Photos: D. Winkler

Photo 1: A Tibetan family looking for Yartsa Gunbu. At this site there were 8 specimens in the ground within a few square meters. 4,400 m, Nagchu County, Nagchu Prefecture, Tibet AR

Caterpillar Fungus *(Ophiocordyceps sinensis)* on the Tibetan Plateau

The vast grasslands of the Tibetan Plateau provide the natural resources Tibetans' traditional livestock herding has been dependent on for millennia. Even nowadays, it seems that every blade of grass on the Tibetan Plateau, no matter how remote, is grazed by a yak or sheep. Most rural households still rely on their pastoral and agricultural products to feed their families.

The integration of traditional subsistence products, such as butter, barley or dried meat into the Chinese economy has not taken place due to a range of constrains, amongst them culturally differing culinary preferences and communication problems. However, Tibet's rural communities have being integrated rapidly in the last 15 years thanks to the phenomenal proceeds of Caterpillar fungus or *Yartsa Gunbu*, a precious medicinal fungus, sought after by Chinese consumers.

Caterpillar fungus

Yartsa Gunbu means "summer grass-winter worm" in Tibetan and describes well how the sedge-like fruiting body (= stroma) of the fungus grows in spring out of the head of a larva *(Figure 1)*. The stroma belongs to the entomophagous fungus *Ophiocordyceps sinensis* (syn. *Cordyceps sinensis*) that parasitizes the larvae of 30+ ghost moths *(Thitarodes spp.)*. Together, the dried club-shaped stroma and the larva are traded as a precious medicinal. The use of *Yartsa Gunbu* probably dates back at least a thousand years in Tibet, but first scriptural reference of *Yartsa Gunbu* in Tibetan medicine is found in a text authored by *Nyamnyi Dorje*, "An Ocean of Aphrodisiacal Qualities – A special work on Yartsa Gunbu" in the 15th Century *(Figure 2)*. In Traditional Chinese med-

icine, where it is known in Pinyin as "dongchong xiacao", which is a literal translation of its Tibetan name, its first mention is by *Wang Ang* in 1694 (*Winkler* 2008a).

In traditional Tibetan and Chinese medicine *Ophiocordyceps sinensis* is recognized as a powerful tonic and aphrodisiac. It is also prescribed for lung, liver and kidney issues. Western medical research on *O.s.* suggests anti-viral, anti-tumor, and anti-cancer activities (*Wong* et al. 2010), immuno-modulating effects, anti-oxidation, reduction of cholesterol, and increase of stamina and libido (*Holliday* and *Cleaver* 2004). This myco-medicinal is mostly consumed by Chinese communities and elsewhere in East Asia. Furthermore it has become a fashionable luxury product, often given as a gift, and used as a culinary status symbol. However, it has not really penetrated the western market. Most *Cordyceps sinensis* sold in the West is dried and ground mycelium artificially grown on grains.

Photo 2: Collectors camp along highway in Caterpillar fungus habitat in Litang around treeline in 4,500 m a.s.l., Litang County, Garze Tibetan Autonomous Prefecture, Sichuan

The quality of Caterpillar fungus collected in the wild is mostly based on size of the larva, the bigger the better. Another important quality feature is firmness of the larvae and the length of the stroma, which ideally should be the length of the larva or shorter *(Figure 1)*, indicating an early harvest before the stroma started to produce spores. When *Yartsa Gunbu* is collected late in the lifecycle of the fungus, the larva becomes soft and shrinks during drying. This late stage *Yartsa Gunbu* has just a fraction of the economic value of a specimen harvested in

