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CORDYCEPS SINENSIS

A precious parasitic fungus infecting Tibet

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Thick clouds enshroud the glaciated peaks towering beyond the alpine pasture. Even in June it is chilly here at 4300 meters. But Tsering and his wife Wangmo seem immune to the cold. Dressed in 21st Century Tibetan street wear, jeans, jackets and canvas shoes, they are combing the alpine pasture in slow motion. Their attire attests to feeling completely at home in this harsh environment. I have a hard time keeping the pace uphill with them. The lack of oxygen at this altitude troubles my lungs. Luckily, they move slowly - often stooped and from time to time kneeling down scanning the ground. Their eyes are fixed to the pasture

searching for yartsa gunbu, the elusive caterpillar-fungus.

Yartsa gunbu literally means “summer-grass winter-worm“ and describes well this strange life form; in early summer there grows out of the head of what used to be a worm in winter, a blade of grass. The “grass” is the fruiting body of *Cordyceps sinensis*, recently renamed as *Ophiocordyceps sinensis* (Sung *et al.* 2007) a strange fungus that parasitises alpine *Thitarodes* ghost moths. What faintly resembles the brown flower of a short sedge is actually the spore-producing fruiting body. *Cordyceps* and its thirty or so host species of ghost moth are endemic to the Tibetan Plateau and the Himalayas. Its habitat is the grass and shrublands around the treeline between 3000 m and 5000 m (Winkler 2005).

One day a healthy caterpillar will overwinter in these alpine grass lands, deep down in the roots of *Polygonum* knotweed, *Kobresia* sedges or *Astragalus* milk-vetch. Safely nestled in the roots of its favorite foods, a healthy caterpillar might hibernate, dreaming about metamorphosing into a gracious white-winged ghost moth that will flutter above flower-studded meadows. At first tentatively flapping its virgin wings it will quickly get to work scenting out a mate willing to engage in the eternal dance of the sexes in the three to five days of its transient moth lifespan.

Meanwhile, infected larvae are in for a completely different, although not less excit-



Fig. 1. A yartsa gunbu collectors' camp at 4200 m with Mt. Pema Karpo (Baima Xueshan, NW Yunnan) behind. Photo © Daniel Winkler.

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Fig. 2. A mature *Cordyceps sinensis* exposed in the ground, cleaned of the mycelial velum that usually encloses the larva. Note the red 'eyes', the head segment of the larva. Photo © Daniel Winkler.

ing, experience. The larva turned fungal host, having been diverted from its seasonal migration to deeper ground by the invading fungus, will wait out the harsh but arid Tibetan winter close to the surface. "Host" might be too innocuous a term to describe this abusive and fatal relationship. For once the guest has made itself comfortable, having forced its way through the exoskeleton, it starts feeding on its host. At first the "guest" dines respectfully on non-vital tissue. By then the moribund larva moves sluggishly. As a last rite of their union, *Cordyceps sinensis* directs the larva to crawl into a position ideal for fungal spore dispersal – essentially taking the host on one last outing before immobilizing it for good. This phenomenon is also reported from several other *Cordyceps* species.

By the time spring kicks in a fungally compromised larva is not much of an insect any more. The fungus will have completely gutted the interior of the larva replacing its contents with a mycelium of thread-like hyphae. Although the insect's remaining exoskeleton supports the illusion of a continued larval existence, by then it functions solely

as a fungal food cache, ready to be completely raided when warmer temperatures allow the fungus to burst forth as a fruiting body right out of the larva's fontanel (frontal region of the head capsule). This grass-like fruiting body will then serve as the means to disperse its millions of spores, thus initiating the next hostile take-over.

