Yartsa Gunbu (*Cordyceps sinensis*) and the Fungal Commodification of Tibet's Rural Economy[1]

DANIEL WINKLER

EcoMontane Consulting, 9725 NE 130th Pl., Kirkland, WA 98034, USA. me@danielwinkler.com; www.danielwinkler.com

***Yartsa Gunbu* (*Cordyceps sinensis*) and the Fungal Commodification of Tibet's Rural Economy**. *Cordyceps sinensis* is a mushroom that parasitizes larvae of *Thitarodes* (*Hepialus*) moths, which inhabit the alpine grasslands of the Tibetan Plateau. Tibetans have used the mushroom, which they call *yartsa gunbu* ("summer-grass, winter-worm") for many centuries, if not millennia. A 350% increase in the price paid to pickers between 1997 and 2004 has turned this tiny mushroom into the single most important source of cash for rural households in contemporary Tibet. On average, 40% of the rural cash income in the Tibet Autonomous Region is derived from its collection, which government statistics figured at 50,000 kg in 2004, contributing at least CNY (Chinese yuan) 1.8 billion (USD 225 million) to the Tibet Autonomous Region's GDP. A dramatic fungal commodification of the rural Tibetan economy is occurring, as the income from sale of *Cordyceps* often accounts for 70%–90% of a family's annual cash income in areas where it grows. The ever-increasing harvesting pressure raises the question of sustainability. The fact that *Cordyceps* has been collected for centuries and is still common argues for its resilience, but the lack of harvest studies for *C. sinensis* precludes a definite answer as to whether the harvest can be sustained at its current level.

Key Words: *Cordyceps*, grassland products, medicinal mushrooms, mushroom harvest, mushroom income, rural Tibet, Tibet AR, Tibet GDP, Tibet income.

Introduction

The caterpillar fungus, *Cordyceps sinensis* (Berk.) Sacc., is an expensive medicinal mushroom (Figs. 1, 2 and 3) commonly seen in Chinese gift shops and traditional pharmacies. In China it is known colloquially as *chongcao* ("worm-grass"), a shortened form of *dongchong xiacao,* which is itself a translation of the Tibetan name *yartsa gunbu* ("summer-grass, winter-worm"). Although formerly used as a medicinal food, often cooked with chicken or duck, it is now so expensive that most users cannot afford it except in medicinal quantities. Nonetheless, among the wealthy and powerful in China, *Cordyceps* has come to rival French champagne as a status symbol at dinner parties or as a prestigious gift. In late 2006, retail prices for top quality *Cordyceps* reached CNY (Chinese yuan) 240,000 (USD 32,000) per kg in the coastal cities of mainland China, as well as in Hong Kong and San Francisco.

Although widely perceived as a Chinese medicine, *Cordyceps sinensis* is profoundly Tibetan in origin as well as historical use. Mushrooms have a long medicinal and culinary history in Tibet. The earliest known documentation of *yartsa gunbu* is by Nyamnyi Dorje, a Tibetan physician and lama who lived from 1439 to 1475. His text, titled "An Ocean of Aphrodisiacal Qualities," describes the value of the mushroom as a sexual tonic; I reproduce here the first few stanzas, translated by Jakob Winkler:

> In this world sexual desire is
> The most marvelous of all earthly pleasures,
> The essence of the enjoyment of all the senses...
>
> As to this medicinal substance:
> It grows in regions of beautiful mountains
> Such as remote grassland mountains.

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Fig. 1. *Cordyceps sinensis* arranged for sale in a rural Tibetan market with medicinal *Fritillaria* bulbs in the background. The fungus-permeated larvae form the bulk of the biomass; the slender, dark-fruiting bodies are difficult to see in this photo. (Photo by Daniel Winkler, all rights reserved.).

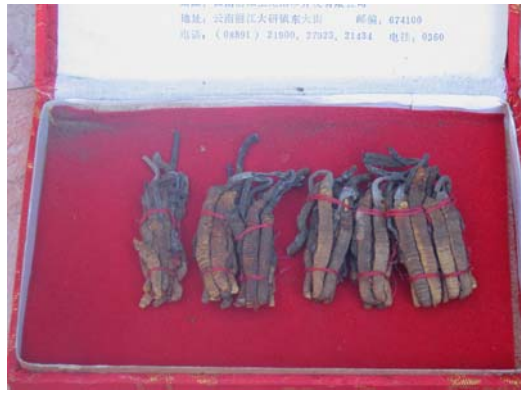

Fig. 3. Small and relatively inexpensive specimens of *Cordyceps sinensis* for sale in a Chinese pharmacy in Kunming, the capital of Yunnan. Most of the larger, more expensive specimens are sold in eastern China and abroad, where discretionary income is greater. (Photo by David Arora, all rights reserved.).

In the summer it is a blade of grass [growing] on a worm

Similar to the leaf of mountain garlic.

The flower resembles a silken green sedge.

The root resembles cumin seed at the end of autumn.

The taste is sweet and a little astringent.

The post-digestive [taste] is sweet and the quality is oily.

It has a slight warming quality.

It removes prana diseases, cures bile diseases and does not raise the phlegm; a marvelous medicine.

Fig. 2. The mushroom or fruiting body of *Cordyceps sinensis* arises from an infected caterpillar which must be carefully excavated from the ground to retain its value. (Photo by Daniel Winkler, all rights reserved.).

In particular, it especially increases semen.
It is a flawless treasure of an ocean of good qualities.

By contrast, the first record in China seems to be more than 200 years later in Wang Ang's 1694 compendium of material medica, *Ben Cao Bei Yao* (Grace Yue, pers. comm. 2005); a recent claim by Halpern (1999) that *Cordyceps sinensis* was mentioned in Chinese texts from the 8th-Century Tang Dynasty has not been substantiated.

According to Gawä Dorje (1995), another name for *Cordyceps sinensis* in Tibetan medicine is *tsa daji* (Wylie 1959: *tswa da byid*). A medicine known as *daji* (not *tsa daji*, however) is mentioned even earlier in the fundamental Tibetan medical text Gyü Zhi (also known as the "Four Tantras;" Wylie 1959: *rgyud bzhi*), composed between the 8th and 11th centuries and frequently republished (e.g., Yutog 2002). However, the identity of *daji* as *Cordyceps* remains controversial.

