

Threats and conservation of *Paris polyphylla* an endangered, highly exploited medicinal plant in the Indian Himalayan Region

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Manuscript received: 29 August 2015. Revision accepted: 23 October 2015.

Abstract. Paul A, Gajurel PR, Das AK. 2015. Threats and conservation of *Paris polyphylla* an endangered, highly exploited medicinal plant in the Indian Himalayan Region. *Biodiversitas* 16: 295-302. The Indian Himalayan Region is home of numerous globally significant medicinal plants. *Paris polyphylla* Smith is an important medicinal perennial herbaceous species used mostly in traditional medicine, having medicinal properties like anticancer, antimicrobial, antioxidant, anti-tumor, cytotoxicity, steroid saponins etc. The present study highlights the uses, population status and threats to *P. polyphylla* in Arunachal Pradesh. *P. polyphylla* is distributed in tropical to temperate region of South East Asia, particularly in Bhutan, China, India, Laos, Myanmar, Nepal, Thailand and Vietnam. In India it is distributed in the state of Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Uttarakhand. In the Eastern Himalayan state of Arunachal Pradesh, the species found to be occurring with distinct morphological interspecific variations. In the past 5 years the market demand of the species increased tremendously, which ultimately led to the over exploitation of the species and traded illegally in heavy quantities. The present study showed very poor population density, which ranged between 0.42 individuals m⁻² to 1.48 individuals m⁻². While, Importance Value Index of the species ranged between 3.37 to 8.45. Because of the unsustainable extraction and poor natural regeneration of the species, wild populations are at risk of extinction and accordingly it has been listed as an endangered species. The rhizome is the primary mode of regeneration, although it regenerate from seeds. Because of the commercial demand of the rhizome, the population of the species may entirely be wiped out if proper conservation initiatives have not been taken. Effective conservation strategies both *in situ* and *ex situ* may help to protect the species from its extinction. Inclusion of the species under the priority species list of both the National and State Medicinal Plant Boards for cultivation may be helpful for its long term management and conservation. Mass awareness and active involvement of local people for large scale cultivation may reduce the pressure on wild populations. This will meet the market demand and boost the rural economy and will also help in conservation of the species.

Keywords: *Paris polyphylla*, Himalayan region, Arunachal Pradesh, economic value, over exploitation, population status, conservation

INTRODUCTION

Forests play a significant role in life and wealth of human beings. It provides natural resources like fuel, timber, industrial forest products, wildlife habitat, animal products, etc. and also food (fruits, tubers, leaves, meat), medicines and many other commercial products. However, increasing anthropogenic disturbances and unsustainable extraction have caused the extinction of many species with ecological and economic importance. Conservation and management of these species have become a major concern to the scientific community in this 21st century. Human activities associated with deforestation, fragmentation, habitat loss, habitat degradation, over exploitation, unsustainable extraction, etc. have collectively built up the pressure on existence of many aromatic, medicinal, ethnobotanical, economically important plant species such as *Aconitum* spp., *Coptis teeta*, *Cordyceps sinensis*, *Embelia ribes*, *Gymnocladus assamicus*, *Gynocardia odorata*, *Homalomena aromatica*, *Illicium griffithii*, *Panax* spp., *Podophyllum hexandrum*, *Rhododendron* spp., *Swertia chirayita*, *Taxus wallichiana*, etc. in the Himalayan region which have been regarded as home of many valuable aromatic and medicinal plant species. Present

rapid loss of genetic resources due to various anthropogenic activities will not only affect the local/regional biodiversity but also affect the various ecosystem services.

Taxus wallichiana Zuccarini provides an example which, become endangered due to unsustainable extraction for its anti-cancerous chemical Paclitaxel (Taxol[®]), the most effective drug used for a variety of cancers (Cragg et al. 1993; Goldspiel 1997). In recognition of its anti-cancerous properties during 1980s the species has suffered large scale unsustainable extraction, which led to its present status (Paul et al. 2013). It is the most threatened species and has been categorized as endangered by the IUCN (Thomas and Farjon 2011). Today history is again repeating for many other species, including *Paris polyphylla* Smith because of its high commercial demand.

