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Research paper

People's perception on parasitic plants : helping humans, harming plants?

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Abstract

Parasitic plants have a rich ethnobotanical heritage in Nepal. They are harvested for use in medicine, traded as material and invoked during a variety of rituals by practitioners from the low plains to the high Himalayas. However in spite of their local importance, these plant species have received little attention from ethno-biologists due to their unique, often misunderstood, biology. This study seeks to expand the current ethnobotanical knowledge by not only documenting Nepal's parasitic flora but by also providing insight into how these plants are used and perceived in Nepal's biologically and culturally diverse environment. Ethnobotanical data for this research was collected using the Participatory Rural Appraisal (PRA) and Rapid Rural Appraisal (RRA) methods among 52 respondents from different ethnic groups of Nepal (4 districts). A total of 20 plants species from five parasitic families were recorded and identified as ethnobotanical uses. They are 13 species of Mistletoe, 3 species of Dodder with 1 variety, 2 species in Balanophoraceae and 1 species in Orobanchaceae. The perceived knowledge of indigenous people led to the hypothesis Doctrine of Signature. With this information, Nepal's burgeoning state can begin targeting and managing these plant species through agricultural, community forestry and conservation policy.

Keywords: *Doctrine of Signature; Ethnobotany; Medicine; Parasites.*

1. Introduction

Despite a recent boom in Nepal's ethnobotanical research, one cohort of plants with similar life strategies has been notably under studied. These plants are known as parasitic plants. All parasitic species are very diverse both in habit and physiology; however, all are grouped together under the term 'parasite' based on their life strategies (Press & Phoenix 2005).

Parasitic plants or '*Parijibi*' in Nepali language, are taxonomically diverse group of angiosperms that depend on host plants to obtain carbon, nutrient and water from root or shoot through haustoria (Nickrent & Musselman 2004; Press & Phoenix 2005). Haustoria (plural) are intrusive organs that allow the parasite to penetrate into host tissue and establish connection with the host's phloem and/or xylem (Heide-Jorgensen 2008). Parasitic plants come from 20 plant families, of which 12 parasitic plant families are found in Nepal (Press et al. 2000, O'Neill & Rana 2016). In these plant families, over 150 of the planet's 4,500 parasitic plant species (~3%) are native to Nepal (O'Neill & Rana 2016).

This report is the comprehensive effort to consolidate information on Nepal's parasitic plant species, to document how these plants are used in accordance with the Doctrine of Signature and to understand how they are perceived in Nepal. Perceptions of parasitic plant species are vital for crafting conservation strategies and understanding how and why these plants are used in local settings. The traditional use and management of plant species are often times influenced not only by the physical and chemical characteristics of the plants themselves but also by the ways in which plants are perceived within a particular socio-cultural context (Cotton 1996). Integrating both bio-chemical and socio-cultural knowledge with a broad ecological study can be used by a variety of bio-chemical and social scientists when crafting future policy. Our objectives are: 1) to document the Traditional Botanical Knowledge that surrounds parasitic plant species; 2) record the local perceptions and management techniques that may or may not surround parasitic plants.

2. Materials and methods

This research perceived the knowledge on parasitic plant species found in Nepal's three vegetative regions. Our ethnographic research was conducted specifically with the ethnic groups and on the parasitic plant species found in the Baglung (Panchase) and Makwanpur (Chitlang) Districts of Central Nepal. Beside, the study was also carried out in Bardiya district (Taratal, Western Nepal) and Jhapa districts (Garamani, Eastern Nepal). Due to Central Nepal's particularly high biodiversity, unique geo-topography and ethnic diversity (Rokaya et al. 2012), we extensively selected 2 districts in Central Nepal assuming the highest probability of yielding data useful for our study.

