

Yar tsa gumba (*Cordyceps sinensis*): A call for its sustainable exploitation

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SUMMARY

Yar tsa Gumba, the local name for *Cordyceps sinensis*, is an entomophilous fungus in the order Hypocreales and family Sclerotiummataceae, found primarily in subalpine regions, from 3200 to 4000 m asl. The fungus is parasitic on caterpillars, primarily those in the genus *Hepialus*. Studies on *Cordyceps sinensis* indicate that the fungus may improve liver function, reduce cholesterol, adjust protein metabolism, inhibit lung carcinoma and treat aging disorders. In the last five years, since it was found in parts of Garhwal and Kumaun Himalaya, massive exploitation has occurred, leading to a drastic decrease in wild populations. This paper presents results of an exploration carried out on the fungus at several important sites, the mode of trafficking and suggested policy initiative for its sustainable exploitation.

INTRODUCTION

Medicinal fungi have been used as dietary supplements throughout the world for over 2,000 years. There is intense industrial interest in novel compounds extracted from the mycelium or fruiting body of fungi. In 1994, fungi constituted a US\$3.6 billion industry (Chang 1996). Compounds extracted, so-called 'fungal nutraceuticals', exhibit medicinal and/or tonic qualities and have immense potential as dietary supplements for use in the prevention and treatment of various diseases (Chang and Buswell 1996). Modern analytical techniques have revealed that many many fungi contain bioactive compounds including: polysaccharides (*Lentinula edodes*), immunomodulatory proteins (*Ganoderma lucidum*, *Flammulina velutipes* and *Volvariella volvacea*) and protein-bound polysaccharides (*Coriolus versicolor*, *Tricholoma* spp). Some of these compounds have potential anti-cancer properties that appear to be based on enhancement of

the host immune system rather than a direct cytotoxic effect (Chang and Buswell 1996). In the Himalaya, *Cordyceps* is found mainly at higher altitudes in Nepal, Sikkim, Bhutan and Arunachal Pradesh and has recently been discovered in the Kumaun Himalaya, where it is known as *Keera Ghaas* (insect-grass). It also occurs in Nepal, and in Tibet, Sichuan, Qinghai, Xizang, and Yunnan provinces of China. This paper presents the results of a field study conducted in alpine and subalpine zones of Kumaun Himalaya in a remote district of Pithoragarh, India.

The fungus

Kobayashi (1941) listed 137 species in the genus *Cordyceps* and, of these, 125 were parasitic on insects (with one or two growing on subterranean insects), while Dube (1983) identified 200 species. *Cordyceps*

sinensis, or Yar tsa Gumba, is an entomophilous fungus in the order Hypocreales and family Scolecosporaceae. *C. sinensis* is a black, blade-shaped fungus found from 3200 to 4000 m asl. The fungus grows on several species of caterpillar, primarily those in the genus *Hepialus*. The caterpillar exploited in the Kumaun and Garhwal Himalaya has not been positively identified. However, caterpillars of *Hepialus oblifurcus* (Hepialidae) are known to be the host of *C. sinensis* (Arora and Dhaliwal 1997). In late autumn, the fungal mycelium infects the caterpillars and, by early summer of the following year, the fungus has killed the caterpillar and the fruiting body can be seen protruding from the caterpillar's head (Figure 1), resembling a grass sprout, and hence the local name Yar tsa Gumba or 'winter insect, summer grass'. The corpse of the insect enlarges and becomes resistant to decay due to a toxin, cordycepin, produced by the fungus (Dube 1983; Nair and Balakrishnan 1995). The dead insects remain buried underground, until favourable conditions in spring lead to the development of the club-shaped, orange to bluish-black fruiting body above-ground. The stalk is 7–10 cm long and is used by local people to identify and gather the 'vegetable caterpillar' for their use (Figure 2).

Medicinal use

According to Zhu *et al.* (1998), *Cordyceps* was discovered 1,500 years ago in Tibetan mountain pastures. Chinese herdsmen observed that their livestock became very energetic after eating a grass-like fungus. About 1,000 years later, the Emperor's physicians in the Ming Dynasty learned about this Tibetan wonder and developed powerful potions from it. Practitioners of Chinese traditional medicine believe that *Cordyceps sinensis* has a sweetish taste and a warm character; it enters through the kidney and kidney channels and enhances lung function, bolsters kidney yang energy, relieves coughing, poor vitality, impotence, spermatorrhoea, asthma, lessens sputum, aching back and knees, and general debility caused by long-term illness (Table 1). It is classed as a warm tonic agent, and is highly effective at replenishing the essence and strengthening the body. It is generally not prescribed as medicine but as a food supplement/additive to be cooked with meat (Huang 1999). Chemical analysis has revealed that *Cordyceps*