The genus *Paris* L. belongs to the family Liliaceae of monocots comprises rhizomatous herbaceous species. The genus comprises 24 species which are distributed in Bhutan, China, India, Japan, Korea, Laos, Mongolia, Myanmar, Nepal, Russia, Thailand, Vietnam and Europe (Liang and Soukup 2000). China has the highest number of species (22 species) with 12 endemic species. In India the genus is represented by 2 species, namely *P. polyphylla*

and *P. tibetica* with about 6 intraspecific taxa (Liang and Soukup 2000). The *P. polyphylla* has been widely known specifically with different subspecies and varieties. It is distributed in Bhutan, China, India, Laos, Myanmar, Nepal, Thailand and Vietnam (Liang and Soukup 2000). In India the species have been recorded from the Himalayan states like Arunachal Pradesh (Chowdhery et al. 2009), Himachal Pradesh (ENVIS 2010; Goraya et al. 2013), Jammu and Kashmir (ENVIS 2010), Manipur (Gogoi 2010), Meghalaya (Mao et al. 2009; Mir et al. 2014), Mizoram (Lalsangluaii et al. 2013), Nagaland (Jamir et al. 2012), Sikkim (Maity et al. 2004) and Uttarakhand (ENVIS 2010). It is a rhizomatous herb grows up to a height ranging from 10-100 cm and distributed in an altitudinal range between 100-3500 m asl. The whorled leaves number ranging from 5-12 with a long petiole (stalk) and flower with leafy bracts on a long stalk are the main identifying characters. The fruit is berry in nature, oval or round in shape with many seeds and become red on ripening. Seeds are enveloped by red, succulent aril. Flowering and fruiting occur during March to November (Liang and Soukup 2000). The species *P. polyphylla* has got much attention in recent times owing to its important medicinal properties, biological activities and pharmaceutical demand.

Rhizome of various species of the genus *Paris* is the major source of raw material for 'Yunnan Baiyao', a very famous Yi ethno-medicine used against various diseases and injuries like back pain, bleeding, fractured bones, fungal diseases, poisonous snakes or insect bites, skin allergy, tumors and a variety of cancers (Long et al. 2003). The rhizome of the species *P. polyphylla* is used in various Chinese traditional medicine, including analgesic, antiphlogistic, antipyretic, antitussive and depurative (Duke and Ayensu 1984; Yeung 1985) whereas, the whole plant is used for the treatment of febrifuge, liver and lung cancer and laryngeal carcinoma (Khanna et al. 1975; Ravikumar et al. 1979; Sing et al. 1980; 1982). In Nepal, the rhizome is indigenously used against snake bites, insect bites, alleviate narcotic effects, internal wounds, external wounds, fever, food poisoning and are fed to cattle during diarrhea and dysentery (Dutta 2007; Baral and Kurmi 2006). It is also used to treat headache, vomiting and worms (Upriety et al. 2010). A drug called as Gong Xue Ning (GXN) capsule has been developed from the saponin extract of *P. polyphylla* var. *yunnanensis* in China for the treatment of abnormal uterine bleeding (AUB) (Zhao and Shi 2005; Guo et al. 2008). Rhizome of the species is also used against uterine contractile effects (Tian et al. 1986; Zhou 1991). *P. polyphylla* is a folk medicinal plant in the Indian Himalayan Region, traditionally used against analgesic, antibacterial, anti-phlogistic, antispasmodic, antitussive, any poisonous bites, burn, cut or injury, depurative, detoxification, diarrhea, dressing, dysentery, febrifuge, fever, gastric, gastritis, intestinal wounds, narcotic, poisoning, rashes or itching, scabies, skin diseases, sleeplessness, snake bite, stomach pain, typhoid, ulcer and wounds (Farooquee et al. 2004; Maity et al. 2004; Tiwari et al. 2010; Jamir et al. 2012; Lalsangluaii et al. 2013; Pfoze et al. 2013; Mir et al. 2014; Sharma and Samant 2014). Further Shah et al. (2012) reviewed the various medicinal properties of the *P. polyphylla*

and categorized the species as the 'jack of all trades'.