We collaborated 52 respondents (21 male and 31 female; average age 35 years) for interview in Baglung and Makwanpur districts of Central Nepal; Bardiya (Western Nepal) and Jhapa (Eastern Nepal) (Table 1). Respondents varied in ethnic identity and gender, with Gurung, Brahmin, lower caste, Newar and Tamang from Central Nepal. Tharu, Magar from Bardiya and Satar, Shunuwar from Jhapa were also collaborated (Fig. 1).

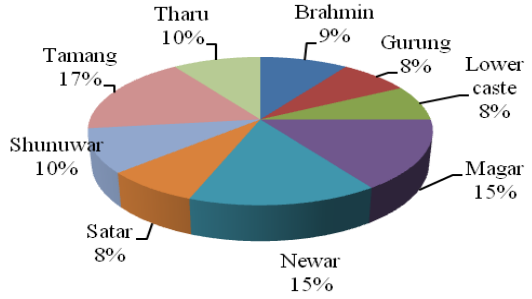

Fig. 1: Percentage of Respondents as Per Ethnic Groups Selected for Ethno Botanical Study in Different Districts of Western, Central and Eastern Nepal.

Ethnobotanical data for this research was collected using the Participatory Rural Appraisal (PRA) and Rapid Rural Appraisal (RRA) methods as highlighted by Cunningham (2001). Informal, one-on-one interview were preferred to obtain ethnobotanical knowledge. Collaborators were chosen randomly within each study site and within each caste or ethnic group. We specifically solicited the knowledge of some spiritual leaders on the basis of cultural documentation and greater community perceptions. Before conducting interviews, prior informed consent was obtained with the help of district-level and village-level community leaders, government officials. Consent was granted by local people for the dissemination of their TBK.

Using known host-parasite data available at both National Herbarium and Plant Laboratories (KATH) and Tribhuvan University Central Herbarium (TUCH) as well as in the previously reviewed botanical literature, we were able to hone our search to proper climates and forest types where our plants of interest could be found. Many parasitic plants species were identified in the field. Regardless, various forms of media were collected to assist our interview efforts and to confirm proper species identification. The unidentified as well as identified plant species were identified and confirmed from the specimen deposited at KATH, Godawari, Lalitpur and TUCH, Kirtipur, Kathmandu, Nepal. Only the sample specimen were collected considering the ethical issues (Rana et al. 2015) and thus prepared herbarium were deposited at TUCH (Supplementary Table 1). Common names collected during interviews were compared with Shrestha's Dictionary of Nepalese Plant Names (1998) cited to confirm common names for host plants noted during interviews.

Table 1: Details on Informants in Each District from 3 Different Regions of Nepal Surveyed Based on Gender and Age Group ([W]western Nepal; [C]central Nepal; [E]eastern Nepal)

Districts	Number of informants	Gender	Age group (years)
Bardiya (W)	12	9 Female	20 – 60
		6 Male	35 – 40
Baglung (C)	14	7 Female	25 – 50
		4 Male	30 – 50
Makwanpur (C)	15	8 Female	30 – 50
		7 Male	30 – 60
Jhapa (E)	11	7 Female	25 – 50
		4 Male	30 – 60

Observation during both our ethnographic fieldwork and interviews also played a crucial part for understanding how people interact and truly understand these plants. Also, observation played a key role in understanding how plant resources were used beyond interview alone and how our observations, specifically in terms of populations, compared with those cited in our interviews.

3. Results and discussion

A total of 20 plants species from five parasitic families were recorded and identified as ethnobotanical uses (Table 2). They are 13 species of Mistletoe (11-Loranthaceae, 2-Viscaceae), 3 species of Dodder with 1 variety (*Cuscuta* spp.; Convolvulaceae), 2 species in Balanophoraceae and 1 species in Orobanchaceae (Supplementary Fig. 1-4).

3.1. Ethnobotanical use of parasitic plants

Variability in the use of Mistletoe ranges from human consumption of their sweet, edible berries to use as glue along with their medicinal values (Table 2). Fresh stems of *Viscum* sp. (Fig. 2d, and Supplementary Fig. 1) bearing immature fruit were used in the treatment of fractured fingers, limbs and spine (Kunwar et al. 2015) (Fig. 3a and 3b) when made paste with Cinnamon bark and leaves (*Cinnamomum verum*), neetle root (*Girardinia diversifolia*), and ground bear bones. Ripe fruit was used as glue when mixed with water and was noted to be especially for useful for trapping birds.

