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Steps towards Sustainable Harvest of Yartsa Gunbu (Caterpillar Fungus, *Ophiocordyceps sinensis*)

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Summary

Caterpillar fungus (*Ophiocordyceps sinensis*) is an insect-parasitizing fungus endemic to the Tibetan Plateau and the Himalayas. It has become the most important source of cash income in wide areas of the Tibetan Plateau and the Himalayas, where it is known as *Yartsa Gunbu*, "summer grass winter worm". The value of this fungus-insect larva complex has increased 10-fold between 1997 and 2011. Centuries of collection indicate that caterpillar fungus is a relatively resilient resource. Still, unprecedented collection intensity, and the recent economic dependence of local economies on caterpillar fungus collection and possibly climate change calls for sustainable resource management. Most promising is an education campaign spreading the knowledge on fungal reproduction to encourage cessation of collection of low-value late-season specimens and an easily implementable establishment of an end date to the collection season, which might allow for sufficient spore dispersal to guarantee sustainability. Interviews with collectors, dealers and administrators during field work in Yushu Tibetan Autonomous Prefecture, Qinghai Province, have yielded promising results that support for such an initiative likely could be obtained if there is sufficient outreach that explains the reproductive mechanism of caterpillar fungus to all stakeholders.

Introduction

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, sheep or goat. 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 fifteen years thanks to the phenomenal proceeds of Caterpillar fungus or Yartsa gunbu, a precious medicinal fungus-larva compound, sought after especially by Chinese consumers.