Several pharmacological properties including anti-bacterial, anticancer/anti-tumor, antimicrobial, antiviral, antifungal, antioxidant, cytotoxic, steroid saponin etc. (Khanna et al. 1975; Ravikumar et al. 1979; Singh et al. 1980; 1982; Zhou 1991; Yu and Yang 1999; Mimaki et al. 2000; Lee et al. 2005; Wang et al. 2006; Yun et al. 2007; Zhang et al. 2007; Guo et al. 2008; Yan et al. 2009; Xuan et al. 2010; Zhao et al. 2010; Chan et al. 2011; Wang et al. 2011; Zhu et al. 2011; Kang et al. 2012; Li et al. 2012; Zhao et al. 2012; Shen et al. 2014) have been reported from the rhizomes of many species of the genus *Paris*.

Arunachal Pradesh in the Eastern Himalayan Region of India is very rich in biological and socio-cultural diversity. However, anthropogenic disturbances in the recent past have led to the depletion of many life forms. Besides, there is a lack of adequate information about the status and importance of the species in this Eastern Himalayan Region. With the large extent of decreasing green cover, many species, including the genus *Paris* are facing the impact of ecological disturbances. Rampant and reckless extraction in the Indian Himalayan Region owing to high market demand has put the pressure on the existence of the species particularly in Arunachal Pradesh. Many studies have been carried out around the world while, no study has been done in Arunachal Himalaya. Therefore, the present study has been undertaken to enumerate the present status of uses, population and threats of this important medicinal plant species.

MATERIALS AND METHODS

During the survey of medicinal plant diversity in the Eastern Himalayan state of Arunachal Pradesh in the past few years, specific observation has been made on some of the selected species which are commercially exploited. Discussion and consultation with local communities have been undertaken to find out the uses and market potential of the species. All the relevant records on the species were also analyzed. Based on the available secondary informations and primary field data from the state of Arunachal Pradesh, an attempt has been made to highlight the taxonomic diversity, distribution, medicinal importance, status of occurrence, threats and conservation strategies. The present scenario of harvesting and trade has also been discussed.

To assess the population status of *P. polyphylla*, three study stand viz., Bomdila, Mayudia and Talle Valley were selected from West Kameng, Lower Dibang Valley and Lower Subansiri districts, respectively. The study sites were selected based on the availability of the species. To study the community characteristics the sampling of the vegetation was carried out using the quadrature method. Twenty five quadrates of 1 m x 1 m were laid randomly in each study stands. Community characteristics of each of the stands were studied using quantitative analytical methods. Important ecological parameters like density, frequency, Importance Value Index (IVI) were worked out by following Misra (1968) and Mueller-Dombois and Ellenberg (1974).

RESULTS AND DISCUSSION

Paris polyphylla in Arunachal Pradesh

In Arunachal Pradesh, the species *P. polyphylla* is distributed in subtropical to temperate forests in most of the districts. It grows mainly in moist and shady areas of forests, thickets, bamboo forests, grassy or rocky slopes and nearby water channel in rich humus soil. Total number of occurrences of taxa of the genus *Paris* in Arunachal Himalaya has not been assessed till date. In the present survey, distribution of four distinct variances of *P. polyphylla* has been recorded from Arunachal Pradesh, which is harvested from the wild (Figure 1 A-E). Authentic identification of the variability of the species and further study is under process. Locally the species is known as *Mungong* (Monpa dialect), *Orpo* (Adi dialect) and *Aiichangmu* (Sherdukpen dialect). The *P. polyphylla* and other distinct variety of the species are found to be growing in an altitudinal range between 1000-3500 m asl. Till date, except *P. polyphylla* no detail taxonomic enumeration of other taxa of the genus has been described in the flora references of Arunachal Pradesh.