Figure 1 It's rare to find the live specimen of the caterpillar (*Hepialus* spp.). On right, the fruiting body of the fungus – the stroma bearing peritheca emerges out of the mouth



Figure 2 The protruding gray-bluish stalk, which camouflages itself in the surrounding vegetation, is hard to locate, while the body of the worm lies buried inside

sinensis contains vitamin B₁₂, mannitol, cordycepic acid, ergosterol and 25–32% cordycepin-3'-deoxyadenosine (Huang 1999). In recent years, several other *Cordyceps* species have been used commercially in fermentation.

STUDY SITES

The study sites extend between 3200–4000 m asl, 29°21'–30°48'N and 79°48'–81°5'E, in the northern half of the district of Pithoragarh (Uttaranchal) in the Western Himalaya, India. Presently, the fungus is known from Chiplakot at the confluence of the Darma and Choudas valleys, Sumdum, Philam, Bon, Baling, Dugtu and Daantu in the Darma valley, and Ralam Dhura, Panchachuli, Nangnidhura and Namik in the Dharchula-Munsiyari region (Negi 2003). Since these sites are very remote, the study

Table 1 Pharmacological studies conducted on the efficacy of *Cordyceps sinensis* extracts

<i>Pharmacological studies</i>	<i>Results</i>	<i>References</i>
Liver	CordyMax Cs-4 raises ATP in the liver of mice	Dai <i>et al.</i> 2001; Manabe <i>et al.</i> 1996, 2000
Antioxidant	Antioxidant and anti-lipid peroxidation activity and suppresses LDL oxidation	Li <i>et al.</i> 2001; Liu <i>et al.</i> 1991
Immune system	VGH-CS-ME-82 increases major histocompatibility complex class II antigen expression in hepatoma cell lines. May be useful to treat systemic lupus erythematosus. Cordycepin is effective against antibiotic-resistant bacteria	Gong <i>et al.</i> 1990; Chiu <i>et al.</i> 1998; Lin <i>et al.</i> 1999; Yang <i>et al.</i> 1999; Zhu <i>et al.</i> 1998
Blood sugar	Lowers serum and plasma glucose in diabetic and epinephrine-induced hyperglycemic mice	Kiho <i>et al.</i> 1993, 1999
Hepatitis B	May adjust protein metabolism and correct inversion of albumin and globulin	Zhou <i>et al.</i> 1990
Sexual dysfunction	Increases 17-ketosteroid and 17-hydroxycorticosteroid, increases weight of sexual organs in rats; increases plasma cortisol and testosterone in rats	Yang 1985; Liu <i>et al.</i> 1997
Anti-carcinogen	Inhibits tumor growth in mice. Antimetastasis of liver Lewis lung carcinoma and B16 melanoma cells in mice. Inhibits cultured human glomerular mesangial cells induced by LDL	Liu <i>et al.</i> 1997; Nakamura <i>et al.</i> 1999; Zhao <i>et al.</i> 2000; Bok <i>et al.</i> 1999
Improved physical performance and quality of life	May increase energy by improving utilization of oxygen. Cordycepic acid relaxes bronchia and strengthens adrenal glands	Dai <i>et al.</i> , 2001; Zhu <i>et al.</i> , 1998; Zhang <i>et al.</i> , 1997
Anti-aging agent	Jinshuibao capsules treat and relieve symptoms of senile deficiency syndrome by inhibiting the formation of monoamine oxidase	Zhang <i>et al.</i> 1997; Song 1992
Corticosteroid secretion	Increases corticosterone production by adrenal cells	Wang <i>et al.</i> 1998
Blood pressure	Reduced mean arterial pressure, possibly by stimulating release of nitric oxide and endothelium-derived hyperpolarizing factor	Chiou <i>et al.</i> 2000; Francia <i>et al.</i> 1999
Kidneys	Improves kidney function and reduces damage caused by nephrotoxic chemicals. Possible modulation of T-cell-mediated immune function	Li <i>et al.</i> 1996

team was divided into two in order to cover the three regions simultaneously. While the first group covered the Ralam valley, the other group covered the remaining two major sites, Chiplakot and Panchachuli. The study sites were classified in terms of the abundance of the *Cordyceps*, the vegetation and habitat types (Table 2).

