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Economic contribution of Chinese caterpillar fungus to the livelihoods of mountain communities in Nepal

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ABSTRACT

Harvesting of Chinese caterpillar fungus, one of the most expensive biological commodities in the world, has become an important livelihood strategy for mountain communities of Nepal. However, very little is known about the role of Chinese caterpillar fungus in household economy. We estimated the economic contribution of Chinese caterpillar fungus to the household income, quantified the extent of "Chinese caterpillar fungus dependence" among households with different economic and social characteristics, and assessed the role of cash income from the Chinese caterpillar fungus harvest in meeting various household needs including education, debt payments, and food security. Results show that Chinese caterpillar fungus income is the second largest contributor to the total household income after farm income with 21.1% contribution to the total household income and 53.3% to the total cash income. The contribution of Chinese caterpillar fungus income to total household income decreases as the household income increases making its contribution highest for the poorest households. There is significant correlation between Chinese caterpillar fungus dependency and percentage of family members involved in harvesting, number of food-sufficient months, and total income without Chinese caterpillar fungus income. Income from Chinese caterpillar fungus is helping the poorest to educate children, purchase food, and pay debts. However, reported decline of Chinese caterpillar fungus from its natural habitat might threaten local livelihoods that depend on the Chinese caterpillar fungus in future. Therefore, sustainable management of Chinese caterpillar fungus through partnership among local institutions and the state is critical in conserving the species and the sustained flow of benefits to local communities.

1. Introduction

Biodiversity and human well-being are linked through ecosystem services (MEA, 2005). Provisioning ecosystem services, particularly wild plants and animals, make a significant contribution to the livelihoods and well-being of rural people in developing countries (Vira and Kontoleon, 2013). Globally, about 1.6 billion people including 60 million indigenous people depend directly on forest products for their livelihoods (World Bank, 2004; Vedeld et al., 2007). A meta-analysis of 54 case studies shows that biological resources may contribute as much as 20–25% of income to rural people in developing countries (Vedeld et al., 2007). During the last two decades significant progress has been made in understanding the role of biological resources in the lives of poor people, particularly their contribution to the household economy, and their role in alleviating poverty (Vira and Kontoleon, 2013).

It is generally assumed that income derived from wild species meets subsistence needs, provides a valuable safety net by offering a buffer against risks and shocks, and offers a possible pathway out of poverty (Cavendish, 2002; Shackleton and Shackleton, 2004; Vedeld et al., 2004; Angelsen and Wunder, 2003; Babulo et al., 2009; Vira and Kontoleon, 2013). However, there are limited data to determine how the lowest income groups among poor societies actually benefit from biological resources. Some studies suggest that dependency on forests (household income relative to the income from forest resources) among poor households is relatively higher than more well-to-do households (Cavendish, 2000; Fischer, 2004; Mamo et al., 2007; Vedeld et al., 2007; Babulo et al., 2009; Kamanga et al., 2009; Heubach et al., 2011) whereas others indicate that the dependency on forest resources increases with wealth (Adhikari et al., 2004; Coomes et al., 2004; Fischer, 2004; Narain et al., 2008). In addition to household wealth, income derived from

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the extraction of wild resources depends upon organizational, institutional, and social factors including household size, caste, sex of the household head, education of family members, land and livestock holdings, and distance to the resources as well as the markets (Adhikari et al., 2004; Viet Quang and Nam Anh, 2006; Uberhuaga et al., 2011; Zenteno et al., 2013).

Ecosystem services include provisioning and the harvesting of wild species (resources). Poor forest dwellers depend on these resources for their livelihoods. In order to sustain such ecosystem services, we require case studies about the role of each resource in the household economy. Managing such a resource would require ecological data on the abundance and demographic trends of the plant or animal species and how the abundance is affected by current levels of harvesting. Effective management also requires data on the harvesters: their social and economic status, and how each affects the amount of the resource harvested. Because harvesters have so much potential income from resources like Chinese caterpillar fungus, the harvest might begin earlier and last later, depleting the resource. Co-management of the resource might be the answer, but effective co-management depends in part on how close the harvesters live to the resource being harvested. However, information about extraction of wild resource is often fragmentary, confined either to the ecology, economics, or management of extraction. We simply do not have much data on the social, economic, and demographic characteristics of harvesters, or where they live.

Chinese caterpillar fungus, an endemic species complex of the high altitude grasslands of Himalaya and the Tibetan Plateau, has several unique features. Locally called *Yarsagumba* in the Dolpa dialect which is derived from Tibetan word *yartsa gunbu* (meaning summer grass winter worm), it is a parasitic complex formed by parasitic fungi (*Ophiocordyceps sinensis*) and host caterpillar of the moth species belonging to genus *Thitarodes* (Winkler, 2009). Although there no consensus about the nomenclature of this parasitic complex, we adopted Zhang et al. (2012) nomenclature of "Chinese caterpillar fungus" for "*Ophiocordyceps sinensis*-ghost moth caterpillar complex" in this paper. This species complex is used as a medicinal fungus to strengthen lung and kidneys, increase energy and vitality, stop hemorrhage, decrease phlegm and treat fatigue (Holliday and Cleaver, 2008; Zhou et al., 2009). However, it is widely traded as an aphrodisiac and a powerful tonic in the name of "Himalayan Viagra" (Holliday and Cleaver, 2008; Winkler, 2009; Shrestha and Bawa, 2013). Although the Chinese caterpillar fungus, with the current market price of US$ 140,000/kg for the best quality product in China (Xuan et al., 2012) constitutes as one of the most expensive biological resources in the world, it is harvested by hundreds of thousands of some of the poorest people in Nepal, China, Bhutan, and India.

