

Original Article

The Hunt for Himalayan Traditional Medicine Parasitic Treasure: ‘Caterpillar Fungi’

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ABSTRACT

In recent times the demand for conventional medicines is rising day by day in urban cities of the globe. Different sorts of folk meds are widely employed in various therapies by the global communities. Excessive exploration and exploitation of folk meds has alarmingly damaged the ecological diversity around the world. The folk meds are largely created through plants animals and even microbes. In this study an expensive conventional medicinal fungus often alluded to as ‘caterpillar fungi’ that is found in the Himalayan region has been evaluated for its sorted traits pertaining to its origin, morphology, lifecycle, therapeutics, biomolecules and its trade values. This fungus has been an integral compound of traditional medicines in Tibet, Nepal, Bhutan, India and China. It was inferred in this study that the hunt for this Himalayan medicinal treasure has raised tremendously. In recent times studies reveal that the caterpillar fungus has been widely employed as a nutritional supplement or tonic and as an herbal medication. The volume of this medicinal fungus is decreasing due to its over exploitation. Over exploration of this pricey med is contributing towards its degradation. It was evaluated through this investigation, that the caterpillar fungi possess rich aboriginal medicinal traits that has resulted in its excessive exploration and even smuggling in the states of its origin. It is concluded in this study that; strict measures must be taken by the global states to safeguard these valuable fungi that could be loaded with medicinal properties to cure many chronic health ailments. It is inferred in this study that lack of proper concerns on these significant fungi has labelled these fungi under vulnerable species.

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1. Introduction

The exponential global trade of caterpillar fungi is due to its folk medication components, assigning it as one of the significant global ecological products [4]. For the past several years, poisonous animals, plants and microbes have been a source of significant biomolecules from ecological resources that bear potential drug traits [1]. One of such parasitic fungi referred to as caterpillar fungi or *Cordyceps sinensis* (Figure 1) that has been in ancient medicine prescription of Tibetans and Chinese, alluded to as ‘Yartsagunbu’ or ‘Dong Chong Xia Cao’ respectively [2]. The high monetary value that ranges from twenty to forty thousand US dollars per kilogram of this parasitic fungus has termed it as ‘soft gold’ [2]. The fungi actually originate from the dead caterpillar that is loaded with fungal mycelium [2]. This fungus requires a specific low temperature of below twenty degrees centigrade for its

healthy growth [2].



Fig 1. Caterpillar fungi occurring in a natural habitat.
(Source: <https://www.firstpost.com>)

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In the last few decades, the medicinal properties of caterpillar fungi have attracted many scientists, researchers and corporations worldwide. It has been a significant source of income for regions of China, Nepal, India and Bhutan [3]. The ethnic or aboriginal individuals of Himalayas have been dependent on Himalayan ecological diversity and its folk medicines [3]. The caterpillar fungi have been reported to occur in Himalayan region and has been also recognized as ‘Himalayan Viagra’ [3]. Its bioactive molecules have been reported to be active as anticancer, aphrodisiac, antioxidant, anti-inflammatory, aphrodisiac and many more [3]. Keeping the medicinal traits and incidences of illegal trading of caterpillar fungi this inquiry was carried out to evaluate its significance.

1.1 Literatures survey

Various examinations with respect to caterpillar fungi have been accomplished in recent years. In the year 2019 Elkhateeb *et al.*, in their study inferred that the caterpillar fungi or cordyceps fungi releases a significant component alluded to as ‘Cordycepin’ that possess antimicrobial traits [5]. Das *et al* in 2021, their research study inquired that Cordyceps species are characterized as immuno-stimulatory and biological potential [6]. Na reported that the first Cordycepin was studied for *Cordyceps militaris* in the year 2015 [7]. Liu and his associates in their inquiry evaluated the repurcussions and safety of *Ophiocordyceps sinensis* for curing kidney patients [8]. Baral in the year 2017 examined the ecological significance and entomopathogenicity of *Ophiocordyceps sinensis* [9]. Liang and Munster in the year 2022 explored the caterpillar fungi in the Sino-Tibetan trade with respect to anti-corruption e-commerce biotechnology [10]. He *et al* in the year 2022 structured their study based on the soaring monetary merit of caterpillar fungus to tie-up betwixt the consumption of caterpillar fungus and consumers with their monetary status [11]. Amrity and his coworkers studied the livelihood earned from caterpillar fungus in Himalayan Kumaon region [12]. Liu *et al* in their inquiry evaluated *Ophiocordyceps sinensis* and its most common adulterates by using specific species primers [13]. Sah *et al* 2022 examined *Cordyceps sinensis* with respect to its occurrence, morphology medicinal significance and it’s trading [14]. In 2017 Yadav and his associates studied the trading disputes arising due to the dependence of different groups of the Himalaya for the caterpillar fungus [15]. Samarasinghe and Waisundara in 2020 investigated the therapeutic characteristics and anti-lipid characteristics of *Cordyceps sinensis* [16]. Choda in the year 2017 inferred in his study that there has been lack of medicinal trials of *Cordyceps sinensis* in individuals through avante garde therapies but folk medicinal therapies clearly depicts its high medicinal traits [17]. Savioli *et al* in 2022 evaluated the role of nutritional adjunct of *Cordyceps sinensis* in performances of marathons athletes [18]. In the year 2016 Wu and his co workers inquired about an alternative of *Cordyceps sinensis* from Bhutan showing

