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SOCIO-ECONOMIC VOICES

Harvesting of *Ophiocordyceps sinensis* in Remote Villages of Chamoli, Uttarakhand: Economic Benefits and Social Challenges

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Intro: *Ophiocordyceps sinensis*, previously classified as *Cordyceps sinensis (Berk.)*, was reclassified in 2007 by Sung, Hywel-Jones, Luangsa-ard, Shrestha, and Spatafora. Molecular phylogenetic studies confirmed that this species belongs to the *Ophiocordycipitaceae* family, distinguishing it from its earlier classification in Clavicipitaceae. For over 2,000 years, fungi with medicinal properties have been used as nutritional supplements. The pharmaceutical industry has shown strong interest in novel bioactive compounds extracted from the mycelium and fruiting bodies of fungi (Negi et al., 2006). By 1994, fungi accounted for an estimated US$3.6 billion industry (Chang, 1996). The Garhwal Himalayas serve as a primary source of medicinal plants, with the higher-altitude regions acting as biodiversity hotspots. Among these, *Ophiocordyceps sinensis* is one of the most valuable fungal species. While there are more than 310 species of *Cordyceps*, only 150 species had been scientifically recorded (*Webster, 1980; Sarbhoy, 1983*). Of these, three species possess significant medicinal properties, with *Ophiocordyceps sinensis* being among the most *highly prized fungi worldwide (Kobayasi, 1982).

Nearly 1,500 years ago, Tibetan herders observed a peculiar phenomenon—livestock grazing in high-altitude pastures exhibited increased energy and vigor after consuming a grass-like mushroom (Zhu et al., 1998). This natural stimulant, now known as Yarsa Gumba or *Caterpillar Fungus*, became an integral component of Chinese-Tibetan medicine. phio*Cordyceps* sinensis (Berk.) Sacc., a parasitic fungus, infects Lepidopteran larvae, ultimately mummifying the host. Commonly referred to as *Caterpillar Fungus*, it holds significant medicinal importance in Tibetan and Chinese medicine. Locally, it is known as Yar-rsta-dgun-bu (Tibetan) and Dong Chong Xia Cao (Chinese) (Garbyal et al., 2004).

Distribution

Ophiocordyceps sinensis is found in high-altitude mountain regions, with reports of its presence above 4,000 meters first documented in 2000. This species thrives in the alpine and subalpine zones, between 3,600 to 4,200 meters above sea level. The fungus is primarily distributed across Nepal, Tibet, Bhutan, Sikkim, Sichuan, Qinghai, Xizang, and Yunnan provinces of China. In India, it is mainly found at higher elevations in Arunachal Pradesh, particularly in the alpine meadows of Chiplakedar, Darma Vyas, and Ralamdhura in the Kumaon Himalayas, where it is locally referred to as "*Keera Ghaas*" (insect herb) (Negi et al., 2006).

Currently, *Ophiocordyceps sinensis* is also observed in the Chiplakot, Ultapara, Brahmkot, Najari, and Nangnidhura-Munsiari region of Pithoragarh district. In parts of the Garhwal Himalayas, it is found in the Niti and Mana valleys of Chamoli district, where it is commonly known as "*Keera Jadi*".

General Features

Keera Ghaas (*Ophiocordyceps sinensis*) is a parasitic fungus that infects Lepidopteran larvae, belonging to the order Sphaeriales. It thrives in alpine meadows, where it primarily grows on caterpillars and pupae buried in the soil during the months of May and June. Although the exact host species in the Kumaon and Garhwal Himalayas remains unidentified, studies suggest that *Hepialus oblifurcus* (Hepialidae) serves as a potential host (Arora & Dhaliwal, 1997). The fungal structure consists of a worm-like body with fine transverse wrinkles, featuring eight pairs of legs, with the middle four pairs being the most prominent. A dark brown stalk emerges from the collar of the structure, which is slender at the base and thickens toward the middle with a pointed tip.

