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Research

Heterogeneity in Ethnoecological Knowledge and Management of Medicinal Plants in the Himalayas of Nepal: Implications for Conservation

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ABSTRACT. The importance accorded to ethnoecological knowledge for suggesting new paths in scientific research, understanding ecological processes, and designing sustainable management of natural resources has grown in recent years. However, variation in knowledge and practices, both within and across cultures, has not been given much attention in resource management nor in developing scientific understanding of the ecological status of key resources. In this paper, we discuss the heterogeneity and complexity of local ecological knowledge in relation to its practical and institutional context with respect to management of Himalayan medicinal plants. We show factors affecting this variation, and discuss how knowledge is put into action. We assessed variation in knowledge relating to the diversity of medicinal plant species, their distribution, medicinal uses, biological traits, ecology, and management within and between two culturally different social groups living in villages located in the Shey-Phoksundo National Park and its buffer zone in northwestern Nepal. Heterogeneity in levels of knowledge and in practices both within and between these groups corresponds to differences in level of specialization in relation to medicinal plants, to socio-cultural and institutional contexts, and to extra-local factors that govern people's activities. We argue that understanding the heterogeneity of knowledge and practices within a given area is crucial to design management practices that build on the intricate links between knowledge, practices, and institutional context. It is also important to develop ecological studies that will best inform management.

INTRODUCTION

Over the past three decades, the global environmental crisis has led to a belated acknowledgment that man is part of nature, a new paradigm challenging biological and ecological research, which has, in the past, tended to consider natural objects as totally independent of any social or political sphere (Larrère and Larrère 1997, Latour 1997). The Earth Summit in Rio de Janeiro in 1992, through the Convention for Biological Diversity (CBD), firmly acknowledged the role of indigenous knowledge in biodiversity conservation, especially under Article 8j, thus promoting its use as a new norm in environmental management (Cormier-Salem and Roussel 2002). Since then, academics and decision-makers have emphasized the value of local knowledge in determining the co-viability of social and ecosystem dynamics (e. g., Gunderson and Holling 2002) and in informing the design of people-centered resource management approaches (e. g., Cunningham 2001).

The importance of ethnobiological knowledge (we consider here ethnobotany and ethnoecology as different subjects of the overall discipline known as ethnobiology) for suggesting new paths in scientific research, for conservation monitoring, or for understanding ecological processes, has received much attention in resource management (Berkes et al. 2000, Huntington 2000, Olsson and Folke 2001). International agencies such as the World Wildlife Fund (WWF) and UNESCO, in the context of their joint program, the People and Plants initiative, have also promoted research on ethnobotanical knowledge, as well as integration of people's perceptions and practices in resource management at the local level (Cunningham 2001). Incorporation into biological and ecological studies of local-use patterns and of the

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social and institutional background that guides the relationships between people and nature, has led to a greater understanding of the relationship between social and ecological dynamics (Gunderson and Holling 2002).

The dialectical relationship between ethnobiological knowledge and local practices shapes the ecosystem and affects its constituent plant populations. In the context of community-based projects, global perceptions of biodiversity conservation and scientific understanding of ecosystem dynamics are confronted with local communities' knowledge of, perceptions of, and values associated with the different components of the ecosystem. Local knowledge and practices have to be analyzed and understood so that appropriate management practices that build on both scientific and local knowledge may be developed (DeWalt 1994, Berkes et al. 2000, Berkes and Folke 2002, Ticktin and Johns 2002). Recent studies also show that local knowledge and practices have certain similarities to complex adaptive systems, having the capacity to deal with uncertainty and to respond to ecosystem change (Berkes and Folke 2002). By incorporating local knowledge and practices in the process of scientific research, new hypotheses can be developed for research experiments relevant to management (Henfrey 2002). A longer-term objective of our work was thus to use results of our ethnoecological studies to develop new sets of hypotheses for ecological research in order to test the effect of variation in knowledge and practices on the ecology and conservation of threatened species (Ghimire et al., submitted).

Beyond the importance of local knowledge and practices for scientific research, this paper also aims to portray the complexity of local knowledge and resource management systems. Knowledge variation across and within cultural groups has not been given much attention, nor has knowledge variation been clearly related to the goals and behavior of the knowledge holders (Ross 2002). We analyze how local knowledge is put into action in different cultural contexts of specialization and how external trans-local factors may affect this knowledge. Quantitative approaches are also generally lacking in the ethnobiological literature (Phillips and Gentry 1993, Höft et al. 1999). Our study applied a populational approach to knowledge, i. e., determining which parts of a given human population hold specific types of knowledge, in addition to that generally held. This may have important implications for sustaining knowledge transmission in relation to resource management. Furthermore, to understand the dynamics of knowledge and the relationships between knowledge and practices, we discuss the social context, especially the role of active formal and informal institutions, in sustaining the expression of knowledge in the contemporary context of change. Local institutions controlling access to resources have been considered an important element of the success of local resource management (Ostrom 1992, Berkes et al. 2000).

This research was conducted with respect to issues related to conservation of medicinal plants (MPs) in the Nepalese Himalaya. Medicinal plants are an integral part of the diverse traditional medical practices in the Himalayan region and are highly valued both in folk medicine and in codified traditional medical systems, such as Chinese traditional medicine and Ayurveda (Sivarajan and Balachandran 1994, Lama et al. 2001). The exploitation of MPs is expanding rapidly due to the development of medicinal plant industries, both regionally and internationally. Research on MPs traded from Nepal shows that the Nepalese Himalaya contributes a significant amount of high value MPs in the region, especially those species that have become very rare in the Indian Himalaya (Olsen and Larsen 2003). In Nepal the amount of MPs exported increased from 3,448 tons in 1989/90 to 11,694 tons in 1993/94 (Bhattarai 1997), and has continued to increase since then (Olsen and Larsen 2003). Very few studies have approached the issue of management of Himalayan MPs with reference to knowledge and practices of local people (e. g., Lama et al. 2001, Ojha et al. 2001, Larsen 2002). There is a general lack of understanding of how harvesting and management practices vary among different MP users.

This study presents findings of research conducted in the Shey-Phoksundo National Park and its buffer zone in northwestern Nepal. The first objective of our research was to assess variation in knowledge relating to use and management of MPs between two social groups, living in villages located in the national park (NP) and the buffer zone (BZ), that differ culturally. The second objective was to assess variation within and between these two groups related to local perceptions of the biology and ecology of two selected species of MPs, viz., *Nardostachys grandiflora* DC. (Valerianaceae) and *Neopicrorhiza scrophulariiflora*