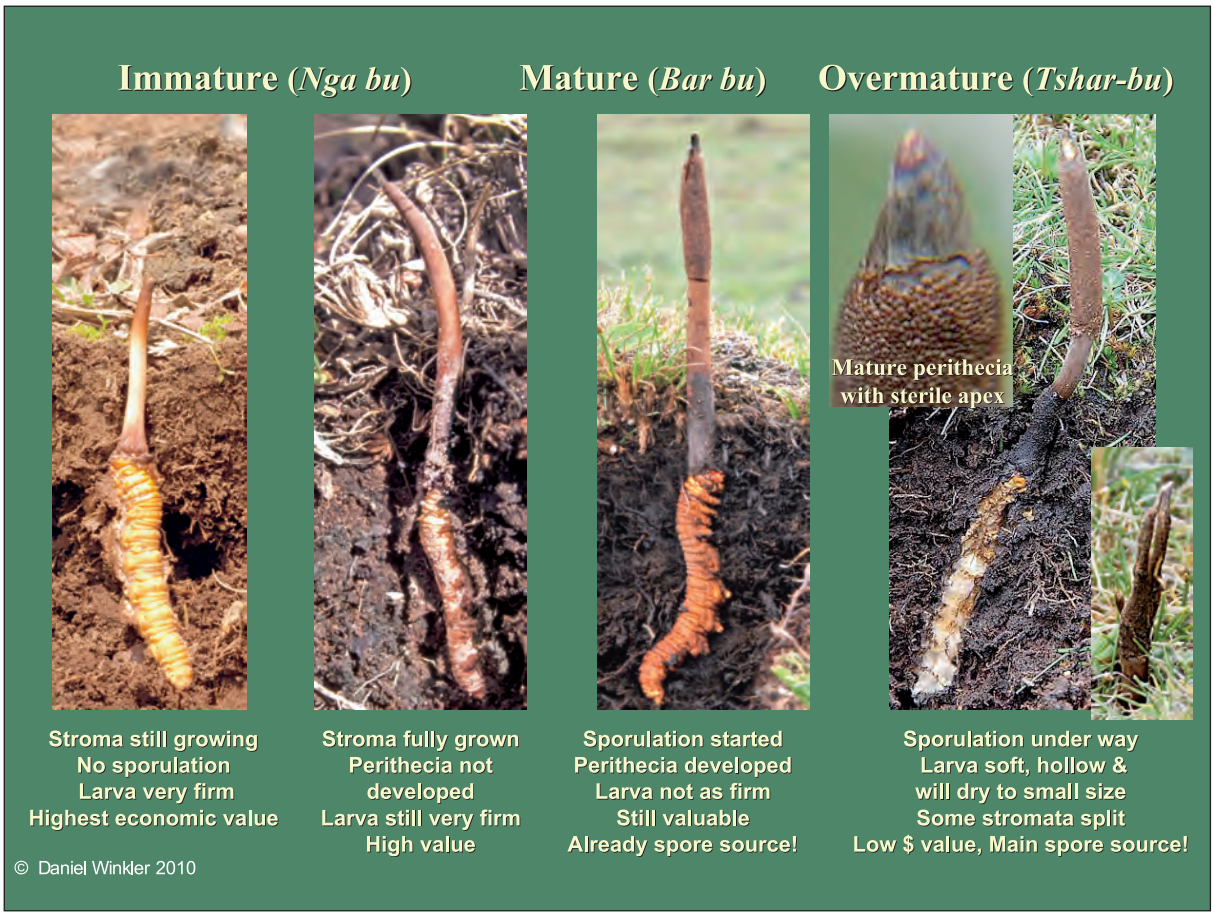

Figure 1: Fruiting stages of Ophiocordyceps sinensis

Design: D. Winkler

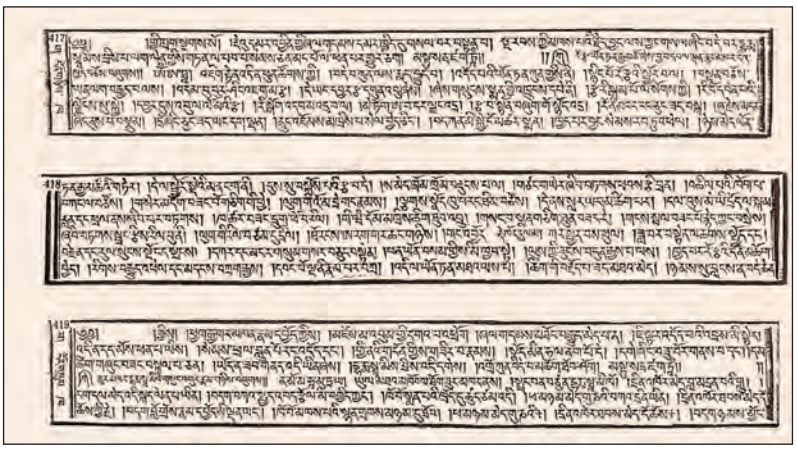

Figure 2: First pages of the Tibetan text on Yartsa Gunbu

Source: Zurkhar Nyamnyi Dorje

prime condition, but since spore dispersal can continue for several weeks, it has the highest ecological value a fact that will be discussed under sustainability issues.

Caterpillar fungus occurs in alpine ecosystems on the Tibetan Plateau and the Himalayas. In China the distribution area spans Tibet Autonomous Region (TAR), Qinghai, Sichuan, Gansu and Yunnan. In the Himalayas it is collected in Nepal, Bhutan and India *(Figure 3)*. It is distributed in grass- and shrublands that receive a minimum of 350 mm average annual precipitation. It occurs in an altitude of 3,000–5,200 m rising from the east to the west of the plateau. Locally it grows within an altitudinal range of 500 m around the potential tree line. In general Caterpillar fungus is a spring fungus, like morels (*Morchella* spp.). The peak fruiting season is in May and June and lasts locally about six weeks.

Economic relevance of Caterpillar fungus collection

Caterpillar fungus has been collected for centuries in substantial amounts, already tens of million specimens in the 19th Century (*Winkler* 2008). In recent years value and collection intensity have immensely increased. Its value has increased by 900 % between 1997 and mid 2008. In mid 2008, average quality sold for ¥30,000 (€3,000) per jin (500 g), top quality sold for up to ¥80,000 (€8,000) in Lhasa. In Shanghai the same quality *Yartsa Gunbu* fetched up to ¥160,000 (€16,000). The importance of the income from fungus collection and trade for rural Tibetans cannot be overemphasized. In 2004, TAR caterpillar fungus production figured at 50.5 tons. At a market price of ¥18,000/jin this represents a value of ¥1.8 billion, equaling 8.5 % of the GDP of Tibet AR, exceeding the complete secondary sector of mining and industry (¥1.5 billion in 2004).