similarity with the species of that of the Chinese in terms of health stimulator and medicine [19] Ashraf and his associates in the year 2020 in their study investigated the therapeutic and nutraceutical potentiality of cordyceps [20]. Pradhan in the year 2016 in his study concluded that caterpillar fungus can act as a potential bio-reserve for trading if proper legislation and involvement of communities of Sikkim state of India is attained [21]. In 2019 Shrestha and his associates inquired the financial dependency of individual groups of hills on the caterpillar fungus in western regions of Nepal [56]. In the year 2019 Wallrapp and his co-workers described the cross-border trading of caterpillar fungi in the terrain areas of Kailash Mountain [57]. Yadav and his associates depicted the safeguarding of caterpillar fungi in the Nanda Devi eco-reserve of India in the year 2016 [58]. Yadav and his co-workers in 2019 studied the alteration of sustenance of individuals residing in west Himalaya through caterpillar fungi [59].

2. Materials and Methods

2.1. Materials

The current study being an exploratory qualitative research work required secondary data. The secondary data collection was implied from secondary sources. The secondary sources included data from articles of journals, books, newspapers, reports, organizations, and various websites.

2.2. Methods

The collected secondary data was subjected to in-depth analysis in-order to evaluate the research study. Thereafter analysis and evaluation of the secondary data conclusion was withdrawn.

3. Results and Discussion

3.1. Dwellings of caterpillar fungi

It occurs in higher altitude areas above sea level of 3800 to 5200 m [38]. It grows favourably in colder grass-like alpine mountain regions of the Himalayas [39]. It is an endemic species that occurs in the Himalayas touching different nations like China, Tibet, India, Bhutan, and Nepal [40]. The caterpillar fungus has a wide distribution in the global arena with prolific import, export, produce and consumption (Figure 2).

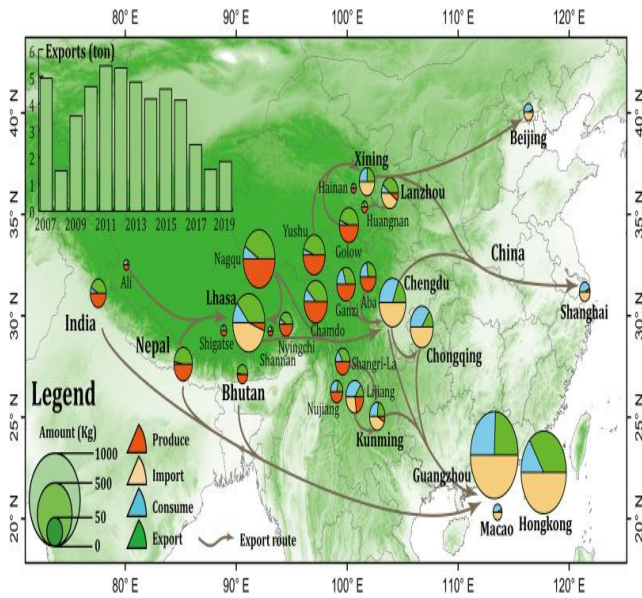


Fig 2. Distribution of caterpillar fungi on the map. (Source: <https://doi.org/10.1016/j.scitotenv.2020.142548>)

3.2 Morphological framework of caterpillar fungi

In English it is termed as Cordyceps mushroom. In Latin it is alluded to as *Cordyceps sinensis* [29]. It is classified under phylum of Ascomycota, class of Ascomycetes, order of Hypocreales, and family Clavicipitaceae. Other relative species of this fungus are *Cordyceps militaris*, *Cordyceps barnesii*, *Cordyceps ophioglossoides*, and *Cordyceps hyphae* [29]. The various local names for this fungus are Yarsagumba, Yarchagumba, Keera Jhar, Jeevanbuti, Keedaghass, Chyoukira, Sanjeevanibhooti, DongChongXiCao, and Tocheikasa [29]. This fungus is a parasite it is a combo of fungi and caterpillar consisting of the base of caterpillar and upper fungi part [28]. The wide spread of this parasitic fungus is highly influenced by the makeup on the vegetation [27].