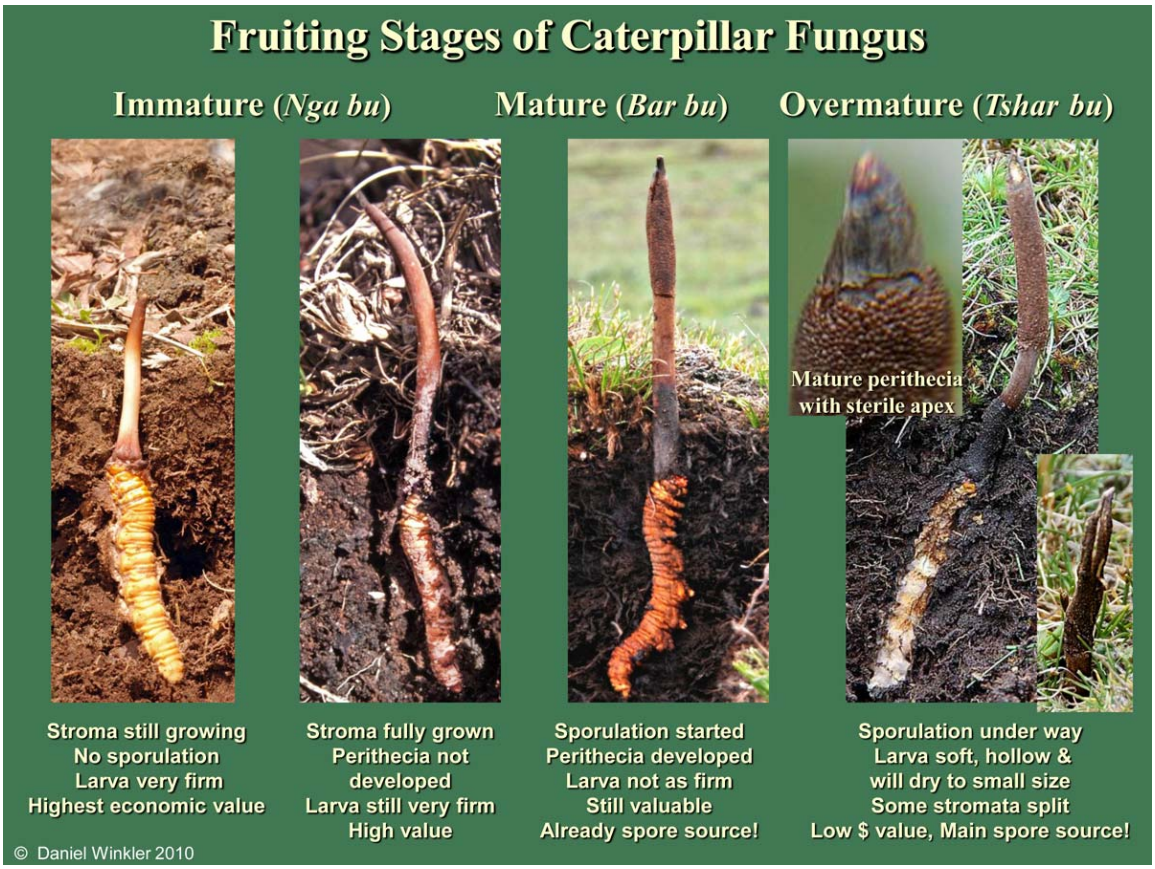
Caterpillar Fungus

Caterpillar fungus (*Ophiocordyceps sinensis* [Sung et al. 2008], synonymous *Cordyceps sinensis*) is an insect parasitizing fungus endemic to the Tibetan Plateau and the Himalayas. Tibetans know it as Yartsa gunbu (Wylie*: dbyar rtswa dgun 'bu*), which means "summer grass-winter worm" and describes well how the sedge-like fruiting body (= stroma) of the fungus grows in spring out of the head of a larva (Fig 1). The stroma belongs to the entomophagous

fungus *Ophiocordyceps sinensis* that parasitizes the larvae of more than thirty 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 Nyamnyi Dorje's 15th Century writing "*Instructions on a Myriad of Medicines* (Wylie: *man ngag bye ba ring bsrel pod chung rab byams gsal ba'i sgron me mal gro gung dkar,* Winkler 2008b). Within this volume there is the text "An Ocean of Aphrodisiacal Qualities - A special work on *Yartsa Gunbu*". In Traditional Chinese Medicine, where it is known as 冬虫夏草 (Pinyin: 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. Medical research on *O.s.* suggests anti-viral, anti-tumor, anti-cancer, immuno-modulating effects, anti-oxidation, anti-aging (i.e. Thiyagarajan et al. 2012) reduction of cholesterol, increase of stamina and libido (see Holliday & Cleaver 2004). For Cordycepin, the best researched active ingredient of Cordyceps, anti-cancer activities (i.e. Wong et al. 2010), and anti-inflammatory (i.e. Kondrashov et al. 2012) capacity has been demonstrated, however no western anti-cancer clinical trial have been published yet. This myco-medicinal is mostly consumed by Chinese communities and elsewhere in East Asia. Furthermore it has also become a fashionable luxury product, often given as a gift (Yeh & Lama 2013), and used as a culinary status symbol.

Fig. 1: Fruiting Stages of *Ophiocordyceps sinensis*



However, it has not really penetrated the western market. Most 'Cordyceps sinensis' sold in the West is dried and ground mycelium derived from the CS4 strain, which is usually artificially grown on grains. None of these products is based on *Hirsutella sinensis*, regarded as the anamorph of *Ophiocordyceps sinensis*, however much of the medicinal research used CS4 derived material and not the costly natural product.

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 (compare Fig. 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 Caterpillar Fungus has just a fraction of the economic value of a specimen harvested in 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 (Fig. 2). It is distributed in grass- and shrub-lands that receive a minimum of 350 mm average annual precipitation. It occurs in an altitude of 3000-5000 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. The peak fruiting season is in May and June and lasts locally about six weeks.