At rural and small town level per capita income from caterpillar fungus collection in 2004 figured at ¥463 based on a conservative value of ¥11,000/jin, representing 25 % of the per capita income (¥1,861 in 2004). The contribution to cash income should be at least 40 % for the rural population in TAR (all figures from *Winkler* 2008a and 2008b). Income contribution in 2009 was comparable; per capita net income of Tibetan farmers and herdsmen reached ¥ 3176, the harvest of Tibet Statistical Yearbook 2008. Beijing: China Statistics Press, 2008.

Similar, astonishingly high, financial contributions can also be expected in the prime collection areas of South Qinghai Province. For Yushu Prefecture *Gruschke* (2008) has calculated that the value of the *Cordyceps* harvest is three times as high as the total budget of the prefecture! Income contribution has further increased since 2004, up to early 2008 when *Cordyceps* value peaked, but in connection with the global financial crisis caterpillar fungus prices came down 30–40 % in China in late 2008 retreating to 2006 levels. A poor harvest in 2009 in TAR, attributed by many collectors to an unusually dry spring and a belated arrival of the monsoon rains pushed prices in summer 2009 nearly back to pre-crisis levels.

Figure 3: Distribution area of Ophiocordyceps sinensis (green, white area: Tibetan Plateau)

Impact on rural communities

This immense stream of cash income to rural communities from Yartsa Gunbu has caused a far-reaching transformation of the social and economic conditions in the last 15 years. Yartsa Gunbu income provides cash for health care, education and transportation – especially motorcycles and plen-

ty of consumer goods (i.e. TV sets, DVD players etc.). Furthermore, the fungal income provides "spore" money for entrepreneurial activities such as trade and community activities. It also opened access to bank loans, which were next to impossible to obtain for rural Tibetans. Thus, income derived through the collection and trade of this precious myco-medicinal has led to an empowerment of marginal communities, often living in extremely remote locations, who used to secure their survival through pastoral and agricultural activities.