Cuscuta species (Fig. 2e, and Supplementary Fig. 2) were primarily used for Jaundice and other hepatic diseases broadly defined and characterized by yellow skin and eyes, fever and gastritis (Fig. 3c and 3d). But they were noted as unfavorable fodder for animals. Medicinally it is prepared by washing fresh tendrils and then grinding them into a paste. This paste is then mixed with hot water and eaten as a soup. It is said, only yellow colored tendrils conferred medicinal properties whereas, red tendrils is used as fodder due to their less bitter taste. Even loombhadi (Tamang), a disease that causes blood in a bull's urine is treated by tendrils of *Cuscuta*.

Plants in the Balanophoraceae, specifically *Balanophora polyandra* and *Rhopalocnemis phalloides* (Fig. 2b, and Supplementary Fig. 3), assumed a variety of magico-religious purposes. This plant is believed to help purify households of evil spirits as well as to confer good fortune to its users. As a ritual item, the fresh plant is decorated with turmeric, kept inside the house, and worshipped in order to bring general prosperity and wellbeing to the user. As this plant is believed to confer certain magico-religious properties, there is a set of rituals regarding its harvest and use. The most notable is that this plant must be collected on Tuesdays if it is to be used for problems related to haunting and may be used with lemon against the evil eye. *B. polyandra* was used for skin abrasions; the whole plant's fresh root is dipped in hot water and rubbed on the flesh wound. As a vermicide, the whole plant is ground and diluted in proportion to the body mass of the user and consumed for approximately a week. But, consumption of this plant was not recommended or preferred because of the plant's potential toxicity and our collaborators highlighted deaths that had occurred in the past when the plant was mistaken as a mushroom and consumed as food.

Table 2: Descriptions and Ethnobotanical Uses of Parasitic Plants Surveyed in Each Districts from 3 Different Regions of Nepal ([W]western Nepal; [C]central Nepal; [E]eastern Nepal; [B]brahmin;[Gu]gurung;[Lc]lower Caste;[Mg]magar;[Nw]newar;[Np]nepali;[Sa]satar;[S]shunuwar;[Th]tharu;[Ta]tamang)

Coll. No.	Name of Species	Localname	Range	Family	Traditional uses	Parts used
SA4	*Balanophora polyandra* Griff.	eklebir[NP,B]	C,E	Balanophoraceae	Religious and medicine	Entire plants
SA6	*Rhopalocnemis phalloides* Jungh.	eklebir[NP]	W	Balanophoraceae	Ritual objects	Entire plants
SA35	*Cuscuta chinensis* Lam.	aakashjeli[NP/SA]	E	Convolvulaceae	Medicine	Entire plants
SA1c	*Cuscuta europea* var. *indica* Engelm.	aakashbeli[NP,B], baora[TH], taarghey[TA], urlang du [TA]	W,C	Convolvulaceae	Medicine, fodder	Entire plants
SA1a	*Cuscuta europea* var. *nepalensis* Yunker	Lahara[NW]	C	Convolvulaceae	Medicine	Entire plants