Fig. 2: Distribution area of *Ophiocordyceps sinensis* (green, white area: Tibetan Plateau)

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 the last 15 years value and collection intensity have immensely increased. Currently 1 kg of dried Yartsa Gunbu costs in Lhasa, Tibet from ¥ 80,000 to 160,000 (US$12,000-25,000) depending on quality. After careful sorting, 1 kg of excellent quality can cost up to ¥600,000 per kg ($90,000/kg) down in Chinese coastal cities. In June 2012, one specimen cost anywhere from ¥10 to 130 (US$ 1.5 to 20) in the field, size being the key factor. Its value has increased by over 1000% between 1997 and 2012. In mid 2011, a bag of mixed average quality sold for ¥40,000 (US$ 6,500) per pound (500g), top quality sold for over to ¥80,000 US$ 12,000) in Lhasa. In Shanghai the same quality Caterpillar Fungus fetched up to ¥180,000 ($28,500). In 2012 prices increased further. The importance of the income from fungus collection and trade for rural Tibetans cannot be overemphasized. In 2004, Tibet AR caterpillar fungus production figured at 50.5 tons. At a market price of ¥18,000 / pound this represented a value of ¥1.8 billion, equaling 8.5% of the GDP of Tibet AR. The contribution to rural cash income should be at least 40% in Tibet AR (all figures from Winkler 2008a & 2008b). Income contribution in 2009 was comparable. Similar, astonishingly high, financial contributions can also be expected in the prime collection areas of South Qinghai Province. 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 Tibet AR, 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 and prices have still increased since then, but at a much slower pace.

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. Caterpillar fungus income provides cash for health care, education and transportation - especially motorcycles and plenty 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. 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 many 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

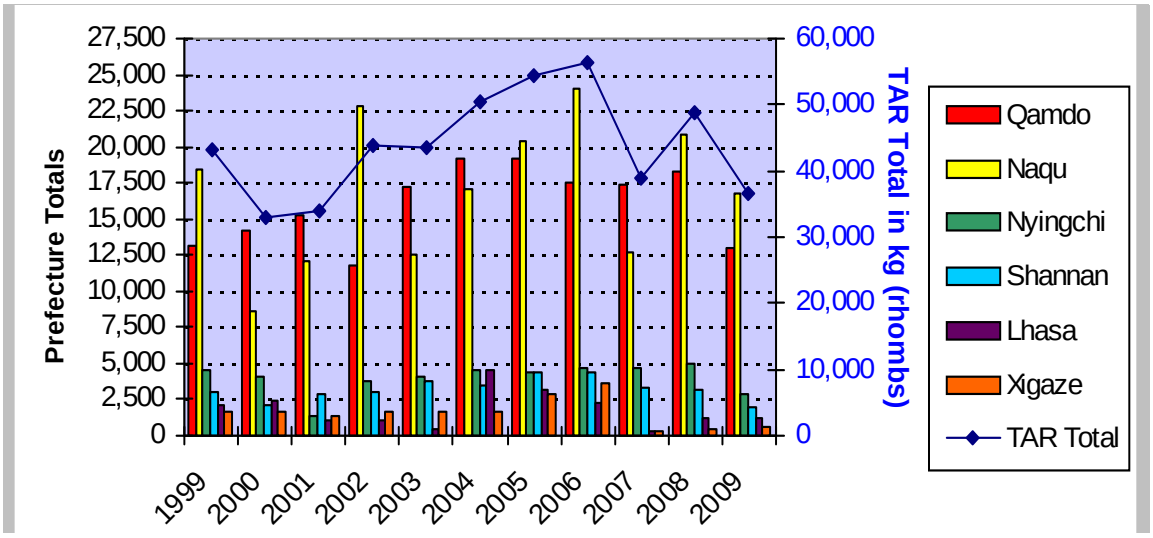
would strengthen local economies and generate incomes year round and possibly beyond the fungal boom. Thus, the immense income that can be made from Yartsa Gunbu collection also undermines engagement in long-term economic activities, which offer much smaller economic returns. Yeh & Lama (2013) report that by making ¥400-500 a day digging Yartsa gunbu, earning the regular rate of ¥50-60 a day is not very attractive. Such a discrepancy of retribution undermines interests in other sources of income. In spite of this challenge economic diversification must be an objective by policy makers in case that Caterpillar fungus proceeds diminish; be it due to resource exhaustion, a breakthrough in artificial cultivation or any other reason. Big amounts of cash floating in the community also cause people to overspend and fall into debt traps. What looked like a loan that could easily paid back with a fraction of another good harvest can turn into insurmountable debt when the harvest turns out be poor like it occurred in many areas in 2011 and was followed by another poor harvest in 2012.