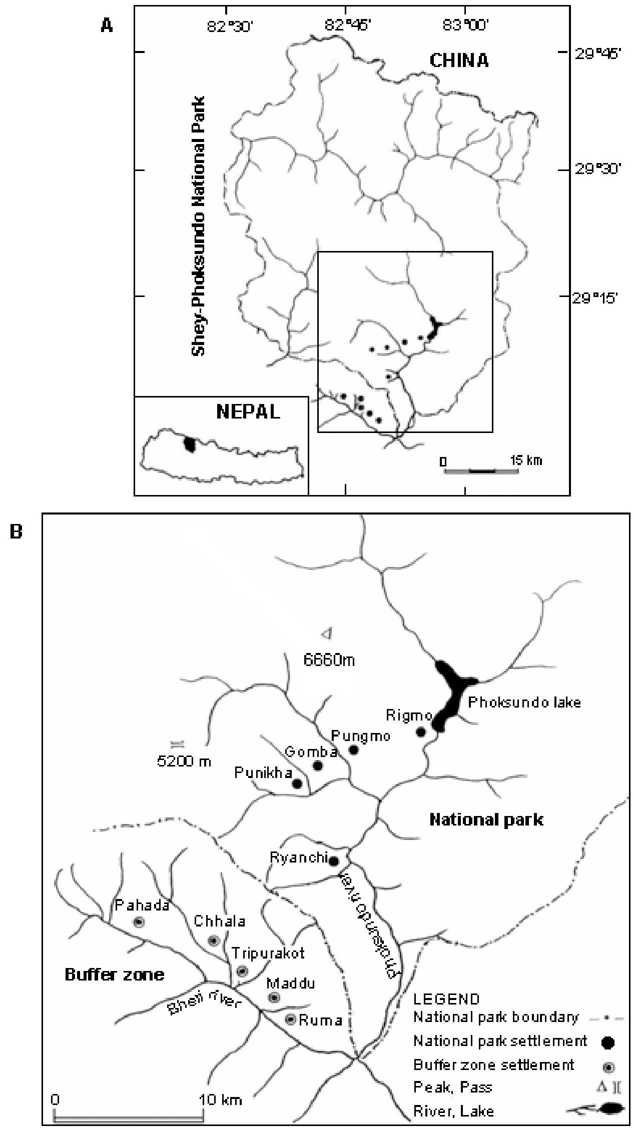
(Pennell) D. Y. Hong (Scrophulariaceae) (hereafter referred to as *Nardostachys* and *Neopicrorhiza*, respectively), the harvesting patterns of users of these plants, and the systems of management. These two species were selected because their rhizomes have a high value both for health care and for trade, not only in the present study area but also throughout the Himalayas, and also because both are highly threatened (Tandon et al. 2001). Both species are perennial herbs. *Nardostachys* is included in Appendix II of CITES, and *Neopicrorhiza* is being examined for inclusion in Appendix II (Mulliken 2000). Collection and export of the latter species is also banned in Nepal, but large-scale illegal collection still takes place because of the very high demand from the Indian and Chinese markets. Harvesting patterns were studied to understand to what extent the harvesting practices of specialist MP users in the NP (traditional Tibetan doctors known as *amchi*) differ from those of specialists in the BZ (mainly commercial collectors).

STUDY AREA

This study was carried out at two sites in Shey-Phoksundo National Park, Dolpa District (also known as Dolpo), Nepal (Fig. 1). The first site includes the settlements and high pastures in Phoksundo Village Development Committee (VDC)—a VDC is an administrative unit comprising many small villages or settlements—located in the upper Phoksundo valley within the national park (NP). The second site includes the settlements and pastures in Pahada and Tripurakot VDCs, located in the upper Bheri valley in the southwestern park BZ. Altitude ranges from 2200 to over 5000 m. The climate is hot in summer, and cold and dry in winter, with low annual rainfall (450–800 mm). The mean annual temperature (recorded in the nearest meteorological stations, altitude ca. 3000 m) varies from 8.9°C to 16.1°C (minimum -2.8–12.8°C, and maximum 10.6–22.0°C). Snowfall starts in October and the area remains under snow for up to six months until March.

Some 500 inhabitants (in 93 households) live in the Phoksundo valley, and they follow the culture and religions of Tibet, including Bon (the ancient religion of Tibet, which prevailed before the advent of Buddhism) and Tibetan Buddhism. They speak a Tibetan dialect known as *Kham*. They migrated into the area in the 7th and 8th centuries from the ancient kingdom of Zhang-zhung, a region located in western Tibet (Kind 1999).

Fig. 1. Map of the study area. A) Location map; B) Detailed map of the surveyed villages in the national park and buffer zone.



About 3950 inhabitants (in 745 households) live in the BZ settlements. Most people in the BZ are Indo-Aryans, mixed with a smaller proportion of Tibeto-Burmans. Most of them practice the Hindu religion, and have traits reflecting a mix of Tibeto-Burman and Indo-Aryan cultures. These villagers mainly speak Nepali (an Indo-Aryan language), but both Tibetan and Tibeto-Burman languages are also spoken in some settlements. The Bheri valley also has a long history of human habitation. However, most of the Nepalispeaking Indo-Aryans migrated to this area only after the 17th century. In Nepal, these groups generally faced complex migration itineraries, traveling from low-lying areas as far away as the Indo-gangetic plains to the mountain areas, and from one mountain area to another (Bista 1994). Social relationships between the NP and BZ groups relate principally to seasonal trade movements between the high and low valleys for exchange of products such as cereals and other grains (Bauer 2004).

The local economy relies on subsistence agriculture, pastoralism, and seasonal trade. The people in the NP have retained traditional trade with Tibet, where they exchange food grains and woolen commodities for salt, Tibetan tea, and other finished goods. Agriculture is little developed because of the rugged terrain, the short growing season, and the harsh climate, and people are highly dependent on forest and pasture resources for their livelihood. The immediate users of MPs in the NP villages are specialists trained in the Tibetan medical system (*Sowa Rigpa* or *amchi* medicine) who harvest for health care purposes, whereas users in the BZ are chiefly commercial collectors. Harvesting of small amounts of MPs for health care is undertaken in the BZ mainly by healers known as *dhami* who practice localized shamanistic healing techniques.

The cultural and social control of high-altitude MPs has been studied for communities living inside the NP (Aumeeruddy-Thomas et al. 2004), and variations of market trends of MPs, as well as social strategies developed by commercial collectors, have been analyzed in the context of a larger interdisciplinary project (Lama et al. 2001) jointly implemented since 1997 by the WWF-UNESCO People and Plants Initiative and by the WWF-Nepal Program. A major finding of this project regarding informal and formal institutional control of resources by local communities is that communities living inside the NP had, in the past, two formal institutions, the Dratsangh and the Yulgigothe, that regulated the use of wild resources. The former institution was led by an assembly of religious heads (*lama*) and *amchi,* and the latter institution was led by the customary chief of the village. These institutions jointly set practical resource-management rules, such as amount of timber that could be extracted from the forest, periods for harvesting MPs and other resources, etc. A system of fines was applied when these rules were not respected. Moreover, a whole set of informal rules embodied through rituals tended to encourage an attitude of cautious and respectful use of environmental resources. Resources are seen as part of a larger cultural landscape and territory that is spatially well defined both by mythical and symbolic landmarks, as well as by landmarks related to relief morphology or major vegetation characteristics. These traditional formal institutions are not fully operational in the present context, where land and resources inside the park are formally under the control of the NP. However, some elements of control and access to resources have remained, such as rotational grazing and a generally cautious attitude. Regarding the southern BZ, no local institution with a role in resource management has yet been identified, although there are certain rules regarding pasture management in terms of seasonal livestock movements. Customary territories are less well defined, and there has been conflict between adjoining villages or VDCs over the use of highland pasture for grazing, as well as for extraction of MPs. Community Forest User Groups (CFUGs), legitimized by Nepal's Forest Act (1993), are the only local institutions governing access to forests in the BZ area, but have not to date developed any management or operational plans for the use of MPs. Commercial collectors of MPs often respond to demand by road-head traders, who advance them money for their overall economic livelihood needs, especially to celebrate major cultural events (e. g., Dashain) or family events (e. g., marriages). The traders may ask the collectors to provide them with any MPs at any period of the year, depending on the market demand. Permits for the collection of MPs are formally issued by the District Forest Office (DFO), but the trade survey undertaken in 1997 showed that the volume of MPs registered by the DFO was highly underestimated compared with the amounts actually collected and traded (Shrestha et al. 1998). It is estimated that some 40 tons of raw dry forest products, including MPs, are annually traded from Dolpa, of which only about 30% are recorded by the DFO (Shrestha et al. 1998).

METHODS

Field work for the ethnoecological study was conducted concurrently with basic field work in ecology during 2-month visits each year between 1997 and 2003. Studies focused on specialist as well as non-specialist MP users. Specialists are people for whom MPs are a major component of their professional life, such as *amchi*, commercial collectors, and *dhami*.

Non-specialists are people for whom MPs are not an important component of their professional life, although they may, in certain cases, use MPs for other purposes or for home consumption.