The infection process begins in autumn, when *Ophiocordyceps sinensis* invades the larvae, gradually consuming its body tissue and eventually killing it. The mummified larva remains underground throughout the winter, with the fungus producing cordycepin, a bioactive compound that makes the insect's body resistant to decay (Dube, 1983; Nair & Balakrishnan, 1995). By May, the fruiting body of the fungus emerges above the soil, marking the start of the harvesting season (Garbyal et al., 2004). The presence of *Ophiocordyceps sinensis* is often associated with specific ecological indicators, such as *Rhododendron anthopogon (Sunpati)*, musk deer, blue sheep, and yak dung, which suggest a suitable habitat (Aryal et al., 2006). In the Indian Himalayan region, the fungus is commonly referred to as "*Keera Jhar*" (Sharma, 2004).

The market for *Keera Ghaas* has expanded significantly over the years due to its high medicinal value. In 2002, its price in India ranged between INR 1,25,000 and 1,30,000 per kilogram, rising sharply to INR 4,00,000–5,00,000 per kilogram by 2012. In international markets, prices vary based on quality, with average-grade specimens selling for US$9,000–10,000 per kilogram, while high-quality specimens can reach US$50,000 per kilogram or more.

In terms of global production, China dominates the market, accounting for 95%–96% of the total supply, followed by Nepal (1.2%–1.8%), India (1.5%–2%), and Bhutan (0.6%–0.8%). The soaring demand in traditional Chinese and Tibetan medicine has led to overharvesting, contributing to habitat degradation and unsustainable exploitation. As one of the most expensive natural medicinal resources in the world, *Ophiocordyceps sinensis* continues to attract significant attention for both its economic and ecological importance.

Medicinal properties

Chinese practitioners of traditional medicine consider that *C.sinensis* is somewhat sweet in taste and warm in nature. Cordycepin, a boiactive metabolic contained in the fruit bodies of these fungi, also exhibits various biological activities (Trigg et al. 1971; Sugar and Mccaffery 1998; Zhou et al. 2002; Li et al. 2003; Yun et al. 2003). *C.sinensis* is effective against bacteria that have developed resistance to other antibiotics. It is also effective in respiratory infections, leprosy and leukemia. It inhibits active enzymes known as monoamine oxidase responsible for ageing. In Tibetan medicine system it is used to increase vitality and in restoring regenerative fluids – especially the fertility of sperms and kidney heat.

Materials and Methods

Study area

Chamoli district is located in the northeastern part of Uttarakhand, India, spanning a geographical area of 8,030 square kilometers. It is bounded by the Tibet Autonomous Region to the north, Bageshwar and Almora districts to the south, Pithoragarh district to the east, and Uttarkashi, Rudraprayag, and Pauri Garhwal districts to the west. Situated at 30°66'N latitude and 79°56'E longitude, the district has an altitude of 1,293 meters above sea level. In

2021, forests covered 33.75% of the total geographical area, contributing to the district's rich biodiversity. Chamoli experiences a moderate climate year-round, with most rainfall occurring during the monsoon season, totaling 1,933.2 mm in 2021–22.

Administratively, Chamoli is divided into six tehsils: Joshimath, Karnaprayag, Tharali, Gairsain, Chamoli, and Pokhri, with six sub-districts, six towns, and 1,246 villages. The official language of administration is Hindi. As per the 2011 census, Chamoli has a population of 391,605, comprising 193,991 males and 197,614 females, with a sex ratio of 1,019 females per 1,000 males. The population growth rate from 2001 to 2011 was recorded at 5.74%, with a population density of 49 persons per square kilometer. In 2020, the district reported 3,269 live births (1,704 males and 1,565 females) and 550 deaths (319 males and 231 females). The literacy rate stands at 82.65%, with male literacy at 93.4% and female literacy at 72.32%, totaling 280,556 literate individuals.

