OPHIOCORDYCEPS NUTANS: AN EVALUATION OF COMMUNITY ENVIRONMENTAL AWARENESS OF PROTECTION OF THE ENTOMOPATHOGENIC FUNGUS AT BIDOUP-NUI BA NATIONAL PARK

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Ophiocordyceps nutans is an entomoparasitic ascomycetes and has long been used extensively in traditional medicine in Asia because of its great aesculapian value. A field survey was undertaken at the Bidoup-Nui Ba National Park to evaluate the local community’s environmental awareness. The results show that public knowledge about Cordyceps collection is significant. However, these fungus resources are expected to decline. The ecosystem for the fungus is changing negatively because the local community, which comprises ethnic minorities, is under considerable pressure due to its need for a sustainable livelihood, its low educational attainment, and hard life conditions. The study focuses on environmental conditions that support in-situ and ex-situ conservation of this species, such as the temperature, humidity, and light, so that it can continue to contribute to the sustainable management and enhancement of biodiversity in Bidoup-Nui Ba National Park.

Key Words: biodiversity conservation, environmental awareness, Ophiocordyceps nutans, survey

1. INTRODUCTION

Ophiocordyceps nutans (O. nutans) is a parasitic complex with intricate relationships among entomophagous fungi, tree species, and stinkbugs. It has been well known for medicinal use for centuries, particularly in China, Japan, and other Asian countries.

It was first described by Patouillard in Japan in 1887, followed by reports from other areas, such as China, Korea, India, Costa Rica, Nepal, New Guinea, and Taiwan. O. nutans is a common genus in the Clavicipitaceae family in the Hypocreales of Ascomycota order. It is a killer fungus that parasitizes on Arthropoda arthropods as part of its particular life cycle. Cordyceps has various active ingredients, of which Cordycepin (3′-deoxyadenosine) is considered the most important because of its anticancer, antioxidant, anti-aging, anti-inflammatory activity. At present, Cordyceps mushrooms are studied extensively all over the world with respect to the extraction and production of their high economic and other types of value.

Because it has a unique life cycle, the process of forming and developing Cordyceps mushrooms is strongly affected by environmental factors, such as temperature, humidity, light, topography, and habitat. Therefore, it is essential to determine the environmental impacts that affect its survival. The trilateral nutritional relationship between fungal, plant, and insect species provides a
model for exploring complex relationships, biotechnology potential, and conservation strategies. When the right conditions are met, with the interaction of fungi, insects, and plants, *O. nutans* develops into a fruiting body. Meting those conditions is a significant obstacle, especially in recent years. Climate change is becoming increasingly serious, with significant impacts on the physiology, reproduction cycle, distribution, and activity of fungi as well as animals and plants.

Bidoup-Nui Ba National Park, located in the center of Langbiang plateau in Central Highlands Vietnam, is considered a conservation area with high biodiversity value due to its rich flora and fauna, an ideal place for the development of macrofungi in general and parasitic fungi in particular. The park has a temperate subtropical climate, and, as a primeval forest with an average altitude of 2,000 m, it is a location that is favorable for the growth and development of *O. nutans*. Current studies on *O. nutans* in Vietnam are conducted only for recording, investigating, finding, and gathering them. During the Cordyceps gathering season, the local people, who are members of ethnic minorities, exploit them excessively, leading to the depletion of natural resources, a loss of biodiversity, and degradation in environmental quality. In the present globalization context, the use of advanced technologies, science, and techniques as well as regional cooperation in sustainable biodiversity conservation with effective exploitation solutions are needed. However, maintaining and developing existing resources are important and indispensable steps forward for organizations and countries.

2. METHODS

This study was undertaken through extensive interviews of Cordyceps gatherers who live in four areas in Bidoup-Nui Ba National Park. A random sample of households that gather Cordyceps in the park participated (Figure 1). Door-to-door interviews were conducted in October 2020 with 85 respondents.

The questionnaire had two sections. The first section included demographic and socioeconomic questions about respondents’ age, gender, level of education, main livelihood, income, and household size. The second section included questions to assess respondents’ level of knowledge about *O. nutans* and evaluate the local community’s environmental awareness.

3. RESULTS

(1) Demography of Respondents

We interviewed 85 Cordyceps gatherers at Bidoup Nui Ba National Park (Figure 2). The majority of the respondents were in the age group from 30 to 39 years old, and almost all age groups had more males than females. None were younger than 20 years old or older than 69 years old. They are the ethnic minorities that have settled here for a long time.

With respect to the education level, more than three-quarters of the respondents had not received any formal education, and 20% had left school before completing the primary level. Only 4% had reached the secondary level and left before completing it. (Figure 3).
The size of the household affects income and expenditure. On average, each household consists of two workers and three children of school age. Household revenue depends on cultivation (coffee, fruits, vegetable) and collection of forest products (ginseng, mushroom, orchid), which is not stable. In some months of the year, they have inadequate income. Meanwhile, harvesting Cordyceps is challenging, but the revenue from it accounts for less than 20% of total household revenue (Table 1).

Table 1 Average household income and expenditure in 2020

|                                | Total income (USD/year) | Total expenditure (USD/year) | Income from *O. nutans* collection (USD/year/ a household) |
|--------------------------------|-------------------------|-----------------------------|----------------------------------------------------------|
| Total income (USD/year)        | 3,107                   | 3,177                       | 611                                                      |

The collection of Cordyceps in Bidoup-Nui Ba National Park started in 2016. The longest experience that people have in Cordyceps harvesting is five years, and the number of gatherers has risen every year since then—with the exception of 2020, due to the Covid-19 pandemic (Figure 4).