Utilization, harvesting and population status

Indigenous medicinal uses of *P. polyphylla* are very limited in Arunachal Pradesh. The rhizome is used against fever by the *Adi* tribe in the Upper Siang district. Rhizomes of the species are also consumed as fresh while ripen fruits (Figure 2 A, B) are eaten sometime. The fruits are also preferred by deer. The paste of the rhizome is used against snake bites by the *Sherdukpen* tribe in West Kameng district. Till recent past the commercial value of the species was not known in the state and the species were found abundantly in wild. However, mostly after 2005 the commercial exploitation of the rhizome started in large scale from most of the districts owing to its high commercial demand in the international markets. Large quantity of rhizomes from wild (Figure 3 A) is harvested, particularly during the month of April to July from various places like Baishaki, Bomdila, Chaglagam, Dirang, Lumla, Manigong, Mechuka, Muktur, Mayudia, Pasighat, Senge, Shakti, Tawang, Zimithang and many other places of the state. Collected rhizomes are sold either in dry or raw form (Figure 3 B) to the middlemen. Middlemen who collect the rhizomes from the local people sell it to outside traders and finally it goes to international market. The local people (Figure 3 C) sell fresh rhizomes at a rate ranging from about Rs. 700-800 kg⁻¹ while dried rhizomes at a rate ranging from Rs. 3500-4000 kg⁻¹. Although it is an off-farm income resource or livelihood of the local communities, but they are not aware of its important

medicinal properties. Moreover, the species has not much utilized in the indigenous medicinal systems of the state, unlike other Indian Himalayan states and also Himalayan countries. Local people reported that although the rhizome of the species has high market potential, but they are not even aware about the importance and uses of the species.

In the present pilot study, the population status of *P. polyphylla* was assessed in three selected study stands (i.e., Bomdila, Mayudia and Talle Valley) of West Kameng, Lower Dibang Valley and Lower Subansiri districts, respectively. Highest density (1.48 individuals m⁻²) was recorded in Talle Valley and lowest (0.42 individuals m⁻²) in Mayudia. While, maximum frequency (32%) was observed in Bomdila and minimum (10%) in Mayudia (Table 1). The present frequency and density of the species was found to be very low than the reported average frequency (60.83%) and density (1.78 individuals m⁻²) from Nepal (Madhu et al. 2010). The Importance Value Index showed the highest (8.45) in Talle Valley and lowest (3.37) in Mayudia (Table 1). The main dominant associated species which sharing the maximum IVI includes *Anaphalis busua* (5.51), *Arisaema* sp. (5.85), *Fragaria vesca* (21.09), *Galearis spathulata* (6.78), *Gnaphalium affine* (9.13), Grass sp. (8.23), *Pteris* sp. (7.11), *Plantago major* (6.78), *Rubia manjith* (7.34), *Rubus calycinus* (6.44), *Rubus nepalensis* (5.07), *Senecio wallichii* (5.36) and *Swertia chirayita* (11.77) in Bomdila. Species like *Artemisia nilagirica* (11.29), *Coptis teeta* (28.46), *Carduus edelbergii* (6.32), *Crassocephalum crepidioides* (5.93), *Cyperus cyperoides* (13.10), *Hemiphragma heterophyllum* (9.96), *Hydrocotyle asiatica* (10.15), *Geranium pratense* (6.96), Grass sp. (10.17), *Plantago asiatica* (11.61), *Polygonatum verticillatum* (9.39), *Pteris* sp. (28.48), *Rumex nepalensis* (10.47), *Selaginella* sp. (5.07) and *Senecio raphanifolius* (9.14) were dominant in Mayudia. While *Anaphalis busua* (9.29), *Arisaema* sp. (9.95), *Artemisia* sp. (13.29), *Centella* sp. (19.79), *Carduus edelbergii* (10.68), *Fragaria nubicola* (13.86), *Hydrocotyle himalaica* (11.12), *Impatiens* sp. (9.72), *Podophyllum hexandrum* (5.40), *Polygonum hydropiper* (9.28), *Potentilla plurijuga* (11.56) and *Viola* sp. (6.26) were the dominant species in Talle Valley. The natural populations of *P. polyphylla* are affected because of anthropogenic activities like extraction and habitat destruction which leading to its endangerment. Mao et al. (2009) also reported that the species has become rare due to over harvesting from the wild. Owing to unsustainable extraction and illegal trade the species had already been categorized as endangered in Himachal Pradesh, Jammu and Kashmir and Uttarakhand (ENVIS 2010).