SA48	*Cuscuta reflexa* var. *reflexa* Roxb.	Amarlathi[TH], Akashe Lahara[MG]	W,C,E	Convolvulaceae	Medicine, fodder, religious	Entire plants
SA44	*Dendrophthoe falcate* (L.f.)	Nihi[TA],Banda[SA],Ainjeru[NP]	W,C,E	Loranthaceae	Medicine, food	Aerial part, fruit
SA40	*Dendrophthoe pentandra* (L.) Miq.	Ainjeru[NP,S]	E	Loranthaceae	Fooder	Entire plants
SA19	*Helixanthera ligustrina* (Wall.) Danser	Ainjheru[MA],Bhringe[GU], Lisso[NP,LC]	W,C	Loranthaceae	Medicine, food	Entire plants, fruit
SA22	*Loranthus lambertianus* Schult. f.	Lisso[NP,LC]	W,C,E	Loranthaceae	Fodder	Entire
SA37	*Loranthus odoratus* Wall.	Ainjeru[NP],Donglanais[TA]	E	Loranthaceae	Medicine, food	Entire plants
SA38	*Macrosolen cochinchinensis* (Lour.) Tiegh.	Ainjeru[NP]	W,E	Loranthaceae	Medicine, fodder	Entire plants
SA24	*Scurulla elata* (Edgew.) Danser	aibjheru[NP], lisso[NP]	W,C,E	Loranthaceae	Medicine, fodder	Entire plants, fruit
SA26	*Scurulla parasitica* L.	Ainjeru[NP],Lisso[NP],	W,C,E	Loranthaceae	Fodder, food	Entire plant, fruit
SA16	*Scurulla pulverenta* (Wall.) G. Don	Bhringe[GU], Ainjeru[NE/NP]	W,C,E	Loranthaceae	Medicine, fodder	Entire plant, fruit
SA18	*Taxillus umbellifer* (Schult. f.) Danser	Ainjeru[NP], Lisso[NP]	C,E	Loranthaceae	Fodder, food	Entire plant, fruit
SA27	*Taxillus vestitus* (Wall.) Danser	Ainjeru[NP], Lisso[NP]	W,C,E	Loranthaceae	Medicine, fodder	Entire plant, fruit
SA46	*Orobanche aegyptiaca* Pers.	Thokaa[TH], Nil jhar[NP]	W,C,E	Orobanchaceae	Material	Seed
SA28	*Viscum album* L.	bang [TH], Hadchur[NP]	W,C	Viscaceae	Medicine, fodder, food	Entire plant, fruit
SA30	*Viscum articulatum* var. *liquidambaricolum* Burm. f.	kathkomunjga[S], harchu [NW]	W,C,E	Viscaceae	Medicine, material	Entire plant, fruit

3.2. Parasitic plant populations

Over the course of collaborators life time, local people perceived the dramatically increase in Parasitic species population except *Cuscuta* population. The loss of habitat and host plant over exploitation along with the increased fodder collection has led to the degradation of *Cuscuta* habitats, which have consequent effects on the number of potential hosts that *Cuscuta* can parasitize. Common host plants detailed by our research were *Callicarpa macrophylla*, *Uria acuminata*, *Dichroa febrifuga*, *Maesa chisia*, *Berberis aristata*, *Citrus* spp. and *Jatropha curcas*.

Species in the Balanophoraceae were noted to have stable but slowly increasing populations. According to collaborators, populations have decreased due to poaching by outsiders for both spiritual and ritual use. This answer quite possibly could have been affected by the short blooming time of these plants and the non-correspondence of our interviews with the correct season. However, the specificity of this answer leads to our conclusion that these plants are quite possibly being harvested. The host species that Balanophoraceae species preferentially parasitized were *Symplocos ramosissima*, *Rhododendron* spp. and *Quercus glauca*.

Specifically in regard to Mistletoe species, all collaborators responded dramatic increase in population and particularly in Loranthaceae. Many of these study sites were near community forest systems, which by simple observation demonstrated the great destruction that are locally available. Loranthaceae species (Fig. 2c, and Supplementary Fig. 4) at our study sites preferably parasitized mature or newly maturing trees (Devkota et al. 2007) of *Alnus nepalensis*, *Myrica* spp., and *Pyrularia edulis* (O'Neill & Rana 2016). Mistletoes in the Viscaceae preferentially parasitized *Myrica* spp. and *Quercus* spp.