In traditional Chinese medicine, the caterpillar fungus is mostly used as a tonic. According to Liu (1994), its main applications are for treating exhaustion, respiratory and pulmonary diseases (e.g., tuberculosis, asthma), renal, liver, and cardiovascular diseases, back pain, and sexual problems (e.g., lack of sex drive, premature ejaculation). Its use as an aphrodisiac seems to be the driving force with male consumers in China, or at least that is the perception of Tibetan harvesters, who often make a point of saying that they, by contrast, have no need to take it for this purpose (!).

In a recent treatise on Tibetan medicine (Gawä Dorje 1995), *Cordyceps* (referred to as *yartsa gunbu*) is placed in the category of *tsi men* (Wylie 1959: *rtsi sman*), the "medicinal essences," which includes several tonics. It is recommended as a general tonic, for boosting the immune system and virility, and is prescribed, usually in conjunction with other medicines, for kidney, lung, and heart problems, as well as for Hepatitis B; nowadays it is also frequently mentioned as improving eyesight. For an overview of modern research on *C. sinensis*, including possible anti-tumor, anti-cancer, and anti-viral activity, immuno-modulating, cholesterol-reducing and anti-oxidant effects, and potential to increase stamina and libido, see Zhu et al. (1998), Holliday and Cleaver (2004), and Canney (2006).

With the recent advent of a cash economy in the Tibet Autonomous Region (Tibet AR), the collection and sale of economically valuable mushrooms have gained increasing importance. *Cordyceps sinensis* is by far the most profitable mushroom on the Tibetan Plateau. It is the most widely distributed of Tibet's economically important wild mushrooms because it occurs in grasslands, the environmental basis for livestock herding. In contrast, most other commercially-collected wild mushrooms in Tibet are restricted to forested areas, including the matsutake, *Tricholoma matsutake* (Ito & Imai) Singer, and morels (*Morchella* spp.). Much of the recent research on *Cordyceps sinensis*, as well that on other economically valuable grassland products, such as *Fritillaria* bulbs, *Rhodiola* roots, and *Saussurea* plants, can be found under the acronyms NWFPs for "non-wood forest products" (e.g., Bhattarai 1995; He and Sheng 1995; Boa 2004) and NTFPs for "non-timber forest products" (e.g., Zhang et al. 2001; Winkler 2003). Both acronyms are misnomers, since these products do not come from forests. The grasslands of the Tibetan Plateau provide many wild medicines and foods that, in terms of their economic importance, have come to rival traditional livestock products such as butter, milk, yogurt, meat, wool, and hides. In the absence of an adequate collective term for the wild plants and mushrooms harvested in these extensive grassland areas, I feel compelled to coin a new acronym, NLRPs, for "non-livestock rangeland products."

Methods

Most data presented in this paper were collected during a June 2005 research project in cooperation with Luorong Zhandui and assisted by Dawa Tsering, both from China's Tibetology Research Center in Beijing. Semistructured interviews were carried out on site with *Cordyceps* collectors and dealers, and with administrators from county and prefecture government offices in Nyingchi, Chamdo, Nagchu, and Lhasa prefectures (note: alternate spellings for Tibetan place names are given in Appendix); these four prefectures combine to produce nearly 90% of Tibet AR's *Cordyceps*. A total of 55 individuals were interviewed in 2005 and another 35 in June and July of 2006. Dealers and collectors were chosen haphazardly at collection sites and in *yartsa gunbu* markets. Additional information was collected by the author during 15 previous

visits to Tibet since 1998 while carrying out work related to rural income generation, forestry, non-timber forest products, non-livestock rangeland products, and other natural resources. Published literature, including Tibetan and Chinese sources, was also consulted to integrate the research data and draw a more complete picture of the significance of *Cordyceps* in the lives of contemporary rural Tibetans.

The Ecology of *Cordyceps sinensis*

Cordyceps is a genus of mostly entomophagous flask fungi (Pyrenomycetes, Ascomycotina) in the family Clavicipitaceae. Thirty-three species of *Cordyceps* sensu lato have been recognized in the Tibetan Plateau and Himalayan region (Zang and Kinjo 1998), but only a few are collected for their medicinal properties. The best known and most commonly used is *Cordyceps sinensis,* but Zang and Kinjo have described several distinct, closely-related species (*C. gansuensis* K. Zhang, C. Wang & M. Yan, *C. kangdingensis* M. Zang & Kinjo, and *C. nepalensis* M. Zang & Kinjo) that in the past have been mistaken for *C. sinensis*. A recent molecular study by Sung et al. (2007) concluded that *Cordyceps* should be divided into three genera, with *C. sinensis* belonging to the largest of the three, *Ophiocordyceps*. It remains to be seen if this new designation will be accepted, because *C. sinensis* is an economically important species; there is ample precedent for retaining its better-known name, as used here.

Its Caterpillar Hosts

Though the Tibetan name for *C. sinensis* is *yartsa gunbu* ("summer-grass, winter-worm"), it is commonly referred to simply as *bu* ("worm" or "insect"). The full name describes the main life stages of *Cordyceps sinensis*: its infected caterpillar host passes the winter (*gun*) in the soil as a "worm" (*bu,* pronounced "boo" as in "book"); then in early summer (*yar*) the mushroom or "grass" (*tsa*) emerges above ground. The word *tsa* is usually translated as grass, but can also be used to denote some mushrooms.

Cordyceps sinensis parasitizes various grass root-boring *Thitarodes* (*Hepialus*) caterpillars (Fig. 2), which hatch as "ghost moths" when not preempted by *Cordyceps*. Thirty of the nearly 40 species of *Thitarodes* known from the Tibetan Plateau can be infected by *Cordyceps sinensis* (Chen et al. 2000). Many of the regional differences in size of the *Cordyceps* mushroom are probably caused by size differences in the host species. While the normal reproductive cycle for *Thitarodes* species takes up to five years, most of the life cycle is lived as a caterpillar; the whitish adult moth lives for only a few days in order to mate.

