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Commercial Extraction of *Picrorhiza kurrooa* Royle ex Benth. in the Western Himalaya

Patterns of Collection, Processing, and Conservation Threats

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Indiscriminate extraction of *Picrorhiza kurrooa* is a serious threat to the population of this Himalayan medicinal plant. Over 90% of the market demand for this species is met from the wild. We conducted a study on the patterns and

processes of kutki extraction in a part of the Dhauladhar range, Western Himalaya, in the state of Himachal Pradesh (India). Semistructured interviews and participant observations with the medicinal plant collectors ($n = 85$) were used to assess current trends of medicinal plant extraction. It was revealed that the collectors camp at altitudes > 3500 m and collect medicinal plants over a period of 5 months. Individually they collect 5.2 ± 0.37 kg (fresh weight) of kutki/day. To get 1 kg dry weight of the plant, as many as 300–400 individual plants are uprooted. Further, the initial processing

of the material is done in the wild; ca. 1 MT of fuelwood, comprising sensitive tree line species, is burnt to dry the same amount of collected material. This is a threat not only to the survival of the plant itself, but also to that of the sensitive tree line species. The study reveals that the extraction of kutki is unselective and unmanaged, which may be a threat for its regeneration and survival. We recommend spatiotemporal regulation of kutki extraction so as to ensure its conservation. The integrated approach of taking into confidence the local people in the present study has helped in generating a reliable picture of the patterns and processes of kutki extraction. The same may be replicated in other mountain areas for other heavily extracted species.

Keywords: Extraction; medicinal plants; *Picrorhiza kurrooa*; kutki; western Himalaya; India.

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Introduction and trade value

Picrorhiza kurrooa (family Scrophulariaceae; trade name *kutki*), a perennial herb confined to alpine zones of the Himalaya, is in very high demand in the herbal market (Dutt 1928; Ved and Goraya 2008). The roots and rhizomes of *P. kurrooa* contain picrosides of great therapeutic importance (CSIR 1950–1969). In addition to use as liver and stomach medicines, they are also used in drugs prescribed for treatment of respiratory and allergic diseases (Sarin 2008). Consequently, the species is one of the top 15 plant species traded in India in terms of the economic value of traded materials (Malaisamy and Ravindran 2003; Ved and Goraya 2008). With an annual growth rate of 20% in herbal medicines in recent years, demand for medicinal plants has increased by 11.1% (Subrat 2002).

Global estimates of the *kutki* trade (Olsen and Helles 1997; Olsen 1998; Larsen 2002) suggest that the price of this species is higher than for most products from lower altitudes. The annual supply of *kutki* from Nepal, India, and Bhutan has been estimated as 375 MT (Olsen 2001).

The legal annual collection of *kutki* from Nepal has been reported as 25 MT (Malla et al 1995) and for India as 50–300 MT (Olsen 2005). However, the *kutki* supplied from Nepal and Bhutan is *Neopicrorhiza scrophulariflora*, while more than 90% of the species collected and traded as “*kutki*” in India is *P. kurrooa* (Sarin 2008).

Recently the consumption of *kutki* in different sectors in India has been estimated as 415 MT/year (Ved and Goraya 2008). In 1980, 1,468 MT of *P. kurrooa* was extracted from Himachal Pradesh (HP); this figure was 10 times higher in 1990 (Sharma 1995). As much as 9.06 MT of *P. kurrooa* was extracted from the alpine ranges of Chhota Bhangal alone from 1995 to 2000 (Uniyal et al 2006). Similar patterns have also been reported from the Gori Valley of western Himalaya, where more than 5 MT of *P. kurrooa* was extracted by 12 villages in 2001 (Virdi 2004). According to one estimate, up to 6 MT of *P. kurrooa* is extracted annually from Sikkim, a small Indian state in the eastern Himalaya (Rai et al 2000). The extraction figures, however, give only some indication of demand, as most of the trade in medicinal plants is illegal and secretive. Ever-increasing market demand, together with

overexploitation of the species, has led to concerns being raised about its declining status in the wild (Samant et al 2001; Rai and Sharma 2002; Uniyal et al 2002; Olsen and Larsen 2003).