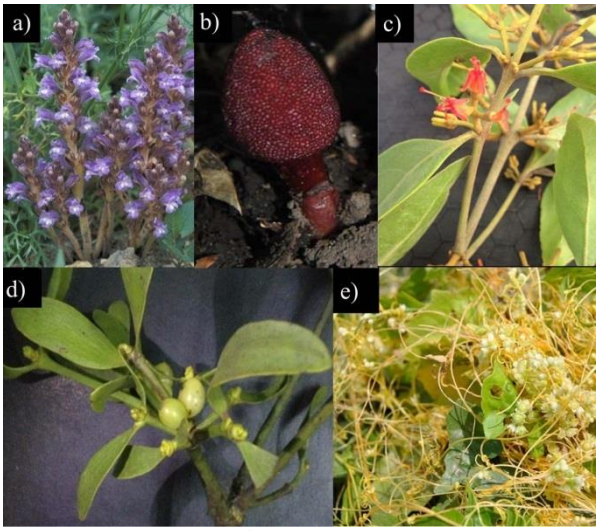

Fig. 2: Photographic Record of Representative Parasitic Plant Species of Five Different Families Collected and Surveyed During Ethnobotanical Study from Different Districts of Western, Central and Eastern Nepal; (A) *Orobanche aegyptiaca*, (B) *Balanophora polyandra*, (C) *Helixanthera ligustrina*, (D) *Viscum album*, and (E) *Cuscuta chinensis*

3.3. Doctrine of signature

Many ethnobotanical studies elucidate locally and culturally useful plants representing symbolically and contextual in medicine. Perceptions, lore, legend, and ritual are essential ethnobotanical data that are too often overlooked and when recorded, not adequately explained. In Nepal's context, the greater ethno-ecological factors that exist between human society and the natural world, especially as they relate to plant-ritual uses and the idea of sacred forests, dictate how people understand and thus locally use parasitic plant as material, medicine, and ritual objects.

One social construct that has particular relevance to the study of parasitic plant species is known as the Doctrine of Signatures. The Doctrine of Signatures (DOS) can be described as form recapitulates function: a plant's physical and sensory stimulating characteristics such as its shape, color, taste, texture, and smell indicate its therapeutic value or material use (Bennett 2007; Pearce 2008). In Nepal, the doctrine of signatures is a symbolic device used to transfer cultural information about parasitic plant species. It serves a purpose for use; however the DOS should be primarily understand in a manner for what it truly is: a way of disseminating information about religion, culture, society and history (Bennett

2007). Because as signatures are post-hoc applications, our questionnaire tried to discover answers as to why and how parasitic plants assumed their post-hoc uses. We found not only information that suggested the use of signatures but also information that substantiated these uses as cultural vehicles.

Our collaborator's primary perceptions of parasitic plants were vital in their construction of signatures and biology associated these species with a unique variety of signatures and lore. These signatures were not overtly mentioned by collaborators; however the descriptive language and use patterns of our collaborators during interview alluded to DOS theory. The aim of this analysis is to deconstruct why these plants are used locally and the signatures that quite possibly cue their uses.

Mistletoe species, besides their use as fodder, were used to treat broken and fractured bones at each of our study sites (Fig. 3a and 3b). Collaborators consistently highlighted the sticky nature of mistletoe seeds as well as the bulbous masses that form at the site of parasite infection. In regard to the healing capacity of these plants, it is indeed possible that species leaves increase blood flow when applied on fractures thus enhancing the healing process. However, it is more likely that signatures or natural cues are the explanation for why mistletoes are used in such situations. Because these plants create a mass on a thin or broken tree branches, effectively making a thinner branch thicker, they become symbolically tied to repair of human limbs (Fig. 3a and 3b).

Mistletoe biology and these species effect on host plants also explain superstitions that surround their used as firewood in Tamang communities. Several informants indicated that burning mistletoe branches leads to goiter and wart-like symptoms (Fig. 3e and 3f). This belief can again be explained symbolically. Mistletoes cause bulbous masses and wart-like protrusions on the branches of effected hosts, later killing the tree. Their presence and nature as a parasite, and thus association with something that should be avoided, is overtly perceived by locally people in a symbolic manner here manifested as non-use in the home.