Uninfected larvae typically hibernate deeper in the soil than infected ones; apparently the fungus is able to force the infected host to situate itself nearer the soil surface in a position more favorable to its fruiting. The hyphae of the mycelium develop inside the body of the insect, first feeding on less vital parts before taking over the complete organism. Eventually the insect is completely mummified and emptied of nutrients, and all that remains is the exoskeleton filled and coated with *Cordyceps* mycelium. In spring, the mushroom (also known as the fruiting body or stroma) develops out of the head of the exoskeleton just above the eyes. The slender, brown, club-shaped fruiting body then emerges from the ground, reaching a total length of 8–15 cm. It is typically nearly twice as long as its caterpillar host, but in rare cases can be up to four times as long.

Distribution, Habitat, and Season

Cordyceps sinensis is endemic to the grasslands and shrublands of central Asia and in particular the Tibetan Plateau (Fig. 4). The grasslands providing habitat for *Thitarodes* ghost moths and thus for *Cordyceps sinensis* consist predominantly of sedges (*Kobresia* spp.), which can cover up to 80–90% of the subalpine grasslands (Wu 1997). *Thitarodes* moths prefer to feed on young roots of plant species of the families Polygonaceae, Fabaceae, Cyperaceae (including *Kobresia*), Poaceae, and Liliaceae (Chen et al. 2000).

Omnipresent grazing by livestock keeps the grass and herbs short, making the small fruiting bodies much easier to find during the collecting season. Tibetan collectors report that fruiting of *Cordyceps sinensis* is enhanced by unusually high precipitation during the preceding monsoon season or in the form of winter snowfall, especially when followed by mild temperatures in the spring. However, if snow cover remains for longer than a few days during the harvest season, *Cordyceps* fruiting bodies decay and much of the harvest is lost.

The known range of *C. sinensis* includes all but the driest portions of the Tibetan Plateau. Administratively this encompasses vast areas of Tibet AR, as well as adjacent areas within the

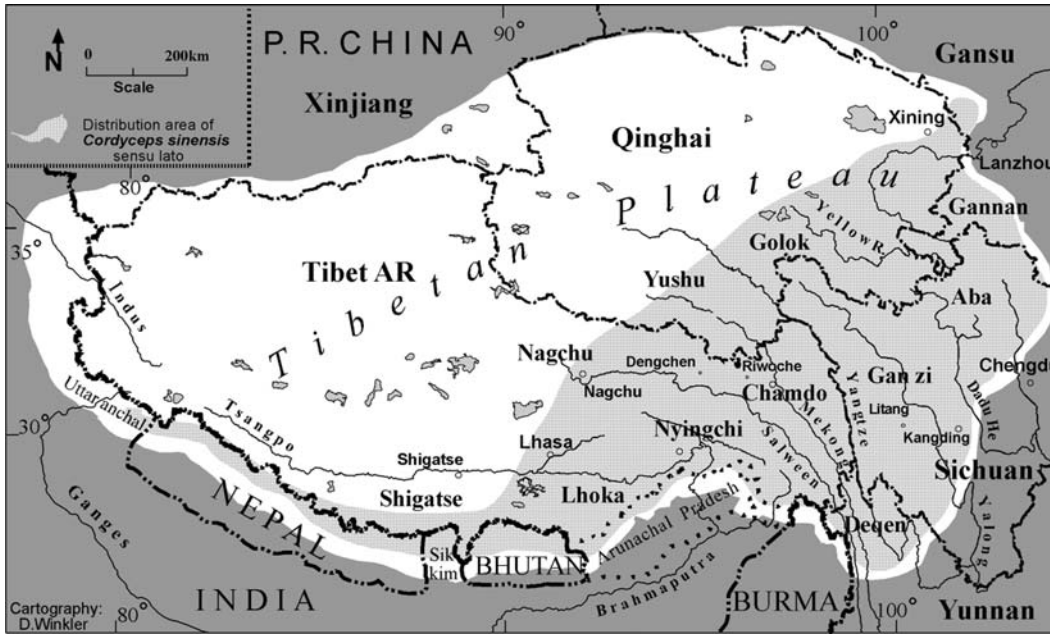

Fig. 4. The distribution of *Cordyceps sinensis*.

Tibetan autonomous prefectures of Sichuan, Yunnan, Qinghai, and Gansu provinces. It is also found in some mountainous areas of southwestern Sichuan and northern Yunnan that are inhabited by other ethnic minorities. Reports of it from the central and eastern Himalayas (Nepal, Bhutan, and India) are difficult to verify because of confusion with other Himalayan species, such as *C. nepalensis* (Zhang and Kinjo 1998). *C. sinensis* has also been reported from Tian Shan and Altai Shan in Xinjiang province of northwestern China (Zhang and Kinjo 1998).

On the Tibetan Plateau, *C. sinensis* occurs at altitudes of 3,000 to 5,000 m, but only where average annual precipitation is at least 350 mm and usually more than 400 mm. In the arid reaches of the northwestern Tibetan Plateau, where annual precipitation is below 300 mm, *C. sinensis* is apparently absent. It generally occurs within an altitudinal range of 600–1,000 m. This distribution zone can be correlated to an amplitude of 400–500 m above and below the treeline, or more accurately the *potential* treeline, since the actual treeline has been greatly altered by deforestation and other human activities. The potential treeline is highest in central Tibet (4,600–4,800 m) and lowest (3,500 m) in the northeastern portion of *C. sinensis'* distribution (eastern Qinghai and Western Gansu provinces). Over the millennia, forests have been replaced by pastures in wide areas of the Tibetan Plateau (Winkler 1998, 2000; Miehe et al. 2006); thus Tibetan pastoral activities have clearly extended the habitat of *Cordyceps sinensis.* However, in general the downward distribution does not exceed 400–500 m into previously-forested areas.

The Commercial Harvest of *Cordyceps sinensis*

Each year as the high elevation grasslands spring to life, Tibetans venture out to look for *yartsa gunbu.* In eastern Tibet, the season begins in April or May, whereas in central Tibet it occurs after the onset of the summer monsoon (usually June) and may last into July in the drier, high-elevation areas. In any given locality, the collection season typically lasts for about a month, but a sharp elevation gradient can extend a locality's season by several weeks since the higher slopes tend to fruit later than the lower ones.