Before the initiation of in-depth ethnoecological studies, substantial background information was obtained on the use, distribution, and status of large groups of plant resources in the area through a baseline survey in 1997. This survey was conducted on a wide scale, involving all sections of the society, in ten out of 23 VDCs in the Dolpa District. In total, 350 randomly selected households were interviewed, using semi-structured questionnaires. In addition to this household survey, *in situ* open, individual and group interviews were also conducted during outdoor field surveys and resource-mapping activities (Martin 1995, Cunningham 2001). Vouchers of all the plants mentioned by the people interviewed were collected, dried, and mounted following standard methods (Martin 1995), and most of them were identified to species level. In addition, photographs, geographical coordinates (using GPS), altitude, habitat type, habitat characteristics (altitude, slope, aspect, substrate type, etc.), and phenology were recorded for most of the species of MPs during a series of transect walks and collection trips. Ecological surveys, employing transects and plots, were also developed concurrently with ethnobotanical studies to explore and verify local knowledge about the distribution and status of plant resources in different habitat types and landscapes. Collection of plants—and recording of their local names, uses, habitat characteristics, and status—has been a continuous process during all subsequent field visits. After 1997, however, we concentrated in the Phoksundo VDC in the upper Phoksundo valley and Pahada and Tripurakot VDCs in the upper Bheri valley. The survey identified more than 500 species of ethnobotanically useful wild plants, of which some 400 species are used medicinally (Lama et al. 2001).

Table 1. Breakdown of people interviewed according to profession, age, and sex

Site	Social group	Type of users	Major profession	Number interviewed	Age range	Sex
NP	*Amchi*	Specialized MP users	Traditional doctor/ agro-pastoralism	5	40–55	All male
	Agro-pastoralists	Non-specialized MP users	Agro-pastoralism/ trans-Himalayan trade	35	20–50	29 male 6 female
BZ	*Dhami*	Specialized MP users	Traditional doctor- Shamanism/agro-pastoralism	5	45–65	All male
	Commercial collectors	Specialized MP users	MP trade	3	30–45	All male
	Commercial collectors	Specialized MP users	MP trade/agro-pastoralism	48	25–50	46 male 2 female
	Agro-pastoralists	Non-specialized MP users	Agro-pastoralism	24	20–50	21 male 3 female

In June 2000 and 2001, we conducted quantitative ethnobotanical studies in order to assess variation in levels of knowledge among different social groups and categories in the selected VDCs in the NP and the BZ. In this process, a total of 120 informants were interviewed (Table 1). Before selecting informants, we conducted village-level group meetings, involving a large number of villagers in both the river valleys, to present our aims and to seek their participation. We interviewed all those who readily accepted to be interviewed, but we took care to involve no more than one informant from the same household. Our selection included 40 informants from NP settlements (43% of all households), including five *amchi*, and 80 from BZ settlements (11% of all households), including five *dhami* and 51 commercial collectors. A total of 130 species of MPs out of 400 reported from the area were selected for the interview, based on their common availability and uses in both sites.

During the interviews, we investigated ethnobotanical knowledge in terms of people's ability to identify MPs and describe their uses. In most cases, each informant was shown freshly pressed plants; in some cases, dried specimens or color photographs were used. Specialist users were also shown live plants along transect walks. All informants were asked if they recognized the plant and had a name for it, if the plant had medicinal uses, and if they personally used it.

Based on this quantitative ethnobotanical assessment, we selected 28 people (five amchi and 23 non-specialists) from the NP and 63 (five dhami, 51 commercial collectors and seven non-specialists) from the BZ, who were found to be harvesters of *Nardostachys* and *Neopicrorhiza,* in order to further assess the detail of their ecological knowledge concerning these two species. Each person was asked a total of 12 questions, covering both general and specific topics. The interviews were mostly open ended. The general questions related to the population level, such as the number of populations they knew of these two selected species, including their localities, habitat types, characteristics of different populations, and relative size and density of each population. Specific questions focused on knowledge of biology and ecology, including the plant's natural history and growth. These questions concerned growth patterns and life-cycle stages, growing season, flowering and fruiting periods, seed production, reproductive biology (vegetative and sexual), and yield of rhizome per plant. The variables related to ecology were coded using a scale comprising three general response categories. Following Ticktin and Johns (2002), we distinguished between no knowledge (0) and basic knowledge (1). When more detailed information was offered, we assigned a third score (2). Features characterizing each score are given in Table 2. Differences in knowledge among social groups, and between categories (specialists and non-specialists), were assessed using Kruskal-Wallis one-way ANOVA, Wilcoxon sign tests, or Mann-Whitney U tests.

The harvesting approaches of *amchi* in the NP and commercial collectors in the BZ were assessed through a series of informal interviews and discussions with them, and through direct observation of harvesting activities.

Fig. 2. Percentages of plants identified, plants whose utility was described, and plants that individuals reported they actually use, by different users. Bars show standard deviation (SD). Different letters indicate significant differences ($P < 0.05$) in performance of different categories of people in the same task.

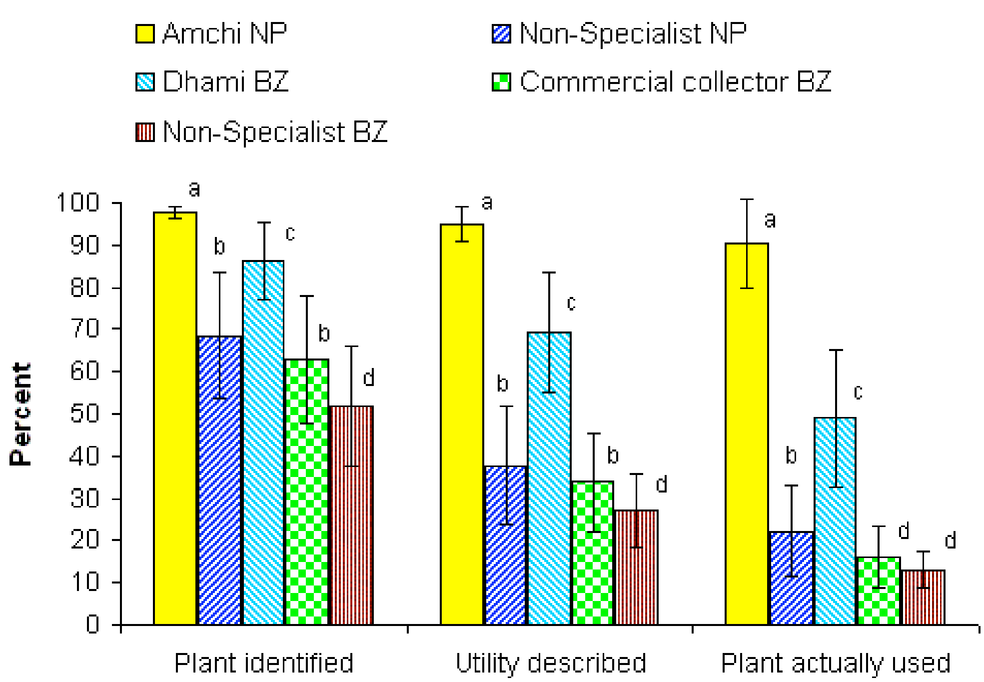


Table 2. Mean scores[1] of ecological knowledge about *N. grandiflora* and *N. scrophulariiflora* for different user categories in the NP and BZ sites