RESULTS

In India, *Cordyceps* has been collected for over a decade by local Khampas (a Tibetan race) in high-altitude areas of the Kumaun hills. June is the peak month for collection, extending to late July. On average, a person can collect around 50–60

Table 2 Habitat and other species associated with *Cordyceps sinensis*

Meadow types	Habitat type	Associated flora
Sunny meadow	Continuous green vegetation	Dominated by <i>Saussurea graminifolia</i> . Other genera: <i>Ranunculus</i> , <i>Delphinium</i> , <i>Corydalis</i> , <i>Draba</i> , <i>Sisymbrium</i> , <i>Arenaria</i> , <i>Impatiens</i> , <i>Geranium</i> , <i>Potentilla</i> , <i>Saxifraga</i> , <i>Astragalus</i> , <i>Pleurospermum</i> , <i>Gentiana</i> and <i>Swertia</i> . Perennial mesophytic herbs are restricted to the edges of melting snow, e.g. <i>Primula denticulata</i> , <i>P. macrophylla</i> , <i>P. munroi</i> , <i>Kobresia hookeri</i> and <i>Caltha palustris</i>
Alpine scree	Dry exposed rocks	Dominated by <i>Euphorbia stracheyi</i> . Other species include: <i>Rheum webbianum</i> , <i>R. australe</i> , <i>Saussurea obvallata</i> , <i>S. gossypiphora</i> and <i>Pleurospermum densiflorum</i> . Outlying patches of <i>Rhododendron campanulatum</i> , <i>R. anthopogon</i> , <i>Juniperus recurva</i> , <i>Lonicera myrtillus</i> and <i>Salix fruticulosa</i> in lower regions of alpine scrub
Shaded meadows	Shaded slopes	Dominated by the genus <i>Aconitum</i> , principally <i>A. atrox</i> . Other species include <i>Aconitum heterophyllum</i> , <i>A. violaceum</i> , <i>Angelica glauca</i> , <i>Pleurospermum angelicoides</i> , <i>Megacarpaea polyandra</i> , <i>Delphinium cashmirianum</i> and <i>Parnassia pusilla</i>
Glacial moraine	–	Poor vegetation cover because of debris flows and avalanches. Common species are <i>Epilobium latifolium</i> , <i>Waldheimia glabra</i> , <i>W. tomenosa</i> , <i>Sedum roseum</i> , <i>S. crassipes</i> , <i>Oxyria digyna</i> , <i>Saxifraga imbricata</i> , <i>Salix</i> spp. and <i>Rheum speciforme</i>
Alpine stony desert	Virtually covered with snow, except for the two months of rainfall (June–July)	Highly specialized, short-lived species: <i>Christolea himalayensis</i> , <i>Arenaria</i> spp., <i>Corydalis bowerii</i> , <i>C. crithimifolia</i> , <i>Draba</i> spp., <i>Pleurospermum</i> spp., <i>Sedum bouveri</i> , <i>S. quadrifidum</i> , <i>Androsace</i> spp., <i>Thylacospermum</i> spp., <i>Saussurea gossypiphora</i> and <i>Cremathodium nanum</i>

samples, with about 3000–3500 mummified insects, weighing about 1 kg, per day. Trafficking starts from the border town of Dharchula, where it currently fetches Rs.80,000–90,000/kg (US\$1778–2000/kg), through Nepal and finally to markets in China (Figure 3). Annually, about 4–5 quintals of Yar tsa Gumba is illegally trafficked into Nepal from Dharchula. Keeping this in mind, the survey was carried out midway through June. Before embarking on the survey (i.e. one day prior to site visit), the locals returning from the site told us that there was not a single specimen left in the meadows. After a week in the meadows they could only find around 30–40 specimens, when they would normally have found that many in a single day.

A total of 19 villages in the three areas were intensively surveyed over the two-month harvesting season. Results showed that:

On average, 80% of the population of each village is involved in the collection of *Cordyceps*, and the collection now lasts from mid-April

through mid-July. This is having grave repercussions on the regeneration potential of the species as the fruiting body needs time to mature and disperse spores.

Awareness of the monetary value of their produce has risen among the villagers. They are now able to obtain up to Rs.60,000/kg (US\$1333/kg) for their produce, whereas they used to get around Rs.15,000–20,000 (US\$ 333–444) (Table 3).

Local villagers have now, in most cases, demarcated their own collection areas where no outsider is allowed to exploit *Cordyceps*.