The collectors consist mostly of herders and farmers; some city dwellers also participate. Collectors establish camps (Fig. 5) wherever *yartsa gunbu*, or *bu,* grows. However, the bigger camps (those with 40–100 collectors) are typically established next to access roads or highways, where supplies can be trucked in and mushroom buyers can visit

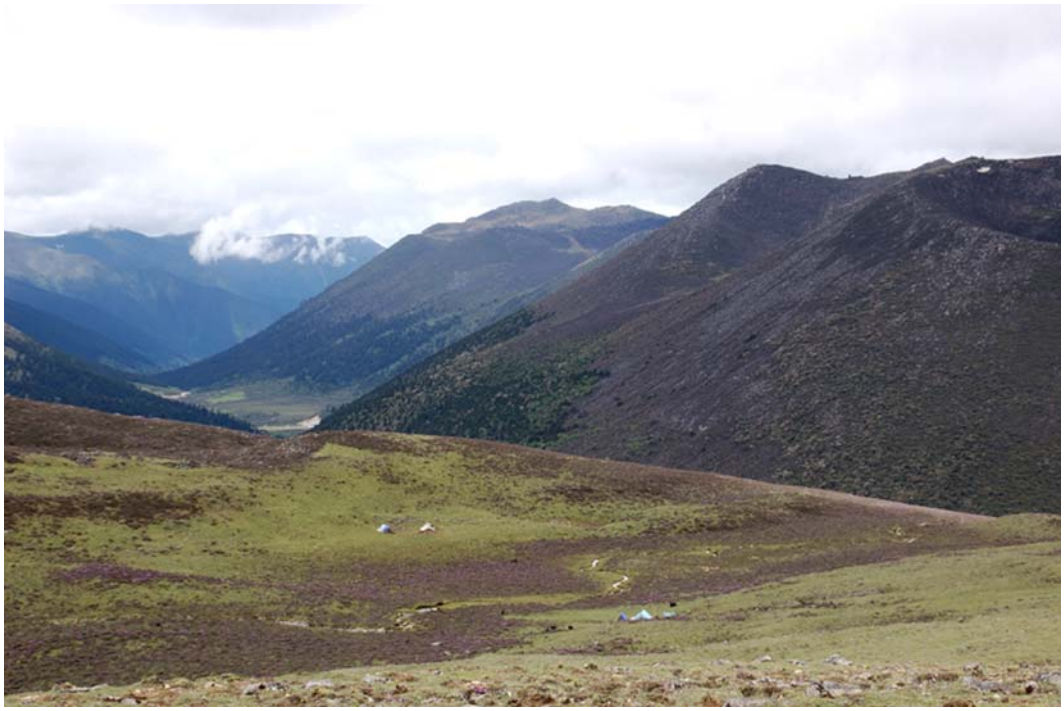

Fig. 5. A small tented camp of *bu* hunters situated in high elevation grasslands, Tibet AR. (Photo by Daniel Winkler, all rights reserved.).

easily. The larger camps are often outfitted with temporary grocery shops, noodle restaurants, and pool tables for entertainment. Collectors tend to camp together with friends and family. Local collectors bring their children, since children are said to be good *bu* hunters because of their sharp eyes and proximity to the ground. Herders move their black yak-wool tents up to the collection areas, but leave their livestock below so that they will not eat or trample the *bu*. In recent years, makeshift tarp shelters or modern tents have become more common. Local farmers also camp in the mountains, since a daily hike from their settlements to the collection area would be too time consuming. Nonresidents (outsiders who migrate to the collection areas) tend to be predominantly male, while local collectors display a more even male-female ratio. When the camp is far from the road, collectors make weekly or biweekly supply runs. Since all grazing land in Tibet is owned by the government, herders maintain mere usage rights, and thus the camps are technically on government land. Therefore, county administrations regularly check the camps for collection permits, as described below.

The high altitude grasslands and shrublands are vast (Fig. 5), and individual specimens of *bu* do not occur in the groups or "patches" characteristic of many ectomycorrhizal mushrooms. Not only are they widely dispersed, but also the visible (epigeous) portion of the organism is very small (4–12 cm) and can only be spotted at close range. As a result, the search for *bu* is intensive as well as extensive, and ground that has already been searched is not necessarily devoid of *bu*.

Most collectors use a knife or small hoe to dig the *bu* out of the ground. This needs to be done carefully, since the *Kobresia* turfs are very dense, and breaking off the *Cordyceps* fruiting body from the head of the larva greatly reduces its value. Collectors dig *bu* whenever they encounter it. However, the caterpillar fungus is more valuable when young, that is, before it sporulates or early during sporulation. In the final stages of sporulation, the host larva becomes soft and undesirable, and the upper part of the mushroom sometimes splits. The price of a specimen depends mostly upon the size of the larval host: the bigger, the better. By contrast, the length of the fruiting body (mushroom) is of little signif-

icance except for exceptionally long specimens, which are regarded as inferior and may even be cut shorter. The healing power of *yartsa gunbu* is believed to be concentrated in the caterpillar, which is indeed filled with *Cordyceps* mycelium. Firmness of the larva is thus important in pricing; collectors and dealers often squeeze the larva between their fingers to assess quality. Dealers also pay attention to the caterpillar's color: a saturated yellowish-brown is preferred to paler tones.

A person's typical daily harvest ranges from a few specimens to several dozen, and rarely as many as 100. During interviews with collectors in Riwoche and Dengchen counties, both in Chamdo Prefecture, I was frequently told that 5 to 10 specimens a day was average, and that 20 was considered very good. Using the official statistics for Dengchen County, the average collection rate comes to 10 specimens per person per day, and the average annual harvest of about 5000 kg represents some 12 million specimens collected by 35,000 people over approximately 30 days. In 2004, a single *bu* was worth about CNY 8–16 (USD 1–2) to the collector. In comparison, a seasonally available manual job in road construction or other rural labor would generate only CNY 15–25 (roughly USD 2–3) per day. Thus a typical day's harvest of 5–10 *bu* represents some three to seven times the typical daily wages in the region, and an unusually good day's harvest could produce income equivalent to a month or more of wage labor.