Dodder species due to their bitter taste, vine-like growth habit, and characteristic color again have ties to the Doctrine of Signatures. As discussed, these species are used to treat yellowing diseases such as jaundice and hepatic failure broadly defined (Fig. 3c and 3d). In the human body it is important to note that liver diseases cause yellowing of the body, notably of the veins. Because dodders not only have an indicative bitter taste, possibly signaling the presence of bioactive alkaloids but also yellow color and shape that people during interviews associated with veins lends toward an intuitive DOS association. Dodder species threefold signature (taste, color, and shape) instills these plants with cross-cultural power as a liver remedy and it is thus commonly used as a medicine.

In case of Balanophoraceae, in regard to color, shape and general appearance broadly defined and/or interpreted DOS as a more complex idea. What if instead of a plant by itself, the environment in which a plant is found instead came to symbolize a signature? In terms of species in the Balanophoraceae, only specialist users could indeed identify these plants, specialists known as '*khabres'*, *'dhamis'*, *'jhankris'*, and '*bonpos*' who invoke a variety of esoteric techniques to user souls to the afterlife, eradicate malignant sprits from homes and perform exorcisms. These users noted that the environment in which these species were found are cold, dark forests (Fig. 2b, and Supplementary Fig. 3). Culturally, these are generally places where people fear and believe that ghosts dwell. This connection to dark moist environments, often at high altitudes, and these species existence almost outside of local ethno taxonomic systems appears to endow these plants with their magico-religious potential. Further these same tree species are often times believed to be gates to spiritual realms. Species in the Balanophoraceae thus become tied to the spirit world and thus can be used to treat extra-ordinary diseases such as spiritual possession.