(2) Exploitation status and environmental impacts

Because the local people have experience with gathering Cordyceps, they already know where it tends to grow. The average yield of the entire area per year is about 80-100 kg. The cost of wild grown fungus in the Vietnam market is around USD 350 for 1 kg. According to our survey, people harvest and sell the mushrooms in the villages of Dong Mang, Dung K’si, and K’long Lanh. In 2020, because of Covid-19, the number of mushroom gatherers in the forest significantly decreased, which declined the price of *O. nutans* to USD 250 per 1 kg.

The results of our survey also show that all the respondents know when the best time is to gather *O. nutans*, i.e. the time of its growing season. The optimal time for *O. nutans* to grow is from June to August. All the respondents indicated that the harvesting season begins as early as April and concludes at the end of October. The mushrooms are in large quantities and easy to find during the harvest season (selling price of USD 200/1 kg), whereas they are more difficult to find and less numerous out of season but can command a higher sales price (USD 250/1 kg).

The data in our survey show that a pattern has developed of prolonging the harvest, by starting early and ending late, leading to overexploitation and species destruction. In biological terms, extraction from the young fungus and full exploitation of mature mushrooms stops the spore-spreading process of wild fungi, which reduces their ability to propagate. This leads to a decrease in the number of individual species, with a clear impact on biodiversity. People also harvest forest products other than *O. nutans*. If no measures are taken to deal with this situation effectively, it will cause the depletion of natural resources.

Fig.4 Rate education level of Cordyceps collectors.

(3) Local community awareness about the environment in Bidoup-Nui Ba National Park

Awareness of conservation and biodiversity among ethnic minorities is limited, which explains why the protection of Cordyceps from the local people is challenging. Yet the most of the respondents to our survey (74/85) indicate that their main source of income is from selling products that they gather in the forest to cover their daily needs.

They only harvest mature fungi, which are dark in color, and if there are too few to sell, they return them to their original location in the forest so that the spore can spread again and complete their life cycle. The local people are well aware of the steps needed to protect this species, showing that they have a keen sense of conservation of natural resources. Immature Cordyceps fungal clumps break down or have a limited release of fungal spores, which is the main problem with wild Cordyceps harvests.

At the harvest site, the mushroom gatherers face weather and natural environmental conditions that can be uncomfortable. In addition, harvesting in the buffer zone and ecological restoration area is illegal, so by going there they risk encounters with rangers on patrol. Although the *O. nutans* has a high economic value, gathering it is very painstaking. The local people have a low educational level and live in harsh conditions, so they are still dependent on natural resources for making a living. Therefore, in response to a survey question asking what they would do if it became more difficult to find
Cordyceps in the wild, all the respondents said that they would stop harvesting it and, instead, gather other forest products, such as reishi mushrooms, red ginseng, and ginseng and grow coffee, vegetables, and fruit at home.

There is no denying the important role that wildlife plays in the livelihoods of needy households. The dissimilar income from different households has resulted in different levels of people’s dependence on natural telecom. However, prolonging the harvest (starting early, ending late) will deplete these rare fungi. Based on our survey, the exploitation of natural resources in Bidoup-Nui Ba National Park by the people who live in it depends on their household size, income, social rank, gender, education level, distance of access to resources, and market.

When asked about their aspirations, 47% of the respondents to the survey expressed a desire to have a different livelihood with higher, more stable income. They stated that they would no longer go to the forest to exploit forest products if they received active support such as subsidies from government agencies. Of those who participate in the mushroom harvest in a forest contracting program, 23% patrol and protect the forest, but the support money from a community-based forest conservation program is reduced by one year and not paid on time; therefore, those involved in this program want to have better remuneration policies and receive income on time as announced. Moreover, those with just a primary education (10%) expressed an interest in protecting O. nutan, but claimed not to know much about current conservation activities. If the rangers notice them in restricted areas and remind them that they should not be harvesting there, they will listen and not repeat the offense. The remaining 20% have no suggestions.

(4) Conservation solutions

Among the solutions we suggest are to Bidoup-Nui Ba National Park management board:

- Offer local people other ways to improve their livelihood, such as beeking or planting trees in the forest.
- Use farming techniques to help cultivate Cordyceps in its natural habitat. This solution not only decreases the use of pesticides in agriculture but also generates sustainable revenue for low-income households.
- Coordinate with government departments and environmental conservation organizations to obtain support for livestock, plants, and credit and loans so that the local people can invest in animal husbandry and cultivation.
- Enhance the effectiveness of forest protection in the villages, and facilitate the establishment of community patrol groups.
- Raise awareness among Cordyceps collectors about biodiversity and nature conservation.

4. CONCLUSION AND DISCUSSION

Bidoup-Nui Ba National Park has the ideal environmental conditions for growing O. nutans (Pat.). Although the people who live in the Bidoup-Nui Ba National Park are limited aware of nature and the environment, they feel responsible for helping to maintain them. A policy solution that supports the development of sustainable livelihoods and increases coordination among stakeholders is necessary for limiting the pressure and potential threat to ecosystems.

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