Variables	*Amchi* NP	Non-specialist NP	*Dhami* BZ	Commer-cial BZ	Non-specialist BZ	Significance[2]	
						χ^2	P
Nardostachys grandiflora							
No. of populations known	2.00	1.74	2.00	1.65	1.33	6.44	0.169
Characteristics of different populations	2.00^{a}	0.95^{b}	2.00^{a}	0.83^{b}	0.67^{b}	18.43	0.001
Habitat type	2.00	1.68	2.00	1.60	1.33	6.68	0.154
Population size	2.00^{a}	1.16^{b}	2.00^{a}	1.48^{a}	1.33^{b}	13.70	0.008
Abundance	2.00^{a}	1.21^{b}	2.00^{a}	1.60^{a}	1.33^{b}	17.08	0.002
Life-cycle stages	1.40^{a}	0.21^{b}	0.25^{b}	0.08^{b}	0.00	29.25	0.000
Flowering time	2.00^{a}	1.68^{a}	2.00^{a}	1.71^{a}	1.00^{b}	10.92	0.028
Fruiting time	2.00^{a}	0.95^{b}	2.00^{a}	1.40^{a}	0.67^{b}	18.02	0.001
Seed production per plant	1.80^{a}	0.74^{b}	1.00^{ab}	0.54^{b}	0.00	14.74	0.005
Reproductive biology	2.00^{a}	0.84^{b}	1.00^{ab}	0.54^{b}	0.00	19.06	0.001
Yield of rhizome per plant	1.80^{a}	0.47^{b}	2.00^{a}	1.13^{c}	0.33^{b}	31.54	0.000
Seasonality of growth	2.00^{a}	1.68^{a}	2.00^{a}	1.75^{a}	1.00^{b}	11.70	0.02
Overall mean	1.90^{a}	1.11^{b}	1.69^{ac}	1.19^{b}	0.75^{d}	22.52	0.000
Neopicrorhiza scrophulariiflora							
No. of populations known	2.00	1.67	2.00	1.53	1.43	8.42	0.077
Characteristics of different populations	2.00^{a}	0.93^{b}	2.00^{a}	0.68^{b}	0.71^{b}	20.17	0.000
Habitat type	2.00	1.60	1.60	1.53	1.43	4.58	0.333
Population size	2.00	1.20	1.60	1.35	1.14	7.14	0.129
Abundance	2.00^{a}	1.27^{b}	2.00^{a}	1.53^{ab}	1.43^{b}	13.13	0.011
Life-cycle stages	1.00^{a}	0.27^{b}	0.20^{b}	0.09^{b}	0.00	24.72	0.000
Flowering time	2.00	1.60	2.00	1.62	1.43	7.12	0.130
Fruiting time	2.00^{a}	1.00^{b}	1.80^{a}	1.18^{ab}	1.14^{ab}	10.17	0.038
Seed production per plant	2.00^{a}	0.73^{b}	0.40^{b}	0.50^{b}	0.14^{b}	16.97	0.002
Reproductive biology	1.80^{a}	0.87^{b}	0.80^{b}	0.50^{b}	0.14^{c}	17.06	0.002
Yield of rhizome per plant	2.00^{a}	0.33^{b}	1.40^{ac}	0.91^{c}	0.57^{bc}	30.71	0.000
Seasonality of growth	2.00^{a}	1.60^{a}	2.00^{a}	1.74^{a}	1.14^{b}	14.72	0.005
Overall mean	1.90^{a}	1.09^{b}	1.48^{b}	1.10^{b}	0.89^{b}	18.20	0.001

[1]Features characterizing each score are: 0 = No idea of any general population characteristics, including features known by people having basic knowledge; 1 = Few populations, habitat types, size of populations, abundance, and some general aspect of seasonality of growth are known; 2 = Precise knowledge of a variety of population characteristics; large number of population and habitat types are known; precise description of population size, abundance, life-cycle stages, and reproductive biology.
[2]Kruskal-Wallis one-way analysis of variance, df = 4. Means in the same row with the same superscript letter are not significantly different at the 0.05 level (pairwise comparisons by Mann-Whitney U tests). In rows with no superscript letters, no significant differences between user categories were found.

Table 3. Major habitat types of *N. grandiflora* and *N. scrophulariiflora* identified by the people

Habitat type Local terminology[1]	Explanation of the term	For *N. grandiflora,* number of localities in[2]		For *N. scrophulariiflora* number of localities in[2]	
		NP	BZ	NP	BZ
Draakri (K), *Bhir* (N)	Rocky slope	20 (90.9)	5 (27.8)	1 (5.9)	0
Penhri (K), *Paatan* (N)	Grassland	2 (9.1)	12 (66.7)	1 (5.9)	3 (30.0)
Tsalip (K), *Butyaan* (N)	Shrubland and scrub	0	0	14 (82.3)	7 (70.0)
Naakri (K), *Ban* (N)	Forest	0	1 (5.6)	1 (5.9)	0
Total localities		21	18	17	10

[1]K = Local term in *Kham* (Tibetan); N = Local term in Nepali.
[2]Figures in parentheses represent percentages of the known localities.