Collection Pressure and Permits

Most of the collectors interviewed complained that each year there are more people collecting. To date, however, the increasing value of *bu* has compensated for the increased competition and reduced individual harvest. The dramatic economic impact of *bu* collection is exemplified in Dengchen County, Chamdo Prefecture, where a local official in charge of *bu* collection stated that 60% of its 63,000 inhabitants had been mobilized by county government intervention to collect *bu* in 2005, and that *bu* collection was the single most important source of money in the county. Though most counties have not yet made similar organized efforts, the recognition of *bu*'s economic importance is spreading.

Most counties in Tibet require collecting permits for local residents, with typical costs ranging from CNY 10 to CNY 300 (USD 1.3–38) per person per season. Nonlocal collectors, or "outsiders," currently pay significantly higher fees than locals. In the 1990s, permits for outsiders were either not required, were very cheap (CNY 10–30, USD 1.3–3.8), or were not enforced. However, in recent years most *bu*-producing counties have imposed steadily-increasing permit fees on outsiders, in many cases outpacing the actual price increase for *bu*. In 2005, collection permits for outsiders ranged from CNY 300–1,500 (USD 38–200) per person for the one-month season. In 2006, the most expensive "outsider" permit, costing CNY 4,000 (USD 500), was in Golok Prefecture, Qinghai Province.

"Outsiders" include Tibetans from neighboring counties and prefectures: for example, in Nagchu and Nyingchi prefectures, most Tibetan outsiders come from Shigatse Prefecture, which has a large population but is relatively poor in economically valuable plants and mushrooms. Non-Tibetan collectors also arrive for the collecting season, notably Hui Muslims from northeastern Qinghai and Gansu provinces who come by the thousands, in some places outnumbering the local population during collection season (Winkler 2005). There is no overall policy for nonlocal collectors, but in recent years, counties have become stricter in regulating access to outsiders. Some counties, such as Riwoche and Dengchen, have phased out permits for outsiders and declared a complete ban on *bu* collecting by nonresidents. Such bans as well as dramatic increases in permit fees have led to unrest and even riots with some fatalities in 2004 and 2005, such as in Dzato County (Zaduo Xian, Yushu Prefecture, Qinghai; ENS 2005), and also, according to local sources, in Gyamda Kongpo County, Nyingchi Prefecture, Tibet AR in 2005, and Dengchen County in 2004 and 2005.

Many county officials that I interviewed noted that permit recipients, both local and nonlocal, are instructed in how to minimize grassland destruction while digging *bu*, for instance, by closing up the holes created by digging, by keeping tent sites clean, and by not using local vegetation as fuel for campfires. Dengchen County even specifies that the size of the hoe used for digging *bu* cannot exceed 5×15 cm. Many county officials explained that the money generated by permit fees is used for environmental protection, by which they mean clean-up after the collecting season. However, campsites that I visited at the close of the season in Dengchen

County (Richu Valley, Seda Xiang) were marked by empty and broken beer bottles, discarded instant noodle containers, and plastic bags, so I could not verify that such clean-up of the campsites was actually taking place.

The Sale of *Cordyceps*

Three main factors enable rural households to participate successfully in the harvest of *yartsa gunbu*: 1) the widespread knowledge about *bu* and how to find it; 2) access to the grasslands where it grows; and 3) the fact that little or no capital is needed to participate, at least for locals. In other words, resource access is assured and the usual barriers to economic success (lack of formal education or access to credit) are absent. As a result, within the distribution area of *bu,* nearly all rural households who practice traditional subsistence herding and agriculture also participate in *bu* collection (see also Winkler 2003).

Typically, small quantities of *bu* are sold after seller and buyer have agreed on a price per specimen and the *bu* have been counted by both parties. In June 2005, prices in Tibet ranged from CNY 3–30 (USD 0.4–3.8) per specimen. This price range is roughly equivalent to CNY 10,000–60,000 (USD 1,250–7,500) per kg figured at 1,800 large *bu* or 3,600 small *bu* per kg). Collectors have several choices of where to sell. Some sell the freshly collected *bu* right on the grasslands or in the collectors' camps. This is often done early in the season to generate some quick cash to pay for living expenses in the camps. But by selling small, unprocessed (i.e., uncleaned) quantities on the grasslands, collectors forgo 10–30% in profit, since this is the range of the common mark-up for cleaned *bu* sold in larger quantities to itinerant *bu* dealers who ply the roads. At this point, *bu* is sold by the piece rather than weight, since they are not fully dried yet.

Market Control and Brokering

Lhasa now has about 15 large brokers of *bu* who buy from smaller brokers or middlemen, a business entailing multimillion-yuan transactions. These large brokers also maintain a network of buyers, sometimes family members, in prefecture towns such as Nyingchi's Bayi, Shigatse, and Lhoka's Tsetang. Native Tibetan brokers control less than half of the approximately 30,000 kg of *bu* dealt annually in Lhasa. Instead, *bu* brokering in Lhasa is dominated by Hui Muslims, many of them originally from Gansu Province, to the northeast of Tibet. Hui brokers in Lhasa typically sell their *bu* to even larger Hui brokers in Xining (Qinghai Province). When asked why they dominate *bu* brokering in Lhasa, one Hui broker replied that the Hui are clever at business, willing to take risks, and have a close network in their communities. A successful Tibetan broker answered similarly: "The Hui have an advantage due to their reliable business relationships, and most Lhasa Tibetans lack the guts for this high-stakes business." There are regional differences, however, in brokering and market share. In eastern Tibet (i.e., Chamdo Prefecture), the market is controlled by native Khampa Tibetans, who prefer selling their *bu* to other Tibetans, and who are renowned in Tibet for their willingness to take risks. Several Hui dealers in Lhasa even reported losing market share to Khampa brokers.