Tsering and Wangmo are searching the ground for this tiny fruiting body, protruding only 5 to 10 cm above ground, between freshly grown green and last year's dried up brown blades of grass. The search is well described as looking for a needle in a haystack; only that the needle has the size of a nail and the haystack is the vast expanses of Tibet's endless alpine grasslands. The search does not have too much in common with a typical mushroom hunt such as searching the forests for morels or matsutake, which are collected intensively in Tibet for export to Europe and Japan (Winkler 2008b). This morning Tsering and Wangmo and a few neighbours from their village Wang Shor, hike an hour to reach today's hunting grounds. They have already been combing the alpine pasture for nearly an hour now, when somebody a bit higher up on the slope breaks out in a loud, joyful whoop announcing the first find of the day. That's a great sign and spreads optimism. Ten minutes later it is Tsering's turn to exult and he proclaims 'bu', "worm" as many Tibetans call the fungus cum larvae. Wangmo rushes over as Tsering carefully inserts his home-forged wood-handled tool resembling a dandelion-digger. He inserts it carefully and lifts up a piece of the densely rooted sedge turf. With a big smile painted on his face he inspects which side the larva points to underground and breaks the turf in half releasing the bu. The underground insect part is all earth-covered.

During the collection season not only the larvae are taken over by the fungus, but most of Tibet seems to be infected too, because Chinese consumers hold it in such high esteem as a medicinal and culinary status symbol that they are willing to pay astronomical prices. Tsering and Wangmo's picturesque farming village, Wang Shor, is located in the Tibetan areas of northwest Yunnan. The village is nestled deep down in the valley between the

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Fig. 3. Yartsa gunbu fruitbodies bundled together and offered for sale, sitting on bulbs of *Fritillaria*, another wild-collected, precious Tibetan medicinal. Photo © Daniel Winkler.

high mountains. During the collection season it is nearly deserted. Only mothers with little children, and the old and infirm stay back. Neighbouring families cooperate to minimize the hands needed to control the simple irrigation channels keeping alive the freshly sprouting crops of barley, maize and rape seed. Often the women staying behind not only take care of the children, but also look after yaks, dzos (a yak-cow hybrid), sheep and horses. In addition, with the cash influx from yartsa gunbu, there is a whole new mobility, allowing more back and forth between hunting grounds and homesteads. A day hike up to the alpine pastures is now reduced to a drive of some hours. One bu season's earning is sufficient to buy a motorcycle. Chinese-made 125 cc motorcycles connect remote villages to market towns, whose streets are now crowded by a flotilla of these vehicles. In the late 1990s, only a few bu dealers made enough money to afford motorcycles.

Everyone available is searching for yartsa gunbu. The sheer vastness of Tibet's alpine pastures does not allow for crowding beyond the camps. There are no huge hordes to be

observed swarming the remote high mountains, but the actual extent of this seasonal migration becomes clear when talking to a Chinese official in Dengchen County. Being in charge of optimizing yartsa gunbu collection he proudly claims that 60% of the population participates in the fungal alpine quest. It doesn't really take governmental prodding to spur on Tibetans seizing this opportunity that supplies more cash to the community than any other economic activity.

Most Tibetans team up with friends and family to collect yartsa gunbu; turning harsh, but lucrative work into a social event. They pitch their tents close together, often along access roads. Such a crowd of collectors, flush with cash, also attracts its very own support system. Improvised stalls offer food for the five-week-long season. Tables to play pool, an obsession of Tibetan men, are transported up into the mountains to attract patrons. Shops offer instant noodles, snacks, bonbons, beer and batteries.

In 2008 there are fewer shouts of joy on the slopes than in the previous year. There are fewer fungi. Tsering explains that in some

years there is more bu, in other years there is less bu. This year's scarcity was caused by last year's light monsoon rains. Still, less yartsa gunbu does not reduce the excitement, since this year's crop is not just valued at an incredible 30 Yuan (£3) each as in the previous year, but mobile dealers are buying up caterpillar fungus for 40-50¥ (£4-5) per piece. Extra big specimens are sold on the slope for up to 100¥. To earn 50¥ would take two days of manual labor. Finding 5 to 15 fungi a day here is not uncommon, in some areas collectors easily find 20 to 40. Before everyone and their mother were swarming the pastures, collectors could even find a hundred specimens or more a day. But back when Tsering was a teenager, he sold a hundred bu at the same price he is selling one good specimen for now! Many old timers in the bu trade wax sentimental thinking of the

bags of caterpillar fungus they collected and sold for next to nothing in comparison to today's prices. Although Tsering is not finding as many fungi anymore – there are so many people collecting now – still he is very pleased with this season's earnings. He and Wangmo each made about 10,000 ¥ (£1,000), three times as much as the average annual per person income in rural Tibet.