RESULTS

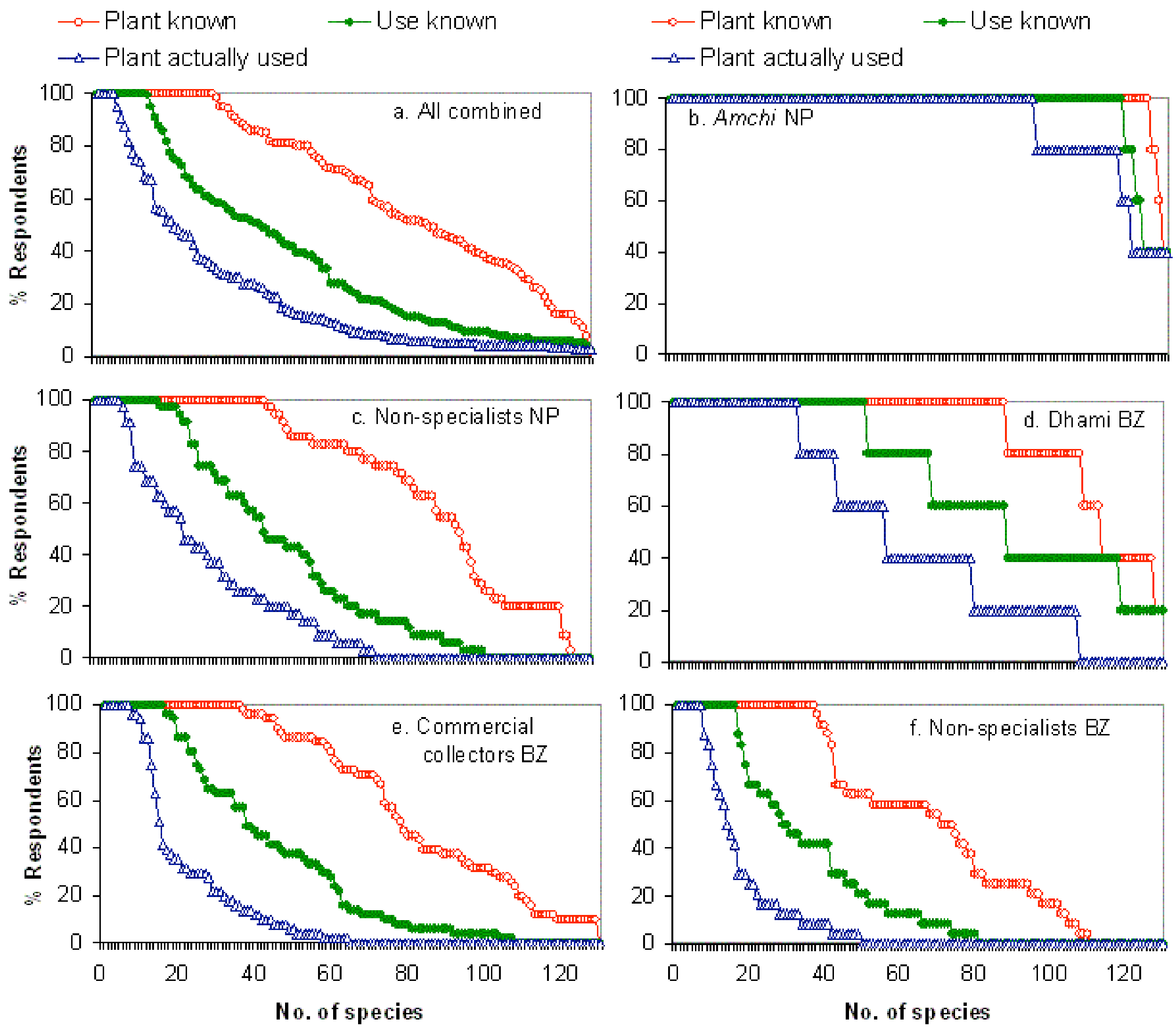
Variation in Ethnobotanical Knowledge

The ethnobotanical study conducted with 120 informants showed significant variation in knowledge among different social groups, regarding ability both to identify MPs (Kruskal-Wallis one-way ANOVA, $\chi^2 = 35.49$) and to describe their uses ($\chi^2 = 35.47$; df = 4, $P < 0.001$ in both cases). Among all the social categories, specialists (*amchi*) in the NP identified and knew utilities of significantly larger proportions of the 130 plant species tested (Fig. 2). In the BZ, the *dhami* knew a larger number of species than did commercial collectors and non-specialist users. Knowledge of commercial collectors in the BZ was most detailed for plants that are traded. The non-specialists from the NP knew more plants than did non-specialists from the BZ.

The non-specialists from both the NP and the BZ, as well as the commercial collectors, identified, on average, more MPs than those for which they knew medicinal uses (Wilcoxon sign test $Z = -5.16$ for NP, $Z = -7.53$ for BZ including commercial collectors, $P < 0.001$). On average, they knew the medicinal uses of almost half the species that they actually recognized by name. Among those identified species, they personally consumed only from 21% (non-specialists and commercial collectors in the BZ) to 30% (non-specialists in the NP) for medicinal purposes. However, most of these species were cited for other uses, such as food, ceremony, fuel, timber, and dyes (data not shown).

The pattern of distribution of knowledge related to MPs (among 130 species tested in all cases) showed that 31 species were known by name to almost everyone from both sites. Of these, 13 species were known for medicinal uses and five were actually used by almost everyone from both sites (Fig. 3a). These are mostly the traded species and many have multiple-use values. An average of 50 species was known by most people (over 50% of the respondents) from both sites. These are the most commonly available species. The remaining species were known by few people, particularly the *amchi*. Almost all the people interviewed knew and were able to identify both *Nardostachys* and *Neopicrorhiza*. Among specialist users, 125 and 118 species out of 130 were known by name and use, respectively, to almost all *amchi*, whereas only 88 and 51 species were known by name and use, respectively, to almost all *Dhami*.

Fig. 3. Distribution of knowledge of medicinal plants (MPs) among different users in the national park (NP) and buffer zone (BZ) sites.

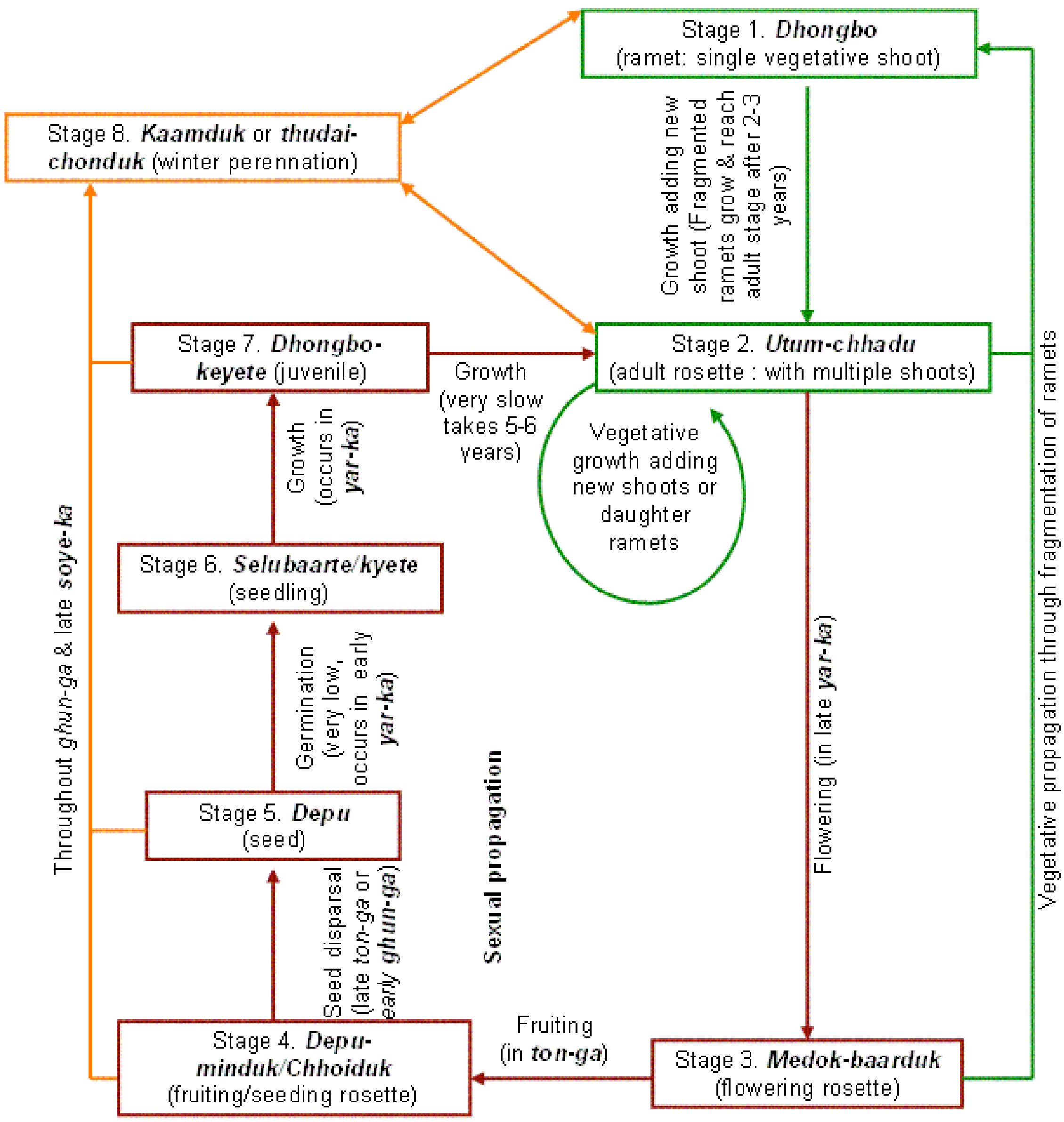


Variation in Ethnoecological Knowledge

The knowledge of local people about the biology and ecology of the two species studied also varied considerably among social categories. *Amchi* obtained significantly higher scores than the other users, followed by *dhami*. Similarly, commercial collectors in the BZ and non-specialists in the NP scored higher than non-specialists in the BZ (Table 2). Of the 12 questions asked, there was little variation in knowledge score for more general questions related to populations (number of populations known, habitat types, population size) and natural history (flowering period, seasonality of growth, etc.). However, scores significantly differed among groups with respect to specific questions related to plant biology, such as life-cycle stages, seed production, and reproductive biology. Only few people responded to these questions. Both specialists and non-specialists from the NP tended to score higher on these questions. In the BZ, *dhami* obtained higher scores on these questions than did non-specialists.

In both sites, more than 50% of respondents provided accurate information on flowering and fruiting periods of both species. About 45 and 50% of respondents from the NP responded to questions about growth stages and life cycles of *Nardostachys* and *Neopicrorhiza*, respectively, whereas only 14 and 13% of individuals from the BZ were able to respond to these questions. Most of those who responded to questions about growth were also able to differentiate two growth forms and eight life-cycle stages for these two species (Fig. 4).