A sharp decline in the harvest, by as much as 30–50%, has occurred in the last two years. Increase in collection is the outcome of increased exploration of other habitat/sites (Table 3).

The villagers used to sell their produce to a single middleman (often from their own or an

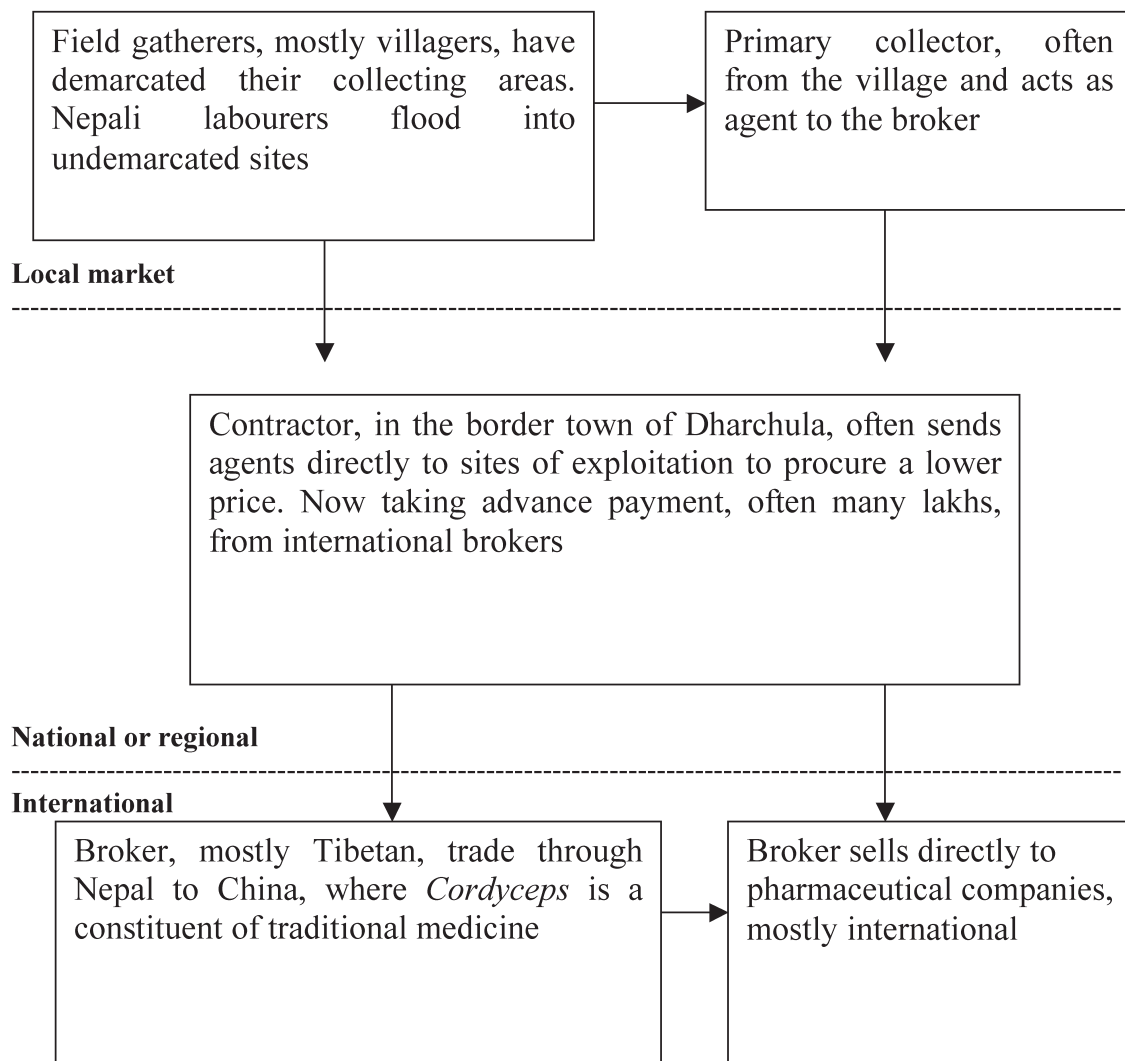


Figure 3 Mechanism of trade in *Cordyceps sinensis*, starting at villages in the subalpine zones of the Gori River catchment and ending at international markets

adjoining village) who controlled most of the dealings, but recently the number of middlemen rose to 3–4, some coming from as far as Dharchula, and coming directly to the village or the site itself.

