostly based on size, a lot of experience is necessary to negotiate a good price when buying fresh or partially dried caterpillar fungus. Depicted here is the *yartsa gunbu* market in Gyegu (Yushu) town, Qinghai Province.



Figure 18. Tibetan *yartsa gunbu* dealers are negotiating a deal. Daily, probably over a US\$100,000 are traded in Lithang town alone, one of the centers of *yartsa gunbu* collection and trade in East Tibet.



Figure 19. Display of “dongchong xiaocao” in a high-end *Cordyceps* store in Chengdu, the capital of Sichuan. All *Cordyceps* are completely cleaned and sorted carefully by size. Beautifully bundled, and impressively priced, an ounce of the biggest caterpillar fungus costs more than an ounce of gold! It is estimated that the annual *Cordyceps* industry is worth more than a billion US dollars in China.

microbiological work around *O. sinensis* and its habitat producing fascinating research results (as partially shared above). However the research effort is driven by the desire to finally be able to grow the insect-fungus complex artificially in order to cash in big time and thus achieve “sustainability.” Unfortunately, this very narrow idea of sustainability completely ignores the reality and needs of the Tibetan and other mountain communities, which are in dire need of assistance to be able to develop sustainable management approaches. Most promising seems to be limiting collection duration to four weeks and/or the amount of collectors allowed per household (Winkler, 2009). Since there are no concrete long-term field trials on the Tibetan Plateau, to my knowledge, it is difficult to offer concrete management suggestions that would guide local administrations and people to harvest their resource truly sustainably to soften the blow of ever-increasing harvest pressure.

Further Reading

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Answer: 26 caterpillar fungus collectors are active on the slope, not counting a baby bundled on the back of its mother.

About the Author

Daniel Winkler, M.Sc., grew up collecting and eating wild mushrooms in the Alps and trained as a geographer and ecologist focused on environmental issues of the Tibetan Plateau and Himalayas. Working in Tibet, Daniel realized that *Cordyceps* is the economic backbone of rural Tibet's diverse mushroom industry and thus has been researching Tibet's ethno-mycology for 20 years and published dozens of papers on the subject. The last 20 years Daniel has also been foraging mushrooms in the PNW. With his travel agency MushRoaming LLC he is annually organizing and leading several mushroom focused eco-adventures to Tibet, such as the upcoming *Cordyceps* & morel expedition (May 29 to June 10, 2017), the Amazon, Colombia, the Austrian Alps and the Pacific Northwest [www.mushroaming.com]. Furthermore, Daniel is the author of field guides to Edible Mushrooms of the Pacific Northwest and California (both Harbour Publishing, 2011 and 2012) and Amazon Mushrooms with Larry Evans (2014).

Figure 20. The author, surrounded by a chain of snow mountains, is dwarfed by a brand new *yartsa gunbu* monument in Lithang. ↑

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