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 (see Winkler 2009). 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, would have a catastrophic impact on rural communities.

Annual Production

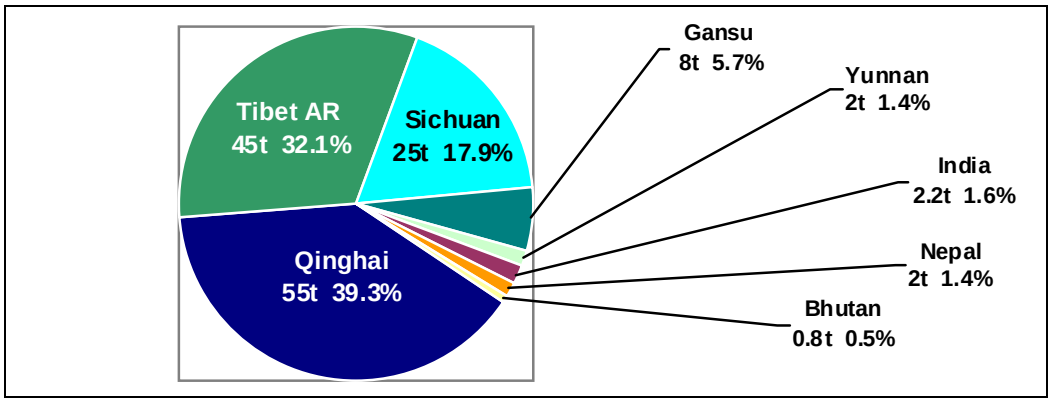
Reliable data on the annual production on Caterpillar Fungus are still lacking from many production areas. So far, the most detailed figures available are from Tibet AR on prefecture level Fig. 3, Winkler 2008 & 2009). Also in recent years localized studies from the Himalayan production areas have been published. In a review of all available figures from the Tibetan Plateau and the Himalayan an annual harvest ranging from 80 to 175 tons was estimated (Fig. 4), most likely figuring annually around 135t (Winkler 2009), but the informal aspect of harvest

Fig. 3: Annual Caterpillar Fungus Production by Prefecture in Tibet AR.



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.

Fig. 4: Estimated Average Annual Production of Caterpillar Fungus presented by Production Regions



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 collectors and in many 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 55t. In short, published and unpublished figures do not indicate a population crash of that nature so far, but don't preclude a 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.

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 (see Winkler 2008a, 2009) seem to report stable or increased production, but the lack of multi-annual reduced harvest amounts could be veiled by two factors; more people searching more intensely and also areas being searched not previously accessed for fungal extraction. However, in my experience, having since 1998 visited nearly annually production areas, be it in Garze Tibetan Autonomous Prefecture (Sichuan), Deqen TAP (Yunnan), Naqu, Qamdo or Nyingchi (TAR), most interviewed collectors and dealers did not report reduced output, but reported reduced harvesting rates per collector due to substantially increased competition. However, visiting collection grounds in Yushu TAP and Maqen TAP

(both South Qinghai Province) in 2010 and 2011, the common perception there seemed to be that caterpillar fungus productivity is declining [but incomprehensibly no agency is collecting any production data in Qinghai that would confirm or contradict this notion]. Many collectors reported on dwindling caterpillar fungus resources in this region. Seasoned collectors in Zadoi County, Yushu TAP reported during field work carried out in cooperation with World Wide Fund for Nature in China (WWF China), how spots that used to have very rich fungal populations are now barren of Yartsa gunbu. These reports impressed me deeply and made me reconsider my previously overall quite optimistic evaluation regarding the resilience of the caterpillar fungus resource. These reports indicated to me that continued overly intense collection could lead to local resource extinction since no more spores get into the environment to produce future harvests. In addition many dealers in Yushu and Xining also stated in interviews that they have the impression that the resource seems to dwindle.