Price Development

Cordyceps trade between Tibet and China goes back at least to the 17th century and probably much further. For Tibetans, it was an important bartering item for obtaining tea, a mainstay in the Tibetan diet, as well as silk (Winkler 2005). Dried *Cordyceps*—being so valuable, small, and light in weight (<0.2–0.5 g per specimen)—has functioned traditionally as a form of currency and still does today. During the commune period (1956–1981), *Cordyceps* collection was marshalled by state-decreed quotas that had to be fulfilled. A typical quota was three specimens per person per day for each household during the collecting season, handed over to local authorities. Surplus collection above the quota levels was traded. During the Cultural Revolution (1966–1976), the *Cordyceps* market collapsed (as it did for many other products). For example, in the 1970s, 1 kg of *bu* was traded for CNY 21 (less than USD 3) in Xining, Qinghai Province (Wen 2004), an extremely low price by today's standards even after inflation is taken into account.

Following economic liberalization in the early 1980s, prices increased dramatically (Table 1). In 1985, *bu* traded wholesale for CNY 1,800 per kg in Lhasa, rising to CNY 8,400 in 1997 (an increase of 366%) and to CNY 36,000 in 2004 (a further increase of 1,900%). However, when rampant inflation is taken into account (Tibet Statistical Yearbook 2006), the real increase in

Table 1. *YARTSA GUNBU* WHOLESALE PRICE DEVELOPMENT IN LHASA (TIBET AUTONOMOUS REGION) AND LITANG (GANZI TIBETAN AUTONOMOUS PREFECTURE, SICHUAN).

Location	Year	1970	1982	1985	1988	1990	1992	1995	1997
Litang big size		-	600	800	1,800	2,000	2,200	4,600	5,000
Lhasa mid-sized		22	-	1,800	3,800	4,000	4,400	8,000	8,400
	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Litang big size	5,000	9,000	10,000	14,000	20,000	26,000	30,000	36,000	46,000
Lhasa mid-sized	9,600	12,000	15,000	18,000	24,000	30,000	36,000	42,000	50,000
Lhasa annual price increase	9.5%	25%	20%	20%	33.3%	25%	20%	16.6%	19%

Prices are in Chinese yuan (CNY) per kg and are not adjusted for inflation. Approximate USD values can be obtained by dividing the CNY prices by 8.

value amounts to only 38% from 1985 to 1997. Inflation was largely controlled after 1997, and the increase in wholesale price from 1997 to 2004 amounts to 342% after adjustment, representing an average annual price increase of 21.2% (Table 1)

LOCAL INCOME GENERATION AND CONTRIBUTION TO GDP

Income from the collection of wild plants and mushrooms goes directly to rural households, a sharp contrast to many other natural resource-based industries in Tibet, such as logging, mining, and hydroelectricity, in which profits are almost entirely captured by the state sector (Winkler 1999). Areas rich in *Cordyceps*, such as northern Chamdo Prefecture and southeastern Nagchu Prefecture, have experienced a highly-visible boom in discretionary spending. The once self-sufficient, cash-strapped subsistence farmers and herders are now patronizing small rural shops to buy instant noodles, crackers, candy, sodas, beer, flashlights, and batteries. Many households with access to electricity are buying TV sets and DVD players from stores in the larger towns. The trade in *yartsa gunbu* has provided most or all of the cash for the proprietors and customers of these businesses, and has spurred local economic development in an unprecedented fashion that has left government-sponsored development projects pale by comparison. Capital is also accumulating locally. Farmers are building new houses, and their contributions are allowing the rebuilding of monasteries and other traditional cultural sites, many of which were destroyed during China's initial takeover of Tibet in the 1950s, or later during the Cultural Revolution. Herders and farmers alike are able to finance motorcycles (Fig. 6), jeeps, and trucks from China. Travelling through *bu* country, one is immediately struck by the abundance of new 125 ccm motorcycles crowding the streets of market towns, whereas in the late 1990s, only a few *bu* dealers and no *bu* collectors had motorcycles. Apparently, nomadic men, in contrast to farmers, invest in mobility before home improvement.

Government data from six counties in core production areas demonstrate the marked importance of the *yartsa gunbu* harvest to rural income generation, with 53% to 100% of total per capita annual income accounted for by reported harvest at a typical producer's price (Table 2). Evidently, such governmental data coming out of Tibet AR must be interpreted with caution (for a detailed discussion, see Winkler n.d. and also Fischer 2006). Still, considering the available evidence, it seems reasonable to surmise that *yartsa gunbu* harvest accounts for some 50–80% of the overall rural income where it occurs, with the higher figures applying to counties with exceptional growing conditions in southeastern Nagchu Prefecture (i.e., Driru, Lhari, and Sog counties) and northern Chamdo Prefecture (i.e., Dengchen and Riwoche counties).

Turning from local to national records, the reported harvest of *yartsa gunbu* in Tibet AR was 50,000 kg in 2004. Using the conservative producer's price of CNY 22,000/kg, this amounts to a value of CNY 1.1 billion (USD 133 million in 2004), an overall per capita income contribution of CNY 463 (USD 58) to the approximately 2.4 million rural and small town inhabitants who account for 92% of Tibet's total population. Thus, *yartsa gunbu* harvest would represent about 25% of the total per capita income of CNY 1,861 (USD

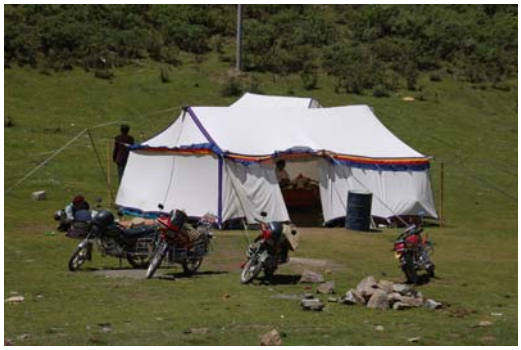

Fig. 6. Motorcycles bought with *yartsa gunbu* money (and often used in the trade) are now a common sight in rural Tibetan. (Photo by Daniel Winkler, all rights reserved.).

248) reported in 2004 for rural and small town Tibet (Tibet Statistical Yearbook 2006). Discounting noncash income (which is included in government statistics), *yartsa gunbu* harvest accounts for about 40% of the cash income for all of rural Tibet AR, including nonproducing regions. It is clear, then, that the *yartsa gunbu* harvest is a major driving force in the Tibetan rural economy.