Agriculture is the primary economic activity of the district, with a majority of the population engaged in farming. The key crops cultivated include wheat, maize, rice, pulses, millets, and seasonal vegetables, while potatoes, rajma (*Phaseolus vulgaris*), and ramdana (*Amaranthus caudatus*) serve as major cash crops. The district has seen an increase in agricultural productivity due to the adoption of new farming technologies. Despite its abundant mineral resources, including soapstone, copper, iron, graphite, gypsum, lead, slate, and limestone, Chamoli remains scantily industrialized.

Kanol and *Sutol* are the most remote villages of Ghat block, situated approximately 30 km from the nearest market in Sital and Ghat. Their economy primarily relies on traditional agriculture and animal husbandry. *Sutol* has a population of 650, while *Kanol* has 900 residents, with a total of 275 households. These villages are located along the Lord Karjan trekking route, which is known for its rich biodiversity. The landscape includes mixed forests and alpine meadows, with dominant tree species such as Quercus semicarpifolia (Himalayan oak), *Rhododendron arboreum* (Buransh), *Taxus baccata* (Himalayan yew), *Cedrus deodara* (Deodar cedar), *Hippophae rhamnoides* (Seabuckthorn), *Abies pindrow* (West Himalayan fir), *Picea smithiana* (Spruce), and Lyonia ovalifolia (Maesi). This region's diverse flora and high-altitude ecosystem make it a significant area for medicinal plant conservation and sustainable resource management.

Methods

Data collection and analysis

A random house hold sampling carried out for the records of information about the Yarsa gumba in interior village of Chamoli district. A questionnaire was used for the information about different parameters of *Keera Jhar*. A complete inventory was made about following objectives.

- To know the socio-economic impacts and future prospects of *Keera Ghaas*.
- To know about natural collection pockets and states of *Keera Ghaas* in study areas.
- To know the Govt. policies about collection of *Keera Ghaas*.

Collection of *Cordyceps* sinensis in *Kanol* and *Sutol* villages

Kanol and *Sutol* are the last inhabited and most interior villages of Ghat block in Chamoli district. Basically the economy of the villages is traditional crop based. Potato, Rajma, Ramdana etc. are the main crops of the villages. Potato (*Solanum tuberosum*) and Rajma (*Phaseolus vulgaris*) are the cash crops of the farmers but not in wide scale because both villages are far from road head. Both the villages are situated at the average distance of 30 km. from road head. From last five to six years there are drastic changes in the economy of villagers due to collection of *Keera*

Ghaas. It fetches Rs. 60,000 to Rs. 80,000 per Kilogram in Pithoragarh, passes through Nepal and finally reaches markets in China to be sold at Rs. 1, 00,000 per kg. In 2001, it is believed 4-5 quintals of Yar Tsa Gumba found its way into Nepal from the border township of Dharchula alone (Taklakot in Tibet happens to be its largest market).

Every year the average collection of *Keera Ghaas* is near about 140 kg from both villages. Near about 700 people were engaged in the collection of *Keera Ghaas* every year. Per head collection of *Keera Ghaas* was 200 gm per season. The collection period of this species is May to July and the potential natural pockets are *Bedini Bughyal, Homekund* and *Simbe*. It is also found in the track of famous religious "*Nanda Devi Raj Jat Yatra*". Basically the main collectors are men, women, young boys and girls which belong to the age category of 15 to 65 years. The buyers come from Dharchula (mainly *Khampas* - schedule tribes) and Nepal but recently some educated localites and shopkeepers from adjacent areas are working as agents of big buyers. They are earning a good amount from these buyers. The average income of these agents is 50,000 rupees/kg. Based on the above data we can say they are the real beneficiary, because apart from this they are involving other works also. According to localites the average rate of *Keera Ghaas* is Rs. 2, 50000 to 3, 00000 lakh.