Recently, the government of Uttaranchal issued guidance to the district magistrate of Pithoragarh on the exploitation of Yar tsa Gumba, stating that it should be done through the Van Panchayats (forest councils), that a committee of Van Panchayats be formed to monitor exploitation, and that the overall power be vested in the Sarpanch (headman of the village council). All this was to be carried out under the supervision of the conservator, district Pithoragarh. The Samiti (village council) was to

receive 5% of the total collection money. However, no government agency came forward or showed interest in *Cordyceps* commerce, for the simple reason that no one knew the exact purchase price, who were the buyers and what royalty should be paid. On top of all this, ambiguity remained as to the legality of *Cordyceps* exploitation!

During the survey, we came across some villagers who were growing medicinal plants (though at a small scale) near their summer homes at around 3000 m. Important medicinal plants being grown by the villagers of Lenga, Dhilam, Paato and Ralam are Kutki (*Picrorrhiza kurooa*), Jambu faran (*Allium stracheyi*), Chippi or Gandhrayan (*Pleurospermum angelicoides*), Hathajari (*Dactylorrhiza hatagirea*) and

Table 3 Collections of *Cordyceps* from study sites over five years

Year	Study sites and collections/year (kg)			Total (approximate)	Value at local market/ village (US\$/kg) #	Value at Dharchula (US\$/kg) #
	Chipla Kedar ¹	Ralam ²	Panchachuli ³			
1999	3	–	–	3	1000 (333)	1667 (556)
2000	8	1	–	9	3000 (333)	9000 (1000)
2001	8	4	4	16	7111 (444)	21333 (1333)
2002	12	6	12.5	30.5	23711 (778)	47444 (1556)
2003	24	29	13.5	66.5	66500 (1000)	118222 (1778)
2004	30	35	30	95	126667 (1333)	190000 (2000)

1. Gofa, Lodi, Tanga, Bindi, Bhikuria, Dani bagar, Sera and Khatoli constitute the Chipla Kedar zone
2. Lenga, Bui, Dhilam, Ucchetai, Fafa, Basankot, Falyanti, Bhothi and Kultham constitute the Panchachuli zone
3. Pato and Ralam constitute the Ralam zone

Figures in parenthesis represent the then prevailing rate/kg in rupees

(a) Collections range from 50 g to a maximum of 0.5 kg per family per season. (b) Chipla Kedar has faced over-exploitation and sites have shown a declining yield. (c) Villagers in the Panchachuli zone were the last to exploit *Cordyceps*, beginning in 2001, and sites in this zone are currently experiencing maximum pressure. This zone also possesses largest diversity of rare and endangered medicinal plants. (d) Increase in collection over the year is higher because more sites are being exploited

Bajradanti (*Potentilla fulgens*). In a pioneering study conducted in the Nanda Devi Biosphere Reserve, Uttaranchal, Maikhuri *et al.* (2002) calculated the per hectare input cost (hours of labour, external costs and annual monetary value) for the cultivation of medicinal plants. The income generated or the output cost was calculated by multiplying the market cost of each medicinal plant per kg by the total yield per hectare. They showed that, in the majority of the cases, the ratio between input cost and the output cost is 10–12, so villagers will earn ten to twelve times the amount they put in. Such efforts will have an indirect impact, lessening the pressure on the over-exploitation of wild species of medicinal plants. Some rare or endangered species that can be exploited include: *Aconitum atrox*, *Dioscorea deltoidea*, *Hedychium spicatum*, *Podophyllum hexandrum*, *Viola biflora*.

Gucchi mushroom or morel, *Morchella esculenta*, is another resource, the exploitation of which needs to be studied. In addition to other wild edible species of mushrooms, including *Bolus* spp., will help ameliorate local poverty. Presently, very few villagers collect mushrooms (undertaken only by low-caste people) and they only collect morels for their own consumption. When asked for the price per kg of dried morels, the villagers gave a range of prices, from Rs.200–1000 (US\$4.5–22.0). Obviously, the majority of collectors were unaware of

the actual market value, which at present is above Rs.4,000 (US\$89).

CONCLUSIONS

Poverty drives people to over-exploit Yar tsa Gumba, even though they are concerned about declining yields. Encouraging more villagers to cultivate other medicinal plants and, at the same time, spread traditional knowledge, will not only bring about an improvement in the economic conditions of these people but will go a long way to lessening the pressure on Yar tsa Gumba. Extension programmes and awareness campaigns should be carried out among the villagers involved to educate them in the best mode of collection, such as leaving a few areas untouched each year to allow the regeneration of the species.

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