Table 1. Frequency, density and Importance Value Index of *Paris polyphylla* in the selected study stands of Arunachal Pradesh

Study sites	District	Frequency (%)	Density (individuals m ⁻²)	IVI
Bomdila	West Kameng	32	1.32	6.07
Mayudia	Lower Dibang Valley	10	0.42	3.37
Talle Valley	Lower Subansiri	22	1.48	8.45

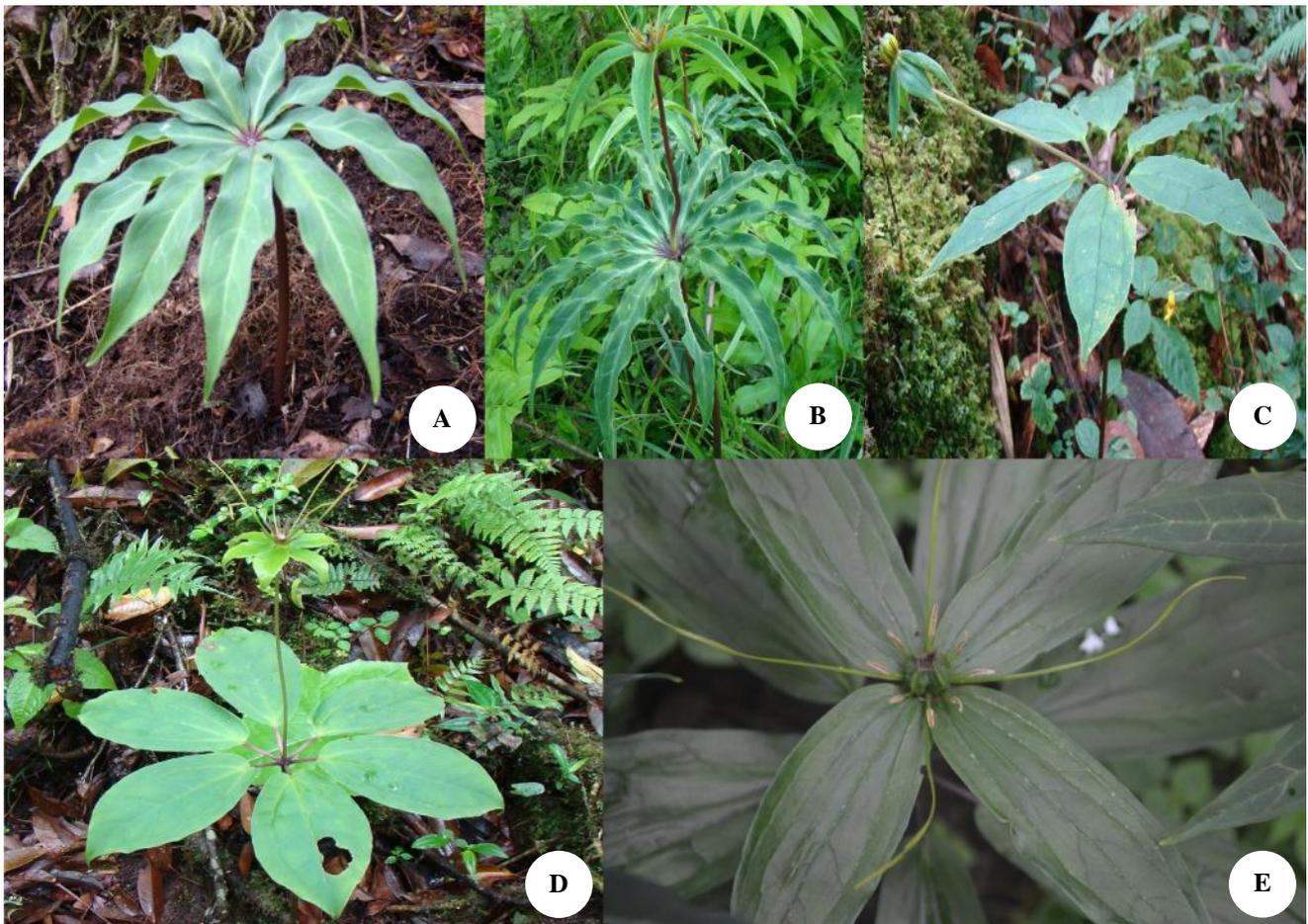


Figure 1. The genus *Paris* in Arunachal Himalaya. A. *Paris polyphylla*, B-E. Distinct variances of *Paris polyphylla*