So far, Tibetan and Chinese administrators, statisticians, and economists have not specifically examined the value contributed by the *yartsa gunbu* industry to Tibet AR's gross domestic product (GDP). Because of the aggregate nature of official income reporting, it is not clear where or even if this industry is included in the income categories of the Tibet Statistical Yearbook (2006). Using the wholesale price in Lhasa of CNY 36,000/kg as a basis for calculation, the *yartsa gunbu* industry would represent a contribution of CNY 1.8 billion (USD 225 million) to Tibet's economy, accounting for 8.5% of the total 2004 GDP of CNY 21.1 billion. The contribution of *yartsa gunbu* surpasses the entire secondary economic sector (industry and mining), valued at CNY 1.5 billion, and amounts to over 40% of the total primary sector (agriculture, livestock, forestry, etc.), valued at CNY 4.3 billion. By comparison, matsutake production in 2004 contributed CNY 30–40 million to the overall rural income in Tibet AR, or just 2–3% of the estimated contribution made by *yartsa gunbu* (Winkler n.d.). (As already noted, however, the grasslands where *yartsa gunbu* grows are far more extensive in Tibet than the evergreen oak forests favored by matsutake.)

Annual Production and Sustainability

So far, there are no published data on the annual production of *yartsa gunbu*. An unpublished 1989 report from the Plateau Biology Research Institute in Lhasa estimated total potential production of about 70,000 kg annually for Tibet AR, and reported an average annual harvest of 13,400 kg for 1957–1974 and of 15,100 kg for 1975–1983. However, these figures may represent only the amount of *yartsa gunbu* going through the state quota system, and much more might have been traded informally. According to current official statistics, *yartsa gunbu* harvest was below 40,000 kg for Tibet between 1999 and 2001, reached nearly 44,000 kg in 2002 and 2003, and then 50,544 kg in 2004 (Table 3). It is unclear how reliable these figures are, but the official amounts are fairly consistent with information provided by several brokers I interviewed in Lhasa who estimated the annual trade in Lhasa at 30,000 kg.

Table 3 shows a clear trend toward increased harvest of *yartsa gunbu*. The increased number of collectors and discovery of "new" (i.e., previously

Table 2. Selected Tibetan county-level per capita income from *YARTSA GUNBU*, based on officially reported harvest quantities and actual rural market prices in 2004.

				Yartsa Gunbu Income per Capita	
County, Prefecture	Population	*Yartsa Gunbu* Harvest (kg)	Official Average Income	At CNY 22,000 per kg	Percentage of Official Income
Dengchen, Chamdo	62,996	4,607	CNY 1,612	CNY 1,608	100%
Riwoche, Chamdo	37,000	2,107	CNY 1,950	CNY 1,253	64%
Palbar, Chamdo	30,006	1,215	CNY 1,650	CNY 890	53%
Driru, Nagchu	44,293	5,195	CNY 2,807	CNY 2,580	92%
Lhari, Nagchu	24,198	2,231	CNY 2,257	CNY 2,028	90%
Sok, Nagchu	34,939	2,184	CNY 1,743	CNY 1,375	79%

Unpublished data provided by county and prefecture governments. 1 USD=8 CNY.

Table 3. THE OUTPUT OF *YARTSA GUNBU* IN KG IN THE PRODUCING PREFECTURES OF TIBET AUTONOMOUS REGION FROM 1999–2004, BASED ON TIBETAN GOVERNMENT SOURCES.

	Prefecture						
Year	Chamdo	Nagchu	Nyingchi	Shigatse	Lhoka	Lhasa	Total
1999	13,190	18,491	4,510	na*	na	2,075	38,266
2000	14,234	8,554	4,100	na	2,041	2,400	31,329
2001	15,240	12,016	1,394	1,400	2,920	1,000	33,970
2002	11,717	22,803	3,806	1,635	2,973	1,046	43,980
2003	17,185	12,466	4,091	1,596	3,844	4,350	43,532
2004	19,218	17,035	4,518	1,726	3,539	4,508	50,544
Average[a]	36.6%	36.9%	9.0%	6.2%	7.4%	3.8%	100%

*Not available.
[a] Average annual share of Tibet AR production.

unpicked) production areas would appear to drive the increased harvest. However, the spiraling value of the *yartsa gunbu* may be causing authorities to pay more attention to this product, in which case the growing production numbers may also reflect, in part, a reporting bias. There are also some year-to-year inconsistencies in production values. For instance, the data for 1999 did not include Shigatse and Lhoka prefectures, and adding a conservative estimate of this harvest would have raised Tibet's production for that year to nearly 42,000 kg. On the other hand, given the well-established tradition of harvest in Chamdo and Nagchu prefectures, the year-to-year fluctuations recorded there likely reflect actual fluctuations in crop size.

The current and steadily increasing harvest pressure on *yartsa gunbu* is unprecedented. With increasing numbers of Tibetans searching for *yartsa gunbu,* and some local governments now facilitating searches in more remote places, the issue of sustainability looms large (see Bhattarai 1995; He and Sheng 1995; Schei et al. 2001; Zhang et al. 2001; Hywel-Jones 2003; Winkler 2005). Research on the consequences of intensive harvest of *Cordyceps sinensis* is noticeably lacking. Most statistics still report increased production, but this could be resulting from more people searching more areas. Interviewed collectors do not report reduced output, but complain about reduced harvesting rates per individual due to steadily-increasing competition. Similarly, dealers and brokers do not lament reduced output rates, but report increased competition as well.

Studies of ectomycorrhizal mushrooms (e.g., Egli et al. 2006) suggest that harvesting pressure is not a major concern, but the life cycle of *Cordyceps sinensis* differs from that of most ectomycorrhizal species in that the individual *Cordyceps* organism produces one fruiting body and then dies. It is fair to say, then, that the long-term impact of the intensive collection of *Cordyceps sinensis* is unknown and that a definitive assessment of the sustainability of current harvesting levels of *Cordyceps sinensis* is not possible based on the data available. However, a "best guess" assessment can be arrived at by applying the "Rapid Vulnerability Assessment" (RVA) technique as developed by ethnobotanist Tony Cunningham (after Wong 2000) and formalized for analysis by Wild and Mutebi (1996). RVA integrates indigenous and scientific knowledge, drawn from ecology, socioeconomics, and economics, to facilitate a quick and broad assessment of sustainability. Following this method, an RVA assessment for *C. sinensis* by this author (Table 4) generated a score of 20, indicating a moderate degree of vulnerability. Namgyel (2003) similarly applied RVA and obtained a score of 26 for Bhutan's *Cordyceps* species (probably C. *nepalensis*), noting that the score would be slightly lower "if the traditional rights of the collectors are recognized and a community-based natural resources management system is put in place" (Namgyel 2003).