During the collection season in May and June, regular backcountry life nearly comes to a standstill in the caterpillar-fungus areas. Schools close down; many students will accompany their parents into the mountains. Kids are highly esteemed collectors; being closer to the ground their sharp eyes are valuable assets when looking for the fungal needle in the haystack. It is next to impossible to hire workers unless one offers absurdly high

wages. For many years now county administrations or simply locals have set up roadblocks to prevent outsiders from poaching yartsa gunbu. However, in 2008 the manning of checkpoints was a moot point since Chinese paramilitary police had already erected roadblocks all over the Tibetan areas after the March uprisings that had spread into the yartsa gunbu areas, but not to Northwest Yunnan. As a result of the Chinese clampdown Tibetans needed special permits to leave their villages. However, the collection season went without major events; Tibetans chose to focus on the



Fig. 4. A happy Dondrup, holding a yartsa gunbu and sitting on a dwarf *Rhododendron*, 4400 m, Kongpo Barla, Tibet AR. Photo © Daniel Winkler.

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fungus, since it is the main source of cash income. The fungal money has become crucial for rural Tibetans. Not only essentials like school fees, hospital stays and taxes but also motorcycles, TV sets, DVD players and satellite dishes are paid for with this cash and it serves as “spore money” for investment in new businesses or other economic activities.

In June 2005 I researched the *Cordyceps* collection and trade in Tibet Autonomous Region in cooperation with Luorong Zhandui, a Tibetan economist, who was fascinated by my previous *Cordyceps* research (Winkler 2005), especially in regard to its contribution to rural income. For three weeks we toured the Tibetan hinterland rich in *Cordyceps*. We visited government offices in county and prefectural towns, improvised street markets, and collection camps in the mountains. One result of this cooperation was that Luorong submitted a policy advisory to the Tibetan government, which formed the basis for the first Tibetan regulations on collection and

protection of yartsa gunbu. In brief, the regulations stipulate surveys, development of a protection program, minimizing resource conflicts and standardization of the licensing system. It is still too early to judge if these initiatives are bearing fruit. Furthermore, based on the official production data and sales prices we collected in the field, I calculated that *Cordyceps sinensis* collection generates 40% of the cash income in rural Tibet (Winkler 2008a). In prime production areas, income contribution reaches 70 to 90%. Bachen, Biru and Tsok in Nagchu Prefecture are such filthy-fungus-rich counties. In Bachen some farmers hire Tibetans from resource-impooverished Shigatse Prefecture to work their fields and have bought apartments in Nagchu or Lhasa! Clearly, yartsa gunbu has developed into the most important source of cash for rural Tibetan families. And prices have kept going up every year. The first year I collected data on yartsa gunbu in 1998, I could have bought a pound of average quality bu for around ¥2000.



Fig. 5. A yartsa gunbu broker showing his morning heist of four pounds of fruitbodies worth over £10,000. Photo © Daniel Winkler.

In early 2008 I would have needed to fork out at least ¥35,000 for the same pound. Each year we see an increase in value of at least 20%. Top quality, defined by the length of the larva – size matters, especially for an aphrodisiac – costs up to ¥100,000 in the Tibetan areas and will sell in retail for ¥200,000 or more, being nearly as precious as gold. However, the global crisis has reached into the most remote corners of Tibet. Yartsa gunbu prices fell by over a third in late 2008. Looking at it from a different perspective, we might talk about a price correction and state we are back at a 2006 price level. However, a drought in 2009 drove prices nearly up to early 2008 levels.