Its basal construction initiates from a host insect *Hepialis armoricanus* larva [42]. The body structure ends with a club-like cap that integrates stipe and stroma [41]. The fruiting body of the fungi is darker brown [43]. The root structure of this parasite along with the larva structure clubbed with the intruded mycelium is brown or yellow in colour [44]. The undeveloped host larval structure lies about six inches beneath the ground surface [44]. Upon maturity the fungi consumes around ninety percent of the host [45]. As the stroma body reaches its maturity it grows bigger in size by swelling and ultimately developing into perihelia [46]. The average weight of the caterpillar fungi ranges to about three hundred to five hundred milligrams [44]. The entire *Cordyceps* fungi develops within the host insect body (Figure 3).

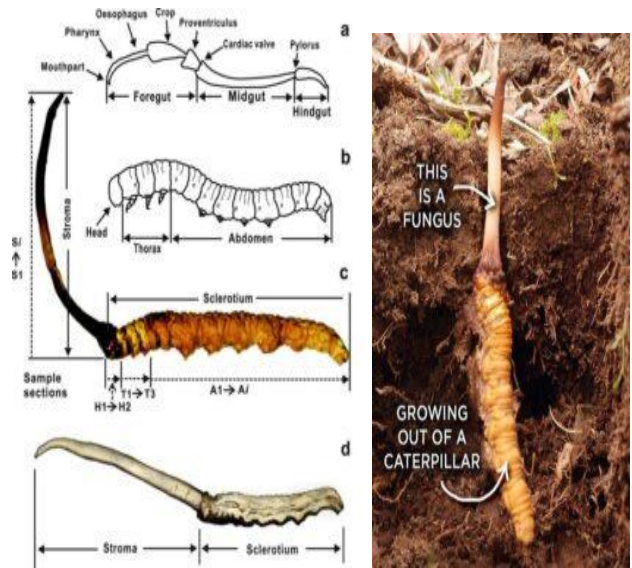


Fig 3. Cordyceps fungi developing in the host insect body. (Source: <https://learnagro.com>)

3.3 Life cycle of caterpillar fungi

The life cycle of caterpillar fungi consists of two stages viz. teleomorphic and anamorphic [52]. The infection initiates with the infection of the larva beneath the ground in the late autumn season [52]. The mycelium of the fungi enters the larval hemocoel [52]. The infected larva moves beneath the ground about two to five cm and further dies in a position with its face upwards [52]. Thereby the fungi develop, by moving out, by piercing the head of the insect and forms a bud stroma, that is frozen in the winter season (Figure 4) [52]. On the arrival of spring season bud stroma grows out of the soil forming a stalked fruiting body [52].

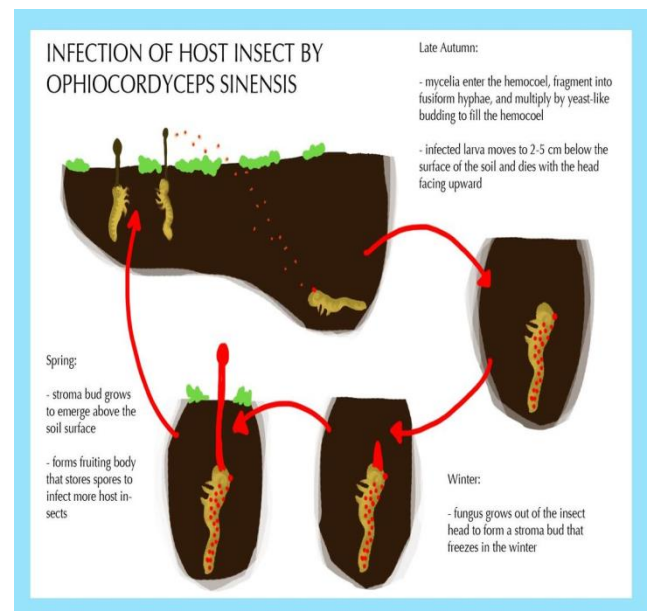


Fig 4. Life cycle of caterpillar fungi. (Source: <https://microbewiki.kenyon.edu>)

depression, anti osteoporosis, anti cerebral ischemia, anti fatigue, antiasthma, steroidogenesis, erythropoiesis, anti arrhythmia, antiaging, testosterone production, sedation, and adjunction, as well as the ability to do the following: prevent and treat injury to the bowel, promote endurance capacity, improve learning-memory, prevent allograft rejection, and attenuate lupus [2].