Fig. 4. Perception by *amchi* of the growth stages and life cycle of *N. grandiflora* and *N. scrophulariiflora.* The local terminology in Kham is shown in italics. *Amchi* differentiated between a single individual as *dhongpo* (ramet) and a group of plants arising from the same rootstock as *pong* (genet). *Amchi* also distinguished eight growth stages in the life cycle of both species (Stages 1 to 8). These growth stages were described with respect to the four seasons (each of three months) in a year based on the Tibetan calendar, viz., *soye-ka* (February–April), *yar-ka* (May–July), *ton-ga* (August–October), and *ghun-ga* (November–January). Both species are small, long-lived, rhizome-bearing perennial herbs with seasonal growth. The growing season is short, starting in early *yar-ka,* when the winter snow melts, and ending near the late *ton-ga* or early *ghun-ga,* when the winter perennation starts. At the end of each growing season (stage 8), the aboveground rosettes dry up and the plant is buried under snow. The underground rhizomes remain dormant throughout *ghun-ga* until late *soye-ka,* and grow out the next growing season (early *yar-ka*), producing new rosettes of leaves.



In both sites, most individuals possessed good knowledge about distribution, preferred habitat conditions, population size, and abundance of populations of both species. Collectively, they described 40 localities for *Nardostachys* and 27 localities for *Neopicrorhiza* within the study area. They distinguished four major habitat types, according to structural and bio-physical characteristics, to describe the distribution of populations of both species (Table 3).

Interviewees also reported variations among plant populations growing in different habitats, based on local indicators. Indicators reported to vary among populations within each species are given in Table 4. Such perceptions influence harvesting strategies through selection of preferred areas for collection of MPs (Table 5). The most important morphological characters reported were the overall vigor of the plant in terms of size of rosette, rhizome, leaf, and flower, and plant height, whereas minor characteristics considered were color of the flower, leaf, and rhizome. *Amchi* were able to differentiate populations of *Neopicrorhiza* on the basis of color of the rhizome, which ranges from white to yellow in harsh rocky habitats, and from white to grey with red spots in less rocky and more mesic habitats. *Amchi* also differentiated populations of these two species on the basis of organoleptic perceptions (taste, smell, or both), indicating underlying biochemical variation. They reported that populations of *Nardostachys* growing in rocky and dry habitats possess strongly aromatic rhizomes compared with those growing in less harsh sites. For *Neopicrorhiza*, populations growing in dry and rocky habitats were reported to possess rhizomes that were more bitter than those growing in more mesic conditions. Plants growing in harsh habitats were considered to have greater potency and medicinal efficacy.

Mode of Harvesting and Management

There exist two approaches to harvesting and management of MPs in the study area: i) selective or choosy harvesting, which is conducted by Tibetan communities in the NP; and ii) non-selective and massive harvesting, which is typical of exploitation of these plants in the BZ. In addition, other local management approaches also applied in the NP site include i) certain levels of controlled access to the harvesting sites; ii) social and cultural rules limiting harvest to specific periods; iii) transplanting of ramets *in situ* and cultivation in home gardens; and iv) rotational grazing of livestock. Rotational grazing of livestock is the only known management approach aimed at limiting pressure on pasture resources in the BZ.

Table 4. Indicators as perceived among populations within each species (*N. grandiflora* and *N. scrophulariiflora*)

Indicators	% of people citing the indicator	Major characteristics[1]	Minor characteristics[1]
Morphological	74.4	Plant vigor: rosettes size; size of leaves, rhizome, flower; plant height.	Color: flower, leaf, and rhizome
Availability and overall population size	66.2	*Pe-maangbo/Ekdam-dherai* (plant found dominantly everywhere in the habitat), *Maangbo/Dherai* (plant found commonly), *Saane-dingba/Kam* (plant found frequently); and *Saane-ngyungyung/Thorai* (plant found rarely).	*Thukpo/Baaklo* (thick population), *Taapo/Paatalo* (thin population)
Physical characteristics	23.4	Soil, slope, aspect and altitude	
Organoleptic qualities	13.7	Taste, smell, or both	

[1]Local terms are given in italics. *Kham* (Tibetan) terms are given first followed by Nepali, separated by a slash (/).

Table 5. Characteristics of *N. grandiflora* and *N. scrophulariiflora* in different habitats, based on local perceptions, and harvesting preferences expressed by *amchi*

Habitat (*Kham* name)	Morphological indicators[1]				Organoleptic indicators[1]	Harvesting Preference
	Plant height	Root/rhizome size	Leaf size and shape	Flower color and size		
Dry rocky slope (*Draakri*)	Very small	Very short & thick	Very small, narrow, and linear (NG)	Small & white (NG) Dark blue (NS).	Strong scent (NG)/ strongly bitter (NS)	High
Moist rocky slopes (*Draakri*)	Small	Short & thick	Short & broad (NG)	Large white (NG) Dark blue (NS).	Strong scent (NG)/ strongly bitter (NS)	High
Moist alpine grassland (*Penhri*)	Small	Long & thick	Short & linear (NG)	Small violet (NG), Dark blue (NS).	Strong scent (NG)/ bitter (NS)	High
Moist alpine scrub (*Tsalip*)	Large	Long & thin	Long & linear (NG)	Small violet (NG), Light blue (NS)	Weak scent (NG)/ less bitter (NS)	Low
Forest (*Naakri*)	Large	Long & thin	Long & linear (NG)	Small violet (NG), Light blue (NS).	Weak scent (NG)/ less bitter (NS)	Very low

[1]NG = *Nardostachys grandiflora*; NS = *Neopicrorhiza scrophulariiflora*

Selective harvesting, mainly applied by *amchi,* is based on their ethnobiological and ethnoecological knowledge. According to *amchi* knowledge, the harvesting stage of MPs depends upon the nature of diseases, nature of plant parts used, and recipes of the codified Tibetan medicine. The periods chosen for harvesting of MPs in general are determined first by availability of the target parts (e. g., spring for young leaves, summer for flowers and mature leaves, and autumn for fruits, seeds, and rhizomes). However, some plant parts are available year round, but are collected at the time when they are considered to have their highest medicinal efficacy. For example, spring is said to be the best season for collecting tree bark, whereas winter is considered to be the best season for collecting rhizomes. Over 41% of respondents from the NP (including all *amchi*) said that they harvest both species during September and October (Table 6). Harvesting of MPs by *amchi* is also regulated by religious practices and beliefs. Harvesting is undertaken after a specific ritual is performed, in which they propitiate the *menlha*—medicine (*men*) deity (*lha*)—prior to collecting the plants. *Amchi* also determine harvesting periods according to the cultural and religious calendar. The *tahangsung rikhi* is a specific period of about 7 days (in late September or early October) determined by the Tibetan calendar when most of the alpine herbs start to complete their life cycle. It is a preferred period for harvesting fodder grass for winter and high altitude MPs whose underground parts are used. The first winter shower (*dhuchi man char*, which means "medicine rain") that occurs during this period is believed to enrich MPs and thus increase their medicinal potentialities. Thus, underground parts of MPs that are harvested during this period would have more potency than those harvested earlier or later.