There is no point in basing any statistics on the economic impact on remote Tibetans on these extreme prices fetched in fancy pharmacies in China's coastal boomtowns, where

nouveau riche Chinese are sure to impress their peers with a medicinal delicacy. Still, when calculating the contribution of 40t of yartsa gunbu production (annual production on the whole Tibetan Plateau is probably 150-200t) these sales figure at 8.5% of the Tibetan GDP, make a higher value than the industry and mining sector combined. Strangely, there is no clear section in Tibet's statistical yearbook tracking yartsa gunbu, but it seems partially subsumed under off-farm employment. However, much of the income is clearly not on the books. All in all, in Tibet a globally absolutely unique fungally fuelled economy has developed in the last decade. Cordyceps cash is now the main agent in the transformation of rural Tibet from a traditional subsistence economy living off livestock herding to a commodified economy.

In Lhasa a handful of big brokers control the business. They supply Chinese lowland phytopharma companies and the Tibet Autonomous Region government, one of their best customers. Yartsa gunbu is a popular gift, since presenting the fungus is not regarded as offering a bribe. Although there are risks and seasonal price fluctuations, the fact that the value of yartsa gunbu has increased tenfold in the last eleven years, makes it a very attractive business. Unfortunately, as with many other industries in Tibet, the caterpillar fungus trade is also dominated by outsiders, especially Huis, Chinese Muslims.

In Tibet, *Cordyceps sinensis* has probably been used for at least a thousand years. The use of the term yartsa gunbu can be dated back to the fourteen hundreds, where it is mentioned in a Tibetan medicine text by Nyamnyi Dorje; the chapter on yartsa gunbu being entitled "An Ocean of Aphrodisiacal Qualities". It starts out with this lovely line: "In this world sexual bliss is the most marvelous of all earthly pleasures, the essence of the enjoyment of all the senses" (Winkler 2008a). However, in Tibetan Medicine the appreciation of yartsa gunbu goes beyond its lust-enhancing qualities. It is regarded as one of the "medicinal essences", a category that includes ginseng and other tonics. It is used for general strengthening, boosting the immune system and increasing virility, and is prescribed for kidney and heart problems. It is

also used for treatment of hepatitis B. Unlike in China, where patients often take the fungus by itself, in Tibetan medicine it is mostly prescribed in formulated composite remedies, which contain a variety of ingredients to balance each other, thus optimizing their efficiency and minimizing side effects.

In traditional Chinese medicine *Cordyceps sinensis* is called dongchong xiacao, a literal translation of the original Tibetan name. It is regarded as a powerful remedy for asthma and TB, and thus was rumoured to help against SARS. However, its main lure is its tonic function, to speed up convalescence, prevent sickness, and boost the immune system and vitality. Of course, anything that boosts vitality will boost libido as well, which in turn attracts the segment of consumers with the most disposable income, namely men over fifty! Many Tibetans perceive the *Cordyceps'* Viagra-like function as the main reason why the Chinese are paying a fortune for these caterpillars. When I asked some Tibetan men if they use some of the "bu" they gather, I was answered with laughter. "We don't need to take that!"

There are a multitude of studies demonstrating the medicinal potential of Cordycepin and Cordycepic acid and many other active components, especially polysaccharides, contained in *Cordyceps sinensis*. Cordycepin is nearly identical to Adenosine, it only lacks one oxygen. Adenosine is one of the four nucleotides that make up our DNA and is also crucial in supplying our cells with energy in the form of ATP (Adenosine triphosphate). Research results document lowering bad HDL cholesterol, improving blood circulation, and increase of stamina facilitating better utilization of oxygen in the body (Holliday & Cleaver 2004, Paterson 2008). In 1993, the latter was brought to the attention of the western world during the athletics world championships in Stuttgart, Germany, when to everyone's surprise Chinese women runners won several long distance races in astounding world record times. This success raised many eyebrows, although their coach Ma Junren, claimed the exceptional success was due to "intense high altitude training, turtle blood and *Cordyceps sinensis*", both substances not restricted as a performance-enhancers. However, some years

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later coach Ma was implicated for illegally doping his athletes. Remember the Chinese athletes, who never arrived for the Sydney Olympic games after a new doping test had been announced just days before the opening? In 1994, the runners' successes were repeated at the Asia Games Beijing, but not at the next world championships. However, you will not read about turtle blood and Ma Junren's doping record on the webpages of *Cordyceps* distributors who still use the 1993 success of the Chinese runners for advertising *Cordyceps* products. Currently much research is directed to possible anti-tumour, anti-cancer and anti-viral activity, for instance a very interesting paper from the University of Nottingham on Cordycepin has just been published (Wong *et al.* 2010). Of great interest also are its immuno-modulating effects. Such effects should not be surprising, since *Cordyceps subsessilis*, a close relative of *C. sinensis*, is the source of Cyclosporine. This drug is administered to suppress an unwanted immune reaction to a transplanted organ, which would reject the new organ.