Figure 2. *Paris polyphylla* fruits. A. Young, B. Ripen fruit

Trade and marketing

Based on the conversation with the local people, all the harvested rhizomes of the *P. polyphylla* are traded to Myanmar and other South East Asian countries illegally routed through Assam and Manipur. Illegal trading occurred either at local or directly to the regional level through middlemen and then outside of the country. The

rhizomes harvested from Dibang and Lower Dibang Valley district are traded to Tinsukia/Dibrugarh via Roing. Upper Siang and East Siang district are traded to Dibrugarh/Tezpur via Pasighat. West Siang district is traded to Tezpur via Silapathar. While harvested rhizomes from Tawang and West Kameng district are traded to Tezpur via Bomdila. Illegal exporting of rhizomes of the *P. polyphylla* from



Figure 3. Rhizomes of *Paris polyphylla*. A. Freshly collected rhizomes, B. Drying, C. Ready to sell

Arunachal Pradesh to China via Myanmar has been reported by Basar (2014). Illegal trade of the rhizomes to Myanmar through Indo-Myanmar border by the local traders have been reported (The Sangai Express 17/08/2008). Trafficking of the rhizomes from the Indian states of Arunachal Pradesh, Manipur, Meghalaya and Nagaland to Myanmar have also been reported (Mao et al. 2009).

Major threats to the species

Most of the population of *P. polyphylla* is depleted due to rampant and reckless extraction. In Arunachal Pradesh the species is facing tremendous pressure because of over exploitation due to its high market demand. Unsustainable extraction of the species owing to its high commercial demand has led to decline in populations and becoming rare in its natural habitat. Developmental activities like broadening of road, urbanization and habitat destruction, etc. collectively put pressure on the existence of the species. Other anthropogenic activities like shifting agriculture, forest resource collection, logging, etc. are affecting habitat and wild populations of the species. Heavy rainfall leading to the land erosion/landslides, etc. is also causing the habitat loss and population depletion of the species. Grazing is also one of the factors for loss of habitat/population of the species. The rhizome is the main mode of regeneration though it regenerates from seeds. Uncontrolled and indiscriminate harvesting of whole plant without leaving any part of the rhizome, harvesting before reproductive/flowering or seed maturity period etc. are causing regeneration failure in its natural habitat. Conversely, regeneration of *P. polyphylla* from seed in wild, green house, laboratory is very poor because of long dormancy period and very slow growing nature (Madhu et al. 2010; Qi et al. 2013) which is affecting the growth and survival of the species. Over harvesting has caused the decrease in natural population of the species. The over exploitation, rampant illegal extraction and trade, wild populations of *P. polyphylla* are at risk of extinction from its natural habitat. Though the species has not yet been assessed by the IUCN Red List however, if the present

trend continues, the species will be wiped out from the wild and thus suitable conservation measures/strategies are of utmost important. Very recently Arunachal Pradesh State Medicinal Plants Board (APSMPPB) expressed concern over the rampant and reckless extraction of *P. polyphylla* from most of the districts of the state. The Board has also urged the local administration (Deputy Commissioner, Superintendent of Police and Divisional Forest Officers) of most of the districts to check the exploitation of the rare, endangered and threatened species before being extinct from the state (The Arunachal Times 22/08/2015).