Results and Discussion

Social Impacts

The collection of *Keera Ghaas* has significantly transformed the rural economy of *Sutol* and *Kanol* villages, bringing both positive and negative impacts. Over the past three to four years, villagers have gradually abandoned traditional agriculture and livestock rearing, which were once the primary occupations in these areas. The seasonal migration of locals has declined, as many now engage in *Keera Ghaas* collection as their primary source of income. The increased earnings have led to improved living conditions, with villagers replacing traditional stone and wood houses with concrete homes. Another positive shift is seen in education, particularly for girls, as families can now afford to send their children to schools in nearby towns such as Ghat, Gopeshwar, Dehradun, and Rishikesh. Additionally, the workload on women has reduced, as economic opportunities have expanded through the trade of *Keera Ghaas*. However, these economic benefits come at a cost. The decline in traditional farming and animal husbandry threatens local food security and cultural heritage. The increasing illegal trade of *Keera Ghaas* has also strained social relations among villagers, causing disputes over collection rights. Additionally, neighboring villages have imposed restrictions on harvesting, raising concerns about unauthorized extractions in protected areas.

As one of the most valuable natural medicinal resources globally, the rising demand and high market prices of *Caterpillar Fungus* have driven overexploitation. In 2020, the International Union for Conservation of Nature (IUCN) listed *Ophiocordyceps sinensis* as a vulnerable species, citing a 30% population decline over the past 15 years due to overharvesting. Beyond unsustainable collection, habitat destruction from unplanned development and climate change further endanger its future. The presence of this fungus is ecologically significant, as its growth and abundance are linked to specific plant species and soil conditions, making it a key bioindicator of alpine ecosystem health. To ensure long-term sustainability, conservation efforts and regulated harvesting practices must be enforced to protect both the species and its fragile Himalayan habitat.

Government Polices about *Cordyceps* sinensis

To ensure the conservation and sustainable collection of *Keera Ghaas* (*Ophiocordyceps sinensis*) in Uttarakhand, the state government has implemented specific guidelines for its legal harvesting and trade. These measures aim to regulate collection, prevent overexploitation, and ensure fair economic benefits for local communities.

Key Guidelines for Sustainable Harvesting in Uttarakhand:

- **Collection Season:** May to July (to allow natural regeneration of the species).
- **Issuing Authority:** *Van Panchayat / Gram Panchayat* (local governing bodies responsible for permit allocation).
- **Permit Issuance:**
  - Collection rights are granted exclusively to local villagers.
  - Each collector must pay a fee of Rs. 1,000 per head to the *Van Panchayat* for authorization.
- **Collection and Verification Process:**
  - Harvesters must deposit their collected *Keera Ghaas* with the *Van Panchayat Sarpanch*.
  - The *Sarpanch* verifies the quantity before approaching approved buying agencies through the Forest Department.
- **Pricing and Trade Regulations:**
  - Authorized buyers must pay a royalty of Rs. 5,000 per kg to the Forest Department.
  - The government-set base price for *Keera Ghaas* is Rs. 50,000 per kg.
  - The Forest Department is responsible for issuing the "*Ravanna*" (transition pass) to licensed buyers.
- **Legal Framework:**
  - In 2018, the Uttarakhand government classified *Ophiocordyceps* as a Non-Timber Forest Product (NTFP) under the Indian Forest Act, 1927, ensuring regulated and fair trade.
- **Sustainable Harvesting in Other States:**
  - In Sikkim, the Department of Forest, Environment, and Wildlife Management introduced similar rules and guidelines in 2016 to promote sustainable harvesting, conservation, and revenue generation for local communities.

These regulations are designed to balance economic benefits with conservation efforts, protecting the fragile alpine ecosystem while ensuring that local communities profit through legal and sustainable trade practices.

Conclusion and Future Prospects

Keera Ghaas or *Cordyceps* sinensis is unique and valuable for its medicinal properties, while it is not extracted sustainable in planed way in the study areas. There is a wide price gap in forest department and outside funding agencies, so it is supplied illegally. The social relations and customs are also affecting for the collection of *Keera Ghaas*. The villagers are not much aware for its conservation priorities. The economic boom is easily seen in villages where the villagers are collecting *Keera Ghaas*. There should be a proper understanding between collectors, forest departments and other agencies for the proper harvesting and conservation of this species. Awareness and scientific knowledge is very necessary for the future prospects regarding to conseve *Keera Ghaas*.

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