Sustainability & conflicts

Not surprisingly, bu collection also causes serious problems. Each year conflicts flare up over access to collection grounds and people get killed. Government agencies try to avoid such calamities by regulating collection and issuing permits, but so far there is no uniform approach in Tibet AR, Qinghai, Sichuan, Yunnan and Gansu, the five provinces dividing up Tibetan cultural areas in China that administrate the yartsa gunbu habitat. Some Tibetans are worried that the easy bu money undermines efforts to integrate and empower Tibetans in the transforming economy. Many Tibetans spend their fungal cash in new stores that have just been opened by newly arrived Hui or Han Chinese. Should the yartsa gunbu market crash, be it by cheap competition from bred larvae that are artificially infested—trials of such programs have been underway for decades—a collapse of demand or a population crash, or should climate change reduce the alpine habitat, the consequences for all of rural Tibet would be extremely dire.

Above all, the issue of whether the current harvest intensity is sustainable looms large. In

the first two weeks of the season none of the fungi are sporulating. Even later on in the season, at least half, if not two thirds, of the bu is collected before spores mature. This is bad news for *Cordyceps*. In an ideal world only *Cordyceps sinensis* that had already produced spores would be collected in order to guarantee sustainability. However, no such practices exist nor are regulations formulated. Yang Darong, a Chinese entomologist claimed last year to have encountered only five specimens in a hundred square meter area where there used to be 40 specimens 25 years ago (Stone, 2009). Firstly, this claim lacks scientific documentation and secondly such an extreme decline would have been observed by Tibetan collectors as well. It does not take a scientist to notice such a population collapse. Furthermore, Yang claims production back then was 5 to 10 times higher than now. This claim contradicts all the historical production numbers I have come across which indicate a rather smaller production back then. Also, I have interviewed numerous collectors all over the collection area; many reported much smaller personal collection amounts in recent years, yet every single collector attributed that to the fact that there is a multitude of collectors. However, ever increasing harvest pressure and the absence of really reliable data clearly demonstrates that more research must be carried out to be able formulate sound management strategies to secure the long-term survival of *Cordyceps sinensis*. So far, I do not see a population crash. Both fungus and moth are collected in the final days of their life cycle. If there are enough spores around it might be possible to keep the bu population in good enough shape until simple and effective management practices can be enacted. I asked many Tibetans collectors and dealers if they share my worries and hardly anyone does. I hope this is not just denial. I pushed this point with Tsering and asked him if he can see a danger in over-collection. He doesn't see a problem. Tsering says, bu grows each year anew. I mentioned to him the widespread disappearance of forests after logging and the intense loss of wildlife in the 20th Century and asked, aren't you worried that might happen to bu as well? He didn't argue over the loss of forests and wildlife, but insisted that this



Fig. 6. A late season yartsa gunbu. The perithecium is fully developed and sporulation is underway. A mouse has chewed off part of the top. Photo © Daniel Winkler.

would not happen to *Cordyceps sinensis*, stating, “bu is very different, bu will always be growing”.

About the author

Daniel Winkler grew up collecting wild mushrooms in the Alps. He received a master in Geography, Ecology, and Biology at FU Berlin. Daniel lives in Seattle and works as researcher and NGO consultant on environmental issues of the Tibetan Plateau [www.danielwinkler.com]. Working in Tibet, Daniel realized that mushrooms play a crucial role in rural Tibetan. Daniel also leads annually “MushRoaming” tours to Tibet [www.mush-roaming.com] and other exotic destinations.

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