Furthermore, informal interviews with collectors all over the Tibetan Plateau have shown that there is no awareness as to how the fungus reproduces. An often used term by Tibetan collectors all over the collection area was “rangjung”, which is also commonly used to describe miraculously self-manifesting religious symbols such as mantras manifesting in a rock wall. In scientific terms “rangjung” is best translated as autogenic. The notion that suggests that Yartsa gunbu is not dependant on the production and availability of spores from a parental generation is undermining responsible resource usage. In addition, previously, collectors would not dig up old specimen in sporulation due to their low value, but now collectors collect Yartsa gunbu in every stage of maturity and thus undermining spore production in a way not done before the current boom and probably one of the reasons for apparently successful resource management in the past.

Steps toward sustainable management

Reports by collectors and dealers of dwindling resources, unprecedented collection intensity, climate change and the recent economic dependence of local economies on caterpillar fungus collection, call urgently for sustainable harvest practices and a new approach to fungal resource management. So far the main objectives of resource management have been minimizing conflicts, orderly collection, and foremost optimizing economic returns for the counties and the community. Now it is time to shift the management focus and making sustainable resource use the central objective, since it is the long-term prerequisite for continued economic benefits and minimizing conflicts.

Such a management shift is not possible without support from all stakeholders, but especially from collectors. As Cannon *et al.* (2009) reported from Bhutan, “In the long term, the only viable way of ensuring sustainability of wild Yartsa Guenbub harvest is through locally focused natural resource management, with the villagers making their own informed decisions about collection policy”. Making informed decisions is only possible if the community has sufficient knowledge that necessary steps and especially sacrifices, meaning cessation of indiscriminate harvest of all specimens, towards sustainable resource management can be taken. Most crucial at this point is that collectors attain a rough understanding of the reproductive needs of caterpillar fungus, so that community support can be gathered in a management approach that secures sufficient spore production each year. All stakeholders are interested in keeping caterpillar fungus populations healthy and productivity thriving.

Recent field work in Yushu TAP in cooperation with WWF China confirmed the previously obtained impression that basically all collectors – just like most people - have no knowledge

regarding the life-cycle of caterpillar fungus and the crucial role spore dispersion plays for continued production. Educating the collectors is a prerequisite to shift towards sustainable collection practices that will help retain sporulating fungi in the ground. The development of easily implementable approaches that can rely on community support will be crucial for successful management.
A two-pronged management approach seems most sensible and least interruptive based on current best knowledge. The two components are, a community education campaign focusing on spreading understanding on the requirements for caterpillar fungus to thrive and a sustainable management framework that establishes a cut-off date for collection.

During interviews in Yushu TAP in late May and early June 2011 all interviewees were very interested in learning about the reproductive cycle of caterpillar fungus. We pointed out that fungal spores are too small to be seen with bare eyes, but that caterpillar fungus like all mushrooms produces “seeds”. Often at this juncture interviewees brought up that Yartsa gunbu is “rangjung”, self-manifesting. We then pointed out that Yartsa gunbu is just like any other animal or plant that reproduces. Once this new knowledge sunk in, we continued to share with the interviewees our sustainable management initiative of retaining low-value late-season caterpillar fungus in the ground by discouraging collection paired with a clear cut-off date. Overwhelmingly such an approach was accepted as reasonable. We were most impressed how quickly collectors were able and willing to accept the new understanding. A commonly voiced concern was that such a management approach made only sense if everyone supports and respects it. Also, it would need full support from all officials, especially at village level to gather full community support. Of course there were a few interviewees expressing doubt regarding the possibility of success of implementing such a management plan stating opinions to the notion of “people will never forgo to collect as much yartsa gunbu as they possibly can”. Still, the common perception in the Tibetan areas of South Qinghai Province of reduced Caterpillar fungus productivity should make it feasible to garner support from a community that understands the objective of the measures taken, especially in the face of potential future productivity decline with all its dire consequences.