Furthermore, the cash influx has led to a commodification of local production and services. In fungal resource rich areas, formerly non-cash based exchanges of local products, and more intriguingly neighborly work assistance, is now being compensated in cash instead of barter goods or work exchange. Farming or herding work services are solicited with the newly available cash resources. Thus, the Caterpillar fungus boom is facilitating the integration of rural Tibetan households into regional, national and international economic cycles by providing the necessary product and cash in exchange for participation.

However, this transformation is also causing challenges. In the past community disputes mostly occurred over grazing rights. Now, they are mostly fought over access to Caterpillar fungus resources. Some of these turn violent, a few even deadly each year. The availability of cash allows for outsourcing of services, which by itself is not negative. However, often outsiders are hired for construction and other jobs and not enough locals are taking up such trades, which would strengthen local economies and generate incomes year round and possibly beyond the fungal boom. Thus, the immense income that can be made from Yartsa Gunbu collection also undermines engagement in long-term economic activities, which offer much smaller economic returns and economic diversification should be an objective by policy makers.

In recent years an array of research papers has shed light on the Yartsa Gunbu phenomenon from many perspectives, such as anthropological, geographical and socio-economic perspectives, documenting the impact especially on rural Tibetan communities (*Winkler* 2010). In a nutshell, all these papers elicit how intricately the income generated from *Yartsa Gunbu* collection and trade is now interwoven with local socio-economic processes and how dependent these communities have become on the fungal income. Loss of this income stream, if it should run dry, be it due to resource exhaustion, successful artificial cultivation or any other reason would have a catastrophic impact on rural communities.

Annual production

Reliable figures on the annual production on Caterpillar fungus are still lacking from many production areas. So far, the most detailed figures available are from Tibet AR on prefecture level *(Figure 4)*. Also in recent years localized studies from the Himalayan production areas have been published. In a review of all available figures from the Tibetan Plateau and the Himalayan an annual harvest ranging from 83.2 to 182.5 t was estimated, most likely figuring annually around 140 t (*Figure 5*, *Winkler* 2010), but the informal aspect of harvest and trade undermines reliability of these production figures and estimates. Having reliable data is of great importance to understand the industry, its importance for the whole region and also to assess its sustainability in light of a lack of sound long-term in-situ studies on the impact of intense annual collection.

The production data for Tibet AR *(Figure 3)* between 1999 and 2009 demonstrates that annual harvest amounts fluctuate. Comparing specific prefectures, i.e. Naqu and Qamdo, it becomes evident that fluctuations occur often in a non-synchronous way;

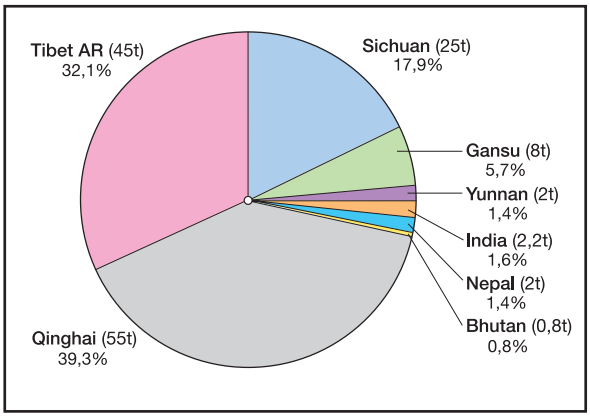

Figure 4: Estimated average annual production of Caterpillar fungus presented by production regions