3.7 Patents on caterpillar fungi

Researchers, scientists and corporations from around the globe are in hurry to obtain patents on caterpillar fungi. In 2011 US Patent No. US 8,008,060 B2 was obtained by Cleaver *et al.*, for developing a protocol for the growth of *Cordyceps sinensis* on a substrate [22]. In the year 2008, Cleaver *et al.*, obtained a US Patent No. 7,407,795 B2 for developing *Cordyceps sinensis* on matter and a special method for hybridising its distinct strains [23]. In the year 2019 Cheng and Wu were granted a US patent, US20190374590 that described the utilisation of the extract of *Cordyceps militaris* for treating kidney disorder [24]. In 2011 Man was granted a patent in Korea with application no. KR20110027411 that depicted the procedure for growing of *Cordyceps militaris* [25]. The Chinese patent, CN101707966A was granted in 2010 that described viable Chinese caterpillar fungus growth by utilising larvae as hosts and procedure for cultivating it [26]. The Chinese woman athletes were credited with the success in the National Games of Beijing, China in 1993 through this fungus usage [28].

3.8 Hunting cases of caterpillar fungi

There have been several instances that report the illegal trading of caterpillar fungi for its rich folk medicinal values. The contractors who are associated with collection of this sacred medicinal fungus often smuggle it from the region of Nepal and thereby illegally trade it to China [30]. In India collection of *Cordyceps* fungi is licit but its trading is unlawful. Due to restrictions for trading in India this fungus is smuggled to Nepal and China for black marketing [31]. The sky high pricing of the caterpillar fungi has resulted in raiding by wildlife collectors for illegal wildlife trafficking in wildlife businesses [32]. Pithoragarh region near the Indo Nepal border, has been the hunting ground for the KeedaJadi or caterpillar fungi collectors who illegally trade to Nepal and China, and have been raided by police and forest officials of Uttarakhand state of India [33]. The trading of *Cordyceps* fungi was equivalent to that of silver or gold prices in the People's Republic of China [34]. In Nepal the trading of caterpillar fungi started in 1987 and further made lawful in 2001 [34]. In Bhutan the *Cordyceps* fungi cultivation was prohibited till 2004, however in order to discourage illegal collection restricted cultivation was allowed [34]. In India the cultivation of *Cordyceps* fungi was initiated in 1990's [34]. In India smuggling incidents concerning caterpillar fungi have also resulted in arrests of smugglers in Leh region [35]. In the past several years there have been reports of Chinese military hunting in Indian territories of Arunachal Pradesh

state for the rare *Cordyceps* fungi [36]. In Bhutan poachers illegally enter from Tibet region to collect the caterpillar fungi and are often successful as the forest reserve is not quite equipped to inhibit the insurgency [37]. In the year 2020 it was reported that the caterpillar fungus is now being listed in IUCN as a vulnerable species [54].

3.9 Caterpillar fungus trade value

It was expressed in 2017 that caterpillar fungus can cost about 140,000 US dollars per kg [53]. Experts are of the view that around 80% of home revenues in Tibetan regions and Himalayan regions hit from trading caterpillar fungi [53]. One of the districts of Nepal collected about 4.7 Million dollars in 2016 through this medicinal fungus [53]. The report of the data bridge market research on global trading forecast of caterpillar fungi till 2029 exhibits that global trading of *Cordyceps sinensis* should raise to about 1499.45 million US dollars (Figure 7) [55].



Fig 7. Global trading forecast estimation till 2029. (Source: <https://www.databridgemarketresearch.com>)

4. Conclusion

This study concludes that a caterpillar fungus is notable folk medicine that is truly Himalayan parasitic treasure. The bioactive constituents of cordyceps and its derivatives are potential treasures for a number of fatal maladies. It is also being inferred in this inquiry that not all the traits of caterpillar fungi concerning its therapeutic applications have been discovered and several of its therapeutic applications are still unexplored. However over exploitation and illegal hunting of this medicinal fungi in the Himalayan region is a serious concern not only to the aboriginal individuals whose family livelihood are being sourced through this medicinal fungi but also the illegal trading has land up this traditional medicinal fungi to the verge of extinction. It is recommended through this study that proper legislative norms should be enforced by the

neighbouring nations of the Himalayan region rich in caterpillar fungi to safeguard this precious Himalayan green gold. The value of this pricey medicinal fungus can be dropped by innovating multiple strategies for propagating species. Nonetheless in vivo studies are required to identify the therapeutic potential of cordyceps

derivatives which can be a stride closer to licensing its utilization as a medication.

Conflict of Interest

None

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