WWF China as a result of our cooperation already designed an educational poster and a small brochure with Tibetan and Chinese text that has been distributed in Yushu TAP just before the onset of the 2011 season. Furthermore trainings with local officials have been organized to educate them on sustainable management options, the value of late-season caterpillar fungus and its reproduction cycle. Interviews with local stakeholders will evaluate the success of these initiatives. Furthermore an educational movie on sustainable harvest of caterpillar fungus is being produced in cooperation with Grassland Monitoring Institute and the Cordyceps Research Unit, both Qinghai Province.

Besides the educational campaign the most promising sustainable management intervention is an easily implementable establishment of a collection season ending after four or five weeks of collection. Such a date needs to be implemented skillfully with a good amount of annual and territorial flexibility necessary to adjust to local realities, since caterpillar fungus fruiting varies each year slightly according to weather conditions and in general according to altitude and latitude. Ideally, at this end point of the season collectors will already have collected substantial amounts, probably having earned already 90 to 95% of their seasonal income.

Enforcing the official ending date is easier in areas where collectors set up tents within the high altitude habitat, often a process that require permits and fee payments. More difficult is enforcing a collection stop where herders or farmers just collect above their homesteads. However, under these circumstances collectors should be motivated to manage their resource to their best

knowledge to secure sustainability. Whatever the specific circumstances, prerequisite for successful implementation is finding community support, which only can be achieved after a successful education initiative.

All in all, requesting informed collectors to give up digging low-value late-season specimens, which on the other side are prime spore producers that will secure next year's harvest, should find crucial community support. Furthermore, a set collection season end date as resource management strategy will be much easier to implement than more interruptive approaches such as further reducing collectors or limiting access to collection grounds.

Conclusions

Rural households benefit substantially from the caterpillar fungus industry. More and more households now are relying on caterpillar fungus income to get them through the year. Still, substantial income from caterpillar fungus collection and trade also challenges the community in many ways, forcing adjustment to new realities and coping with newly arising problems.

Centuries of collection indicate that caterpillar fungus is a relatively resilient resource. Unprecedented collection intensity, climate change and the recent economic dependence of local communities on caterpillar fungus collection in addition to increasingly frequent reports on resource overuse call for sustainable resource management. It is of paramount importance to develop management plans that can be implemented in a simple way taking into account the economic dependence of the population and the remoteness of the production areas.

Collection practices that remove unchecked as many fungi as possible seem to undermine spore dispersal. Late-season low-value fruiting bodies in the midst of spore dispersion are nowadays removed, whereas in the past such specimens were often left in the ground, thus securing spores to infect next year's crop of larvae. Recent field work has demonstrated that most collectors have no knowledge regarding the life-cycle of this fungus and the crucial role spore dispersion plays for continued production. Educating the collectors is a prerequisite to shift towards sustainable collection practices that will help retain sporulating fungi in the ground. The development of easily implementable approaches that can rely on community support will be crucial for successful management. Most sensible is a campaign to discourage harvest of late-season low-value fungi – a product disdained by most buyers - and the establishment of an end date of the collection season. It is hoped that these measures will allow for sufficient spore dispersal to guarantee continued sustainable harvest in order to protect the fungal resource, the production of this precious myco-medicinal and the livelihood of rural communities on the Tibetan Plateau.

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