Harvesting is selective at several levels. First, sites are chosen for harvesting based on knowledge of distribution of plants, or sizes of populations. Most of the respondents in the NP (both specialists and non-specialists) reported using this mode of harvesting (Table 6). *Amchi* also select sites based on perception of biochemical traits of MPs. Secondly, within a chosen site, larger plants are selected. Thirdly, each plant part is harvested in a selective fashion. Harvesting of underground parts involves uprooting only mature and robust parts, leaving younger rhizomes and vegetative shoots to mature until the latter set seeds. However, the selection of plant parts depends on the growth patterns of plants and their habitat. *Neopicrorhiza,* which has shallowly rooted creeping rhizomes, is very easy to harvest. *Amchi* select the larger rhizomes and leave the others intact. In the case of *Nardostachys,* which grows in very tight clumps and is deeply rooted in relatively compact and stony substrates, the selective harvest of larger rhizomes is almost impossible. Thus, for this species, the rhizomes collected often include different size classes. The *amchi* also practice enrichment planting while harvesting *Neopicrorhiza*. Signs of over-grazing, trampling, over-harvesting, spread of pests, and diseases are considered as important indicators of population decline. These are also considered by *amchi* as the main criteria guiding the decision to stop collection temporarily in a particular population. They may also decide to stop collection when they observe that the population size is small, with few mature individuals.

Table 6. Harvesting periods and modes of harvesting of *N. grandiflora* and *N. scrophulariiflora* in the NP and BZ sites

Site	Species	Harvesting periods[1]						Modes of harvesting[1]
		June–July	July–Aug	Aug–Sept	Sept–Oct	Oct–Nov	All months (June–Nov)	
National park	*N. grandiflora*	8.33	8.33	16.67	41.67	20.83	4.17	Selective: based on location (87.5), population size (75.0), and size class (54.2). Random harvesting (12.5).
	N. scrophulariiflora	5.00	10.00	15.00	35.00	30.00	5.00	Selective: based on location (90.0), population size (70.0), and size class (30.0). Random harvesting (20.0).
Buffer zone	*N. grandiflora*	3.64	5.45	7.27	32.72	9.09	41.82	Less- or non-selective: based on location (70.9), population size (49.1), and size class (9.1). Random harvesting (41.8).
	N. scrophulariiflora	4.40	4.40	8.70	21.70	13.00	47.80	Less- or non-selective: based on location (65.2), population size (32.6), and size class (2.2). Random harvesting (30.4).

[1]The values indicate percentages of respondents.

People in the BZ villages harvest selectively in one respect: they select large, dense populations from the best localities in terms of quantity of rhizome available, in order to maximize productivity with a minimum of effort and time. Within these favored sites, harvesting is non-selective. Most of the respondents said that they harvest both the species randomly, irrespective of size classes (Table 6). They collect both species by uprooting the whole clump and do not practice enrichment planting. Harvesting is not restricted to a particular season. Over 40% of the respondents from BZ villages said that they harvest during any period of the year, except during the period of winter snowfall (December–February). People from the BZ harvest rhizomes mainly in summer (as opposed to NP communities who harvest in fall), when the soils are moist and the rhizomes can be uprooted easily. Therefore, they uproot whole plants before they set seeds. Harvesting by some of the users in the BZ is associated with their agricultural and herding activities. Collection of MPs is an especially important side activity for those who stay with their livestock in the high pasture during the summer herding season (April–August). Although the individuals who have been engaged in commercial collection of MPs for a long time are aware of the ecology and biology of the plants, they rarely follow any selective method of collection, harvesting the plant mostly as a function of the market demand and value of the species, and of their own immediate economic needs.

DISCUSSION

Knowledge Variation and Dynamics

The level of ethnoecological knowledge was highest for the *amchi,* followed by the *dhami* and the commercial collectors. The non-specialists, both in the NP and the BZ, were more concerned about agropastoralism and showed less knowledge about MPs than did specialists. However, non-specialists from the NP showed greater knowledge than did non-specialists from the BZ. Similarly, the harvesting strategies of two major groups of specialists, the *amchi* in the NP and the commercial collectors in the BZ, were very distinct. The commercial collectors employed a destructive harvesting approach, despite their good ethnoecological knowledge about species collected. In contrast the *amchi*, who use MPs only for health care needs, harvested with an approach that aims at sustaining the regeneration of plant populations.

Several reasons explain these variations in knowledge level. The variation in knowledge between the *amchi* and the *dhami* may be explained by the fact that the *Sowa Rigpa* (Tibetan medical system) is highly dependent on plant material (Lama et al. 2001) compared with the *dhami* medical system, which is known to use more shamanistic practices based on psychological approaches (Biswas et al. 2000). *Amchi* knowledge is also not essentially local, as they rely on a vast body of scholarly knowledge of the "Four Tantra of Medicines" (*Gyushi*), which constitute the major Tibetan medical manuals (Lama 2003). The latter contain lists and iconographies of a large diversity of MPs, along with general guidelines for collection. In addition to the distinctiveness of their respective cultures, their level of knowledge is further differentiated, in being either highly localized (in the case of *dhami*) or relying on a vast trans-regional body of knowledge (in the case of *amchi*). Cross-cultural variation in knowledge between geographically distinct groups has been analyzed (e. g., Hunn 1985). In Dolpo, however, variation concerns two groups, who use the same resources for different purposes within an overlapping space. The specialized knowledge possessed by both the *amchi* and *dhami* may play a major role in the future in sustaining the Himalayan MPs, provided that this knowledge is transmitted to the younger generation. The major problem limiting knowledge transmission, particularly in the case of *amchi,* is the lack of formal recognition at the national level (Aumeeruddy-Thomas and Lama, *in press*). Management approaches to face the issue of discontinuity in knowledge transmission are discussed below in the section "Local institution and management of medicinal plants."

Regarding commercial collectors, their knowledge has been shown to be significantly higher than that of non-specialists from their own villages. Commercial collectors have acquired their knowledge through their specific activity, that is the commercial harvesting of MPs. Their considerable knowledge, however, seems not to be applied to sustainable management. Although the *amchi* think of the plants in relation to their healing properties, as well as in terms of their relationship with all other sentient beings, the commercial collectors think of the plant mainly in terms of its economic transaction value. The predominance of market forces in determining their practices does not create conditions that encourage commercial collectors to make full use of their knowledge base. In particular, the poorly developed commercial circuit in Nepal leads collectors to react immediately to both market demand and their immediate economic needs (Olsen and Helles 1997). This shows the effects of extra-local socio-economic factors on knowledge. It also shows that knowledge may be either passive or active, and that management relates to how knowledge may be put into practice. Overall, it also emphasizes the dynamic aspect of ethnoecological knowledge and the danger represented by new approaches in resource management, that treat local knowledge as a static set of semantic categories, a danger highlighted by Agrawal (2002).

Although both groups of non-specialists are agropastoralists, they are culturally distinct and their activities also differ greatly. Tibetan agropastoralists inside the NP engage in trans-Himalayan trade much more than do the mixed groups in the BZ. During this period, the Tibetan agropastoralists are entirely dependent on natural resources for their health, as well as that of their livestock (Bauer 2004). Agropastoralists living in the BZ area rely less on medicinal plant resources, as they have easier access to modern medical systems from the nearby district headquarters. Furthermore, the Tibetans' very ancient settlement in this area, as well as the ecological similarity between their area of origin (western Tibet) and their present settlements, has guaranteed a very long continuity of interaction between this society and the natural conditions they inhabit. Compared with the Tibetan agropastoralists, the mixed group in the BZ has had a far shorter period in which to adapt to the new natural environment that they inhabit today, because of their complex migration patterns. The relationship of the mixed group to its land and territory is, therefore, unclear and not profoundly marked by any cultural or customary boundary, and this group has a somewhat lower level of social control over resources. In the case of the Tibetan group, there is a high level of social cohesion, with strong cultural links to nature. Knowledge variation between the two groups studied may thus be attributed partly to the variation in cultural and historical links to their environment, as well as to variation in activities. However, work undertaken in other parts of the world also suggests that mixed ethnic groups that have migrated into new areas can show high levels of adaptation to local conditions and engage in very interesting patterns of resource management, especially regarding commercial products (Dove 2002, Pinedo-Vasquez et al. 2004). The study of Atran et al. (2002) on immigrant groups in Mexico shows their very high capacity to develop ecological knowledge in a new geographical context. The knowledge of commercial collectors in the BZ, which is significantly higher than that of the non-specialists, shows their high capacity to adapt to a changing context. Their interest in engaging in domestication projects (see below) also shows their keen interest in integrating new practices. They are, therefore, still learning. Their capacity to adapt to new market conditions in a changing institutional context must thus be analyzed over a longer time span.