Conclusion

With its extremely mountainous, vast, and sparsely-populated landscape, Tibet is experiencing great difficulties in making the transition from its traditional rural subsistence economy to a market-based economy as now envisioned by China. In the last decade, the sale of the tiny caterpillar fungus, *Cordyceps sinensis,* known as *yartsa gunbu* or *chong*

Table 4. RAPID VULNERABILITY ASSESSMENT (RVA) FOR *CORDYCEPS SINENSIS*.

Factor (with abbreviated outline)	Remarks specific to *Cordyceps sinensis*	Score
1. Life Form: Slow vs. fast growth and reproduction.	Quickly-reproducing fungi dependent on widespread host larvae.	0
2. Habitat Specificity: Narrow habitat requirements increase vulnerability.	Grass and shrub lands, the most extensive ecosystem of the Tibetan plateau; grazing does not appear to undermine growth, but overgrazing might.	1
3. Abundance and Distribution: Abundant, widely-distributed species are less vulnerable.	Widely distributed, but confined to High Asia.	1
4. Growth Rate: Slower-growing species will be more vulnerable to use.	Fungus is fast growing; larvae are relatively fast growing.	0
5. Response to Harvesting: The ability of a species to re-grow as a response to harvesting affects its vulnerability.	As long as sufficient spores are being dispersed and hosts are available, sustainability is presumably guaranteed; harvest before spore dispersal increases vulnerability and is common.	2
6. Parts Used: Part used significantly affects sustainability, e.g., use of leaves has less impact on a plant vs. use of the roots or whole plant.	Whole organism is removed; however, this is done close to the end of its completed lifecycle.	2
7. Pattern of Selection and Use: If a certain size, age, or quality of a species is used, the remaining population may ensure the survival of species.	All mushrooms seen are collected; however, their very small size and cryptic coloration ensure that not all specimens in an area are collected.	2
8. Demand: The level of demand (quantity and frequency) has a major impact on the species.	Very high demand; income derived is crucial for local population.	3
9. Seasonal Harvesting: Demand may be reduced if harvesting is restricted to certain seasons.	Fungus is only collected when fruiting and its host only after infection	1
10. Traditional Conservation Practices: When demand increases and commercial exploitation occurs, traditional practices often break down.	Has been collected for centuries, but rapidly advancing cash economy has substantially increased its economic importance; collecting taboos are disrespected in most places.	3
11. Commercialization: Once a product moves from subsistence use to commercialization, the chances of unsustainable use increases.	Well-established trade networks from most remote Tibetan grasslands to Chinese consumers in lowlands and abroad.	3
12. Substitutes: The availability of substitutes affects species' vulnerability indirectly by reducing demand.	Artificial production of mycelium (spawn) supplies products to Western consumers. Semi-artificial production shows signs of success and might take off soon. However, Chinese consumers prefer the wild product.	2
Total Score		20

cao, has become rural Tibetans' means of entry into a steadily-expanding, cash-dependent lifestyle. It is difficult to overstate the contribution of *yartsa gunbu* to rural income in contemporary Tibet. Currently, an estimated 40% of rural Tibet's total cash income, and in some regions as high as 80%, is derived from the sale of this one mushroom. This fungal commodification has enabled poor rural Tibetans to purchase vehicles and other goods and to pay school fees, hospital bills, and taxes.

As a result of this research, Luorong Zhandui of the Tibetology Research Center in Beijing submitted a policy advisory to the government of the Tibet AR (Luorong and Dawa 2005). This advisory formed the basis for the first region-wide regulations on collection and protection of *yartsa gunbu,* published in April 2006. In brief, the regulations include stipulations for surveying of the resource and development of a protection program, minimizing resource conflict, ensuring environmental protection and clean-up, and an initiative to standardize the licensing system. This was followed in December 2006 by a Tibet AR conference addressing these issues and providing a framework for implementation. It is too early to judge if these initiatives will bear fruit.

Scientific studies of sustainability are lacking. Regions that have been harvested for commercial export continually for hundreds of years, such as Litang in Sichuan province (Boesi 2003; Winkler 2003, 2005), are still producing prodigious quantities of *yartsa gunbu*, a testament to the resilience to human predation of this mushroom and its caterpillar host. However, the level and breadth of harvest now occurring are unprecedented, and research is needed to determine what basic management measures, if any, are required to ensure that *yartsa gunbu* remains plentiful for the generations to come.

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Appendix

ALTERNATE SPELLINGS FOR TIBETAN PLACE NAMES.

English Tibetan	Wylie Tibetan	Tibetan Pinyin	Pinyin
Chamdo	chab mdo	Qamdo	Changdu
Dengchen/Tengchen	steng chen	Dengqen	Dingqing
Drachen/Bachen	sbra chen	Baqen	Baqing
Driru	'bri ru	Biru	Biru
Dzato	rdza stod	Zadoi	Zaduo
Golok/Golog	mgo log	Golog	Guoluo
Kongpo Gyamda	kong po rgya mda'	Gongbo Gyamda	Gongbu Jiangda
Lhasa	lha sa	Lhasa	Lasa
Lhari	lha ri	Lhari	Jiali
Lhoka	lho kha	Shannan	Shannan
Nagchu/Nakchu	nag chu	Naqu	Naqu
Nyingchi/Nyingtri	nying khri	Nyingchi	Linzhi
Palbar	dpal 'bar	Banbar	Bianba
Riwoche	ri bo che	Riwoqe	Leiwuqi
Shigatse	gzhis ka rtse	Xigaze	Rikaze
Sog/Sok	sog	Sog Xian	Suo
Tsetang	rtsed thang	Zetang	Zedang

Sources: Wylie 1959; Xizang 1995; An and Chen 2003; Tibetan and Himalayan Digital Library 2008.