These rural poor depend upon the harvest for their livelihoods. Based on previous studies (Devkota, 2010; Shrestha and Bawa, 2013) and our own calculation, we estimate about 100,000 harvesters are currently involved in harvesting of Chinese caterpillar fungus every year in Nepal. With the current annual production, the estimated trade of Chinese caterpillar fungus globally is US$ 5–11 billion (Shrestha, 2012). The price in international market has increased by 900% in ten years from 1997–2008 (Winkler, 2009) and in Nepal, the price has increased up to 2300% between 2001 and 2011 (Shrestha and Bawa, 2013). In the Dolpa district, where this study is based, about 473.8 kg Chinese caterpillar fungus worth of US$ 6.0–8.5 million (based on the local market price) was traded in 2011 (Shrestha and Bawa, 2013). Due to its enormous market value, it is widely believed that Chinese caterpillar fungus plays an important role in local and national economies. However, we do not know how much it contributes to local household incomes. Neither do we know the extent to which the harvesters depend on Chinese caterpillar fungus for cash income, nor the socio-economic factors that determine the harvesters' income from the fungus.

Here, we quantify the economic contribution of Chinese caterpillar fungus to household economy of mountain communities of Dolpa district of Nepal. Specifically we addressed three questions: (1) How much does Chinese caterpillar fungus contribute to the household income? (2) How much do households depend on Chinese caterpillar fungus, and does that dependence vary among households with different economic and social characteristics? (3) Does the income from the fungus help to reduce poverty and hunger in this area? We discuss the implications of our results on the regulatory mechanisms set up by local institutions for conservation of species.

Our study on the contribution of this unusual species complex to household economy is novel in two respects. First, it provides insights into the conservation and sustainable use of biological resources of an extremely valuable species complex that occurs in extreme environments. Almost all of the previous work on provisioning services provided by non-timber forest products comes from the tropics or sub-tropics and much of it is on low-value species. Second, our economic analyses, in conjunction with our ecological (Shrestha and Bawa, 2013) and institutional analyses, (Shrestha and Bawa, 2014; Shrestha et al., 2014) seeks to provide the basis for monitoring and management of this valuable resource and the associated fragile ecosystems that are also highly vulnerable to climate change.

2. Materials and methods

2.1. Study area

Chinese caterpillar fungus is reported from 27 northern districts of Nepal and of those is widely collected from only seven districts (Devkota, 2010; Thapa et al., 2014). Dolpa district is regarded as a major warehouse of Chinese caterpillar fungus in Nepal, contributing 40% of Chinese caterpillar fungus supply in 2011 in Nepal (GoN, 2011). In Dolpa, the Chinese caterpillar fungus is collected from 24 alpine pastures (DFO, 2010); five of these (Saikumari, Pokepani, Ruppatan, Chinarangsi, and Batule) are located in the Majphal Village Development Committee (VDC) – the lowest administrative unit of Nepal. Although about half of the area of Dolpa is covered by Shey-Phoksundo National Park and its buffer zone, the study area is neither part of Shey-Phoksundo National Park, nor its buffer zone (see Fig. 1).

Dolpa is the largest district of Nepal with an area of 7932 km^2, inhabited sparsely, with a population density 5/km^2 (DDO, 2010). In terms of poverty, it ranks twelfth poorest district out of 75 districts of Nepal; about 42.8% population of Dolpa lives below Nepal's national poverty line (CBS, 2013) Although 90% of 36,700 inhabitants of Dolpa depend primarily on agriculture, only 1.18% of the area of this district is currently farmed (DDO, 2010; CBS, 2012). Because of the lower proportion of land suitable for agriculture and because of low productivity of the land, only 6.4% the households grow sufficient food for the whole year and more than 50% of the households of Dolpa grow sufficient food for only half the year (DDO, 2010). Therefore, Dolpa is regarded as one of the most food insecure districts of Nepal, and subsidized rice is distributed to the poor families by the Government of Nepal and other aid agencies every year. Approximately 31.48% of the land in Dolpa is covered by alpine and subalpine grasslands (DDO, 2010) making Dolpa a very suitable habitat for Chinese caterpillar fungus. It occurs in the south facing slopes of the alpine and sub alpine grasslands and shrublands of an altitude 3000–5200 m that receive a minimum of 350 mm average annual precipitation (Winkler, 2009; Devkota, 2010).