Management and conservation

The present study on the population status revealed very low population density (Table 1) that warrant immediate conservation action. For effective management the following strategies may be adopted: (i) Detailed exploration and documentation for identification of major distribution areas with mapping or ecological niche modeling is needed to save this natural resource. (ii) Critical studies on population structure and regeneration status covering both the open and protected areas provide the useful data for conservation action. Evaluation of species specific or area specific threat is essential for management of this species. (iii) Inclusion of the species under the priority species list of both the National and State Medicinal Plant Boards for large scale cultivation and conservation. (iv) Cultivation and conservation through community involvement. Out of total recorded forest areas, about 60.22% of the forest land (FSI 2013) of the state are traditionally controlled by the communities as per the customary rights called Unclassed State Forest (USF) or community forests, are ideal for large scale cultivation and conservation. This will be accomplished only when local communities are involved. Mass awareness regarding the declining population of the species, its high medicinal properties and economic importance is required. (v) Sustainable harvesting practices must be adopted as the rhizome of the species is used. The whole plant is uprooted to collect the rhizome leading to the destruction of the plant. Hence, appropriate technique should be used for



Figure 4. Cultivation of *Paris polyphylla* in homesteads. A. Monpa villager busy in cultivation, B. Cultivated *Paris polyphylla*

harvesting the mature rhizome without effecting the population like viable portion of the rhizome may be left in its natural habitat, so that it can regenerate naturally. (vi) Local/regional level management approaches with active community involvement and benefits sharing should be undertaken. On-farm and off-farm management and scientific studies of the species is urgently needed. Legal restriction on harvesting or trade of rhizome may be imposed to stop further genetic loss. (vii) Legal protection of habitat that are not covered in the protected area of the state as it has only 11.68% of the total geographical area (FSI 2013) under protected area network that may not be enough for conservation. The selected habitat with a good viable population may be brought under legal protection like Medicinal Plants Conservation Area (MPCA) for *in situ* conservation.

Commercial cultivation for conservation and economic development

The habitat of *P. polyphylla* distributed with an altitudinal range between 100 to 3500 m asl (Liang and Soukup 2000) which is one of the important characteristics for large scale cultivation under the suitable climatic condition. To meet the need of high market demand for its important medicinal, biological and pharmaceutical purposes the species can be cultivated commercially with active community participation. Most of the local communities in this Himalayan region of Arunachal Pradesh can be engaged for large scale cultivation (Figure 4 A, B) in community land, nurseries, homesteads, etc. will boost the economy and income generation of the tribal people of the state. Like *Curcuma longa* L. (turmeric), *Elettaria cardamomum* (L.) Maton (cardamom) and *Zingiber officinale* Rosc. (ginger), *P. polyphylla* can be cultivated in large scale through rhizome in its natural habitat. Domestication and inclusion in Agroforestry and social forestry program with community participatory management will further enhance the rural economy, which contributes towards the conservation and meet the market

demand. For instance, in Yunnan of China, people have already been started cultivation of *P. polyphylla* in their Agroforestry systems to meet the commercial demand (Long et al. 2003). Departments like Agriculture, Horticulture, the State Biodiversity Board, State Forest Research Institute and State Medicinal Plant Board may take active participation for promotion of large scale cultivation. A detail taxonomic study on the genus *Paris* is utmost important to find out the taxonomic diversity as the high variability among the populations have been observed that may lead the discovery of more new species. Although the occurrence of eight taxa of *Paris* from India has been mentioned (Liang and Soukup 2000) while only one species, i.e., *P. polyphylla* has been reported from Arunachal Pradesh (Chowdhery et al. 2009). There is an urgent need for our scientific community to pay their ample attention to this valuable herbaceous species for conservation and further scientific studies in the Indian Himalayan Region particularly in Arunachal Pradesh.

ACKNOWLEDGEMENTS

The authors wish to express their deepest thanks to all the local field guides Chenjeer Dree, Dipu Goyiak, Jamba, Jam Tsering, Kejang Serthipa, Nima Dondu, Pem Dakpa, Rabi Mekula, Tado, all the village headmen and villagers for help and support during the field survey. The first author is thankful to University Grants Commission, Government of India, New Delhi for UGC-Dr. D.S. Kothari Post Doctoral Fellowship. Authors deeply acknowledge the help and support of Dr. Sanjeeb Bharali, Amal Bawri and Lobsang Tashi during the field study. The authors also express their sincere thanks to the various Forest Officials, Department of Environment and Forests, Government of Arunachal Pradesh for permitting us to work in forest areas of the state. We are also thankful to all, those who extended their cooperation during the field study. The authors are thankful to anonymous reviewers for

sparing their valuable times for corrections and suggestions.

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