The greater specific knowledge of *amchi* about plant biology and ecology is related to their experimental approach, including enrichment planting of MPs *in situ,* as well as cultivation in their home gardens. This knowledge is, to some extent, transferred to those non-specialists in their villages who show high interest in MPs. This experiential approach is also one of the reasons why the respondents from the NP scored higher on questions related to plant growth and reproduction. Many people are highly interested in the idea of domestication of Himalayan MPs. It is the results of attempts of some individuals, in this case, the *amchi*, that, if subsequently shared with other members of their community, may lead to new practices such as domestication and cultivation. Similar approaches have been demonstrated by Boster (1983) in the Amerindian context. Thus, knowledge here appears as the sum of the experiences of different individuals, which is then shared and developed in the context of a group (Ross 2002). Commercial collectors have also engaged since 2001 in a project for the domestication and cultivation of threatened Himalayan MPs, a project that draws from knowledge of the *amchi,* of scientists, and from the collectors' own empirical knowledge (Aumeeruddy-Thomas and Lama, in press).

Local Institutions and Management of Medicinal Plants

The territory in which commercial collectors operate in the BZ is not subject to the high level of social control and regulations that characterizes customary territories of Tibetan communities living inside the park, although Community Forestry User Groups (CFUGs) were formed almost a decade ago. On the other hand, in the Tibetan communities in Dolpo, social control, including local customary institutions (e. g., the Dratsangh and the Yulgigothe) regulating access to pasture and forest resources, has played an important role in management approaches to plant resources (Aumeeruddy-Thomas et al. 2004, Bauer 2004). The traditional institutions are, however, not fully operational in the context of the national park. A newly established institution, in the form of a Traditional Health Care Center (THCC), including representatives of the older institutions (*amchi* and *lama*) as well as new groups such as women's groups, park staff, etc., is operating in the present context inside the park (Lama et al. 2001). This center ensures the visibility of the *amchi* and serves as a place for transfer of knowledge to apprentice *amchi* through training, as well as providing high quality and culturally appropriate health care services in a context that is perceived as modern. The THCC also serves to raise general awareness and monitors the sustainable harvest of MPs used in it. Similarly, CFUGs, which have proved to be a highly operational concept in Nepal, are new institutions that show many signs of offering good opportunities for the management of MPs (Ojha and Bhattarai 2003). These developments show the highly flexible nature of local institutions, which may be reformulated in new local contexts

(e. g., THCC in the national park), or develop from a totally extra-local concept (e. g., CFUGs). Traditional formal institutions are no more adapted to resource management, because they do not necessarily fit into the present context of change characterized by the strong relations established today between global views and needs—here, biodiversity conservation in a national park—and more local views and cultures (Aumeeruddy-Thomas and Lama, in press).

In the case of commercial collectors, the MPs have a transaction value depending on factors that are beyond the local context. This stresses the need to work across scales—local, national, and international—with different stakeholders along the supply chain in order to sustain commercial harvesting. In the future, more effort has to be devoted to better organize the market circuits to provide more benefits to collectors and to ensure sustainable approaches along the supply chain. Previous studies by Olsen and Helles (1997) in Nepal show that providing good information on price trends of MPs in the international market may greatly help collectors plan their harvesting activities and reduce their dependence on the views and demands of middlemen. We propose that collectors should be organized into cooperatives in the context of CFUGs in order to have more negotiating power with the middlemen and larger market systems, and to develop better systems for controlling the harvesting territory.

Contribution of Ethnoecological Knowledge to Scientific Study and Management of Medicinal Plants

The analysis of ethnoecological knowledge and local management practices gives precise information on how local practices interact with the population ecology of the species considered. The vast body of knowledge possessed by the local people, particularly the specialist users, on the biology and ecology of the two focal species has great implications for developing appropriate biological and ecological research for resource management. Ticktin and Johns (2000), working on the Chinanteco management system in Mexico, reported that local knowledge relating to optimal environmental conditions for plant growth and flowering phenology—traits for which most of the local people they interviewed showed high levels of knowledge—may make important contributions to science and resource management. Our analysis of ethnoecological knowledge also showed that most of the informants possessed knowledge about both the phenology and environmental requirements of the focal plant species. Besides, local perception of the life-cycle and growth stages of the two focal species, knowledge about variation among different populations growing in different habitats, and preferences in harvesting based on specific morphological and biochemical traits also merit incorporation into scientific research and resource management. In everyday life, *amchi* monitor the state of vigor of harvested populations, based on their perception of the growth and biology of harvested species, and make decisions to shift to other harvesting sites if necessary. Such adaptive management approaches based on local monitoring systems should be taken into account in the development of management guidelines (Johnson 1999, Berkes et al. 2000).

This study also showed that local knowledge and practices can generate a set of scientific hypotheses to understand the population ecology of *Nardostachys* and *Neopicrorhiza*. Local knowledge and practices concerning these plants also suggest experiments designed to test these hypotheses (Ghimire et al. submitted). Local knowledge of population distribution, habitat variation, and people's harvesting preferences enabled us to select populations of *Nardostachys* and *Neopicrorhiza* for ecological study and design experiments to monitor impacts and compare variation. The differences in harvesting approach between *amchi* and commercial collectors further enabled us to design harvesting simulation experiments to compare the effect of varying harvesting intensity on population dynamics of the two species. The local perceptions of the growth pattern and life-cycle stages of these two species of MPs (Fig. 4) were incorporated in the design of the harvesting treatments and during scientific monitoring of their population dynamics. This experiment will enable us to test the hypothesis that the selective approach of *amchi* allows a more sustainable exploitation of the harvested species of MPs. Thus, ethnoecological findings on how people perceive the biology and ecology of these two species and on the factors they take into consideration for collection, can inform scientific research on their population ecology.

CONCLUSION

Striking variations were revealed in the level of knowledge, as well as in harvesting practices, among different social groups and categories within groups.

This variation can be related to types of activities and levels of reliance on natural resources, types of cultural bonds to the land, levels of specialization, and extra-local factors that govern these activities. It appears that the different medical cultures in these two sites strongly determine people's knowledge about both the identification and use of medicinal plants. Other cultural or social traits, such as the previous existence of strong formal institutions governing access to resources and also more informal social rules, also merit consideration. Commercial collectors' knowledge, although considerable regarding the species they collect, is less culturally integrated, but their knowledge base indicates the potential for improving management, provided the market is well organized. There are many signs of commercial collectors' capacity to adapt to new institutional and market conditions, such as their higher level of knowledge compared with non-specialists, and their interest in new domestication and cultivation experiments.

This study shows that the heterogeneity of knowledge and practices within a given area is important to consider in designing sustainable management practices. It suggests the need to reinforce institutional contexts in which knowledge and sustainable practices may find appropriate conditions for their expressions. As highlighted by Agrawal (2002), it is important to bring to the fore the institutions and practices sustained by different forms of knowledge, rather than focusing on knowledge alone. Heterogeneity of knowledge and practices also suggests the utility of approaches designed to facilitate knowledge transfer and learning processes between different social groups. Given the importance of MPs to livelihoods for the two social groups present, developing a common view of problems they face, through consultation between the two groups and general guidelines for adaptive management approaches, as suggested by Johnson (1999), is an important avenue for future work.

This study shows that indigenous or local knowledge is not a simple set of semantic categories or a static cultural resource. The dynamic aspects of knowledge systems, as well as their practical and institutional contexts, should be identified to facilitate their incorporation into new resource management approaches.

Responses to this article can be read online at: http://www.ecologyandsociety.org/vol9/iss3/art6/responses/index.html

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