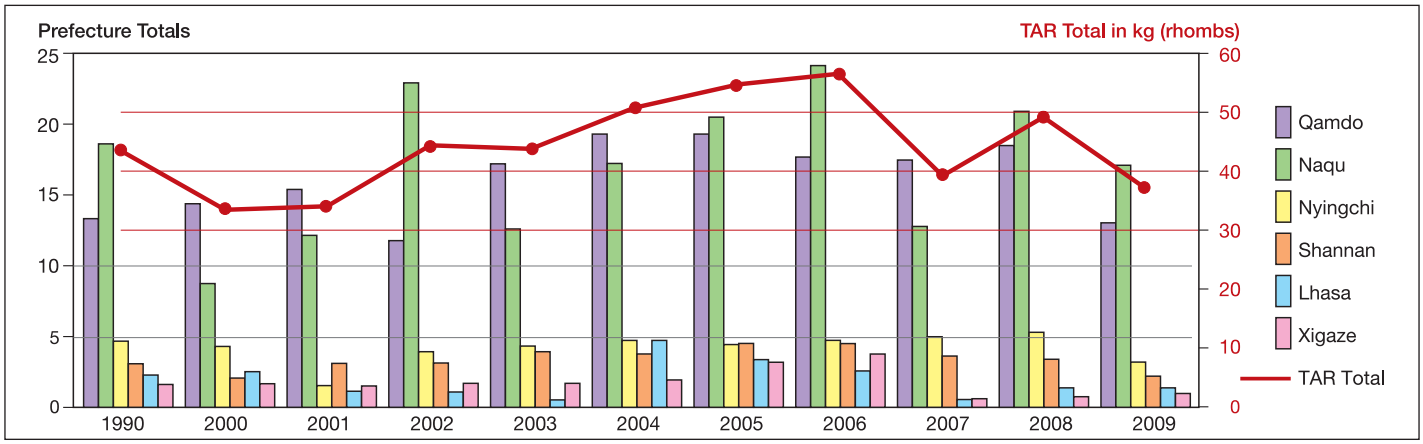

Figure 5: Annual Caterpillar fungus production by prefecture in Tibet AR

for example, in 2002 Naqu had an excellent harvest, while Qamdo had a low harvest, while in 2007 Qamdo's harvest was above average and Naqu had a very low yield. The low overall harvest in Tibet AR in 2009 can probably be correlated to the drought, which was reported the worst in 30 years.

Sustainability of collection

The lack of scientific data regarding sustainability is striking. Any resource of such immense value, and key relevance to rural livelihoods as the main cash source, runs the risk of being over-exploited. The current (and apparently increasing) harvest pressure on Caterpillar fungus is unprecedented. With increasing numbers of Tibetans collecting, the absence of traditional sustainable collection techniques and, in some cases local governments optimizing collection, the issue of sustainability looms large. In a 2008 unpublished report *Yang* suggested that the *Cordyceps* production has collapsed and current output is down to 3–10% of the output from 20 years ago (*Yang* 2008, *Stone* 2008). *Yang's* claim is extraordinary, but is not backed up by baseline data derived from field plots or government agency production figures. Annual harvest in TAR from 1999 to 2009 fluctuated between 35 to 55 t. In short, published and unpublished figures do not indicate a population crash so far, but don't preclude a slightly reduced harvest in specific production areas. Research on the actual consequences of the impact of intensive harvest of Caterpillar fungus is noticeably lacking in China. Interestingly, Bhutan, whose annual *Cordyceps* production figures below 1% of the overall production, has so far the most advanced field study regarding Caterpillar fungus growth and harvest impact (*Cannon* et al. 2009), but it is too early for any results regarding the impact of harvesting on annual production.

Photo 3: For sale: Caterpillar fungus

Collection of *Yartsa Gunbu* is not a new phenomenon; it has been collected in the same locations for centuries and is still present in most such areas, attesting to its resilience to human collection. The few production statistics available (*Winkler* 2008a, 2010) seem to report stable or increased production, but the lack of multi-annual reduced harvest could be veiled by two factors; more people searching more intensely and also areas being searched not previously accessed for fungal extraction. Furthermore, some areas might have lost their production capacity too. However, in my experience, having since 1998 visited nearly annually a production area, be it in Garze Prefecture (Sichuan), Deqen (Yunnan), Maqen (Qinghai), Naqu, Qamdo and Nyingchi (TAR), most collectors and dealers interviewed did not report reduced output, but reported reduced harvesting rates per collector due to increased competition. Overall, there might well be cases where there are reduced harvests, but none reflecting the catastrophic production crash claimed by *Yang* and spread worldwide (*Stone* 2008).