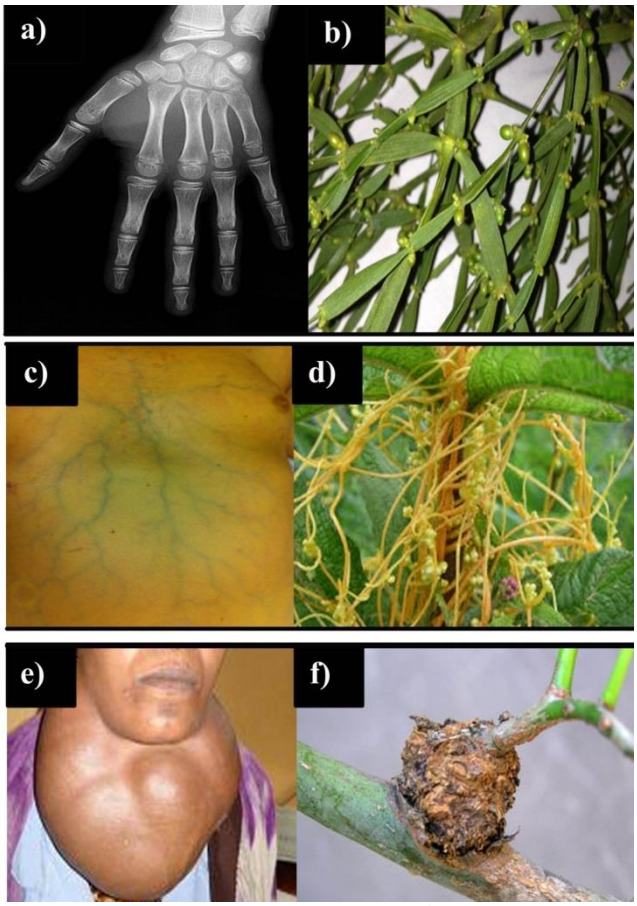

Fig. 3: Photo Plates Showing the Morphology of Parasitic Plant Species Perceived by Respondents as A Doctrine of Signatures; (A) the plants joint-like modified stems resemble human bone structure. Skeletal image available from Http://Dxline.info/diseases/hand-x-ray, (B) *Viscum articulatum* var. *Liquidambaricolum*; (C) the plants vein-like, or 'Nasa' in Nepali language, nature and yellow coloration resemble the effects of liver diseases, as depicted on the right. Jaundice image is available from Http://Iheartautopsy.com/?M=201205, (D) *Cuscuta chinensis*; (E) Wart like diseases that occurs in human neck due to inhaling the smoke of Mistletoes log. The image is available from Http://Diseasespictures.com/wp-content/uploads/2013/07/goiter.jpg, (F) *Dendrophthoe falcate*.

3.4. Plant conservation or parasitic management?

In 2002, Nepal initiated its first biodiversity strategy entitled Nepal Biodiversity Strategy (NBS) and has since carried out a variety of projects with international collaborators to document species and record plant uses (MFSC 2009). Parasitic plants are not mentioned in any of these documents, including but not limited to community forestry and biodiversity conservation policies, and thus deserve poignant attention.

Parasitic plants are major constraints to crop growth globally (Parker 1991) and they demand attention from both agricultural and conservation policymakers. In Nepal, most of the people still rely on agriculture for primary livelihood; the management of these species is of crucial and immediate importance. No parasitic plant species in Community Forest Systems are managed, yet they have dramatic and visible effects on forest communities. We noticed a potential threat to agricultural production in Terai region mostly due to Orobanche spp. (Fig. 2a) People perceived it as a common weed infecting many crop systems in whole cabbage, potato, tomato, mustard (Rao et al. 1988, Mishra & Chaudhary 2010), sugarcane, tobacco fields (Puzzilli 1983). Of all parasites in these systems, mistletoes are particularly damaging, to such an extent that all collaborators noted that their presence on mature trees leads to that plant's quick demise. Because mistletoes generally parasitize newly matured trees, forest systems are inherently becoming less sustainable due to the fact that these plants do not have proper time to reproduce. As soon as they mature and bear fruit, host trees are visited by birds (the major dispersal method for

these species) which consequently lead to the tree's parasitization. Within two to three years, these trees usually die without reproducing. This chain of events leads to a system where people must consistently replant trees because the system is no longer self perpetuating. People do not think to manage these plants and future forestry projects must seek to manage how communities can better protect their woodlands.

Parasitic plant management must be applied in the variety of community forestry and agricultural environments that exist in Nepal. Recent management practices have focused on the use of parasite-resistant crops, the use of herbicides, and agro economic practices. Success in each domain has been marginal at best and even with the minimal success stories, these have little probability of working in Nepal's current context. So, possible management technique could be the introduction of parasite-resistant crop and/or host species. Thus there is an urgent need to re-evaluate control methods in the light of culturally contextual environments if parasitic plant management it to be effective.

Environmental change, climate shifts, and changing land-use patterns must be adequately addressed by any parasitic plant management policies. Some geographical areas currently unaffected may need them in the future, and it is thus essential to preempt the spread of these plants with, for example, quarantine regulations (Rubiales et al. 2009). The parasitic nature is the biggest threat and they have been always considered as a serious menace to forest and agricultural ecosystem. Beside all these constrain, some species of parasitic plant still have ethno medicinal properties as described by DOS as well as plays important role in balancing natural ecosystem. They are crucial as they provide insight how indigenous group perceive and mange natural resources based on indigenous knowledge.

4. Conclusion

These recorded cultural perceptions, beyond medical and material uses alone, have potential applications outside of anthropological review alone. Because of their importance in local contexts, parasitic plants have potential uses in cultural preservation arenas and more immediate potential to mobilize people around resource conservation, land management, and future policy developments in Nepal. These policies must be dynamic and require outreach groups to disseminate and explain information such as that found in this document. Parasitic plant species potential to platform biological agendas is great and their study is only just burgeoning. Thus their management in proper way is crucial to ensure the traditional botanical knowledge in future.

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