Recently, climate change as a possible threat to Caterpillar fungus production has been stated (*Yang* 2008, *Stone* 2008, *Cannon* et al. 2009, and *Winkler* 2010). *Yang* (2008) attributes it as the main cause besides over-exploitation. Recent warming, according to *Yang*, should have pushed up the altitudinal limits of the prime Caterpillar fungus habitat by around 200–500 m. Although *Yang* does not elaborate on this, but a "climb up the mountain" of the habitat would mean a decrease in available surface area just by the nature of the shape of a mountain. In addition, increased altitudinal habitat limits would imply reduction in soil development and soil fertility, reducing suitable habitat for ghost moths populations, since soil development is a very slow process in alpine conditions. Thus, the upward movement of the climatic conditions suitable to Caterpillar fungus growth would seriously undermine overall habitat availability. *Yang* is not considering a fruiting adjustment to potential warming on a temporal instead of spatial vector. However, so far there is no baseline research that would allow comparing past habitat to suggested current habitat, and climate change as a cause for *Yang's* unproven production crash remains a hypothesis and not a fact.

Steps toward sustainable management

The dependency of the rural communities on such a precious resource argues for continued harvest of Caterpillar fungus. The fact that *Yartsa Gunbu* has been collected for centuries indicates that no overhasty measures are required. The licensing system implemented widely in TAR and other regions could be an important step for resource management, if used appropriately (*Winkler* 2008b), since license issuing facilitates communication between collectors and "resource managers", usually local officials.

Cannon et al. (2009) report from Bhutan, "In the long term, the only viable way of ensuring sustainability of wild *Yartsa Gunbu* harvest is through locally focused natural resource management,

with the villagers making their own informed decisions about collection policy". The main conservation initiatives in Bhutan are a limit of the harvest season to one month, only allowing collectors from local households and in addition trials in limiting the amount of household members eligible for collection.

However, in the Tibetan areas in China it is much more likely a top-down approach would be chosen. Government agency formulated regulations addressing issues of sustainable harvesting schemes could be successfully applied, if they are implemented skillfully with a good amount of flexibility necessary to adjust to local realities, since *Yartsa Gunbu* fruiting varies slightly according to altitudes and latitude. The most practical and thus promising approach is limiting the collection season to four or five weeks or simply setting an official ending date to the collection season. Collectors will have had the opportunity to already collect substantial amounts. The end of the season date should be set at the point when the economic value is dropping due to larval decay and the ecological value is exploding due to peak sporulation. The objective is retaining sufficient sporulating Caterpillar fungi in the ground to secure sustainability. And since these overmature specimens are much less valuable, such a management plan should find more easily local support, than alternatives such as closing off certain areas or limiting collection in other ways.

Photo 4 Yartsa Gunbu Seller in Bayi, Nyingchi Prefectutre, TAR

Conclusions

With the steadily increasing value of *Yartsa Gunbu*, rural households on the Tibetan Plateau and in the Himalayas benefit substantially from the caterpillar fungus industry. Fungal wealth is spread into the most remote areas to otherwise marginalized households. Still, developing a resource of such value is becoming more and more pronounced. The lack of clear production data in many areas and the fact that so far only Bhutan is conducting long-term in situ studies on harvest impact is striking for a commodity of such value and importance that runs the risk of overexploitation. However, its long history of harvest suggests that the resource is resilient. It is of paramount importance to develop science-based resource management plans that can be implemented in a simple way taking into account the remoteness of the production areas.

It is long overdue that Chinese research institutes launch their own field trials regarding sustainable harvest methods. In regard of resource management, taking into account the limited scientific evidence available, the most pragmatic approach for the Caterpillar fungus producing region in China would be to announce at county or prefecture level limited collection seasons. Annually set dates could terminate the collection seasons four weeks after it commenced to secure sufficient Caterpillar fungus spore disposal to secure rich Yartsa Gunbu harvests for future generations. III

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