Consequently, *P. kurrooa* is included in the Negative List of Export (GOI), Appendix II of Cities, *Red Data Book of Indian Plants and Prioritized List of Medicinal Plants for Conservation* (Nayar and Sastry 1987–1990; Sajwan and Kala 2007). Although it is heavily extracted from the entire Himalayan range, detailed information on extraction patterns is lacking, while the need for such information has been emphasized (Olsen and Larsen 2003). The present study was therefore conducted to quantify patterns and processes of *kutki* collection and to document its vulnerability.

Distribution and study area

Picrorhiza, an alpine herb usually found above 3500 m, is distributed mainly throughout the west and northwest Himalaya (Polunin and Stainton 1984). It has also been reported from some parts of the central and northeast Himalaya (Haridasan et al 2002; Rai and Sharma 2002). The present study was carried out in the alpine zones of the Dhauladhar Wildlife Sanctuary (DWLS), HP, a typical habitat of *kutki*. The study area (32°01'42" to 32°27'27"N and 76°41'41" to 77°01'42"E) covers 944 km² (Figure 1) and is drained by the Ravi and Uhl rivers and their tributaries. The major mountain range, the Dhauladhar, runs from east to west. The DWLS is located at the conjunction of the western, northwestern, and trans-Himalayan biogeographic zones where rich assemblages of flora and fauna are found.

Forty villages lie in and around the DWLS (Gupta 2004), of which 40% are involved in the collection of medicinal plants, whereas collection is negligible in the remaining 24 villages. Before the 1970s, agro-pastoralism was the main occupation of the villagers, whereas medicinal plant collection that provides the villagers hard cash in a short time has now become an important activity. Recently there have been reports of heavy extraction of *kutki* from the DWLS (Uniyal et al 2006).

Field and research methods

Field surveys were conducted in the DWLS from April 2007 to August 2010. This involved reconnaissance surveys of the villages and interactions with the village headman and the people at large, so as to build confidence with them. Open-ended questionnaires were used to gather information on their socio-economy and seasonal activities (Clarke 1986). The year 2007 was totally dedicated to this purpose. Analysis of the information collated revealed that 40% ($n = 16$ villages) of the villages were involved in the collection of medicinal plants. Of the 16 villages, 9 located away from road head and close to

alpine areas were rated as heavy collectors and 7 as moderate collectors. Door-to-door interviews of the 9 villages revealed that 75% of the households were involved in *kutki* collection.

A total of 85 collectors were identified at the camping sites using snowball sampling (Goodman 1961). They were subjected to semistructured open-ended interviews. Five of these collectors were accompanied during their collection trips (Clarke 1986). Information was recorded on their strategies for collection, species collected, days spent in field, daily routine, quantity collected, method of extraction, fresh and dry weight of the species collected, processing in the field, and selling price(s). Fuelwood burned to dry *kutki* was quantified using a dial balance. Indirect observations such as hardships faced by collectors, their diet, and the resources used during their stay were also recorded.

For estimation of moisture content, the fresh weight of rhizomes and roots was recorded by drawing random samples from the material collected by the extractors. The fresh weight of *kutki* was recorded in the field using a digital balance, and the samples were later oven dried (50°C) until constant weight was achieved (Mishra 1968). This was then compared with other medicinal species in the area. Five local contractors (villagers who act as middlemen between the collectors and wholesale markets) were informally interviewed to generate information on the local market rate of *kutki*, while published information was used for the wholesale market rate (Gupta et al 1998; Samant et al 2007; Ved and Goraya 2008). Rapid vulnerability assessment as proposed by Cunningham (1996) and standardized by Wild and Mutebi (1996) was also carried out for *P. kurrooa* based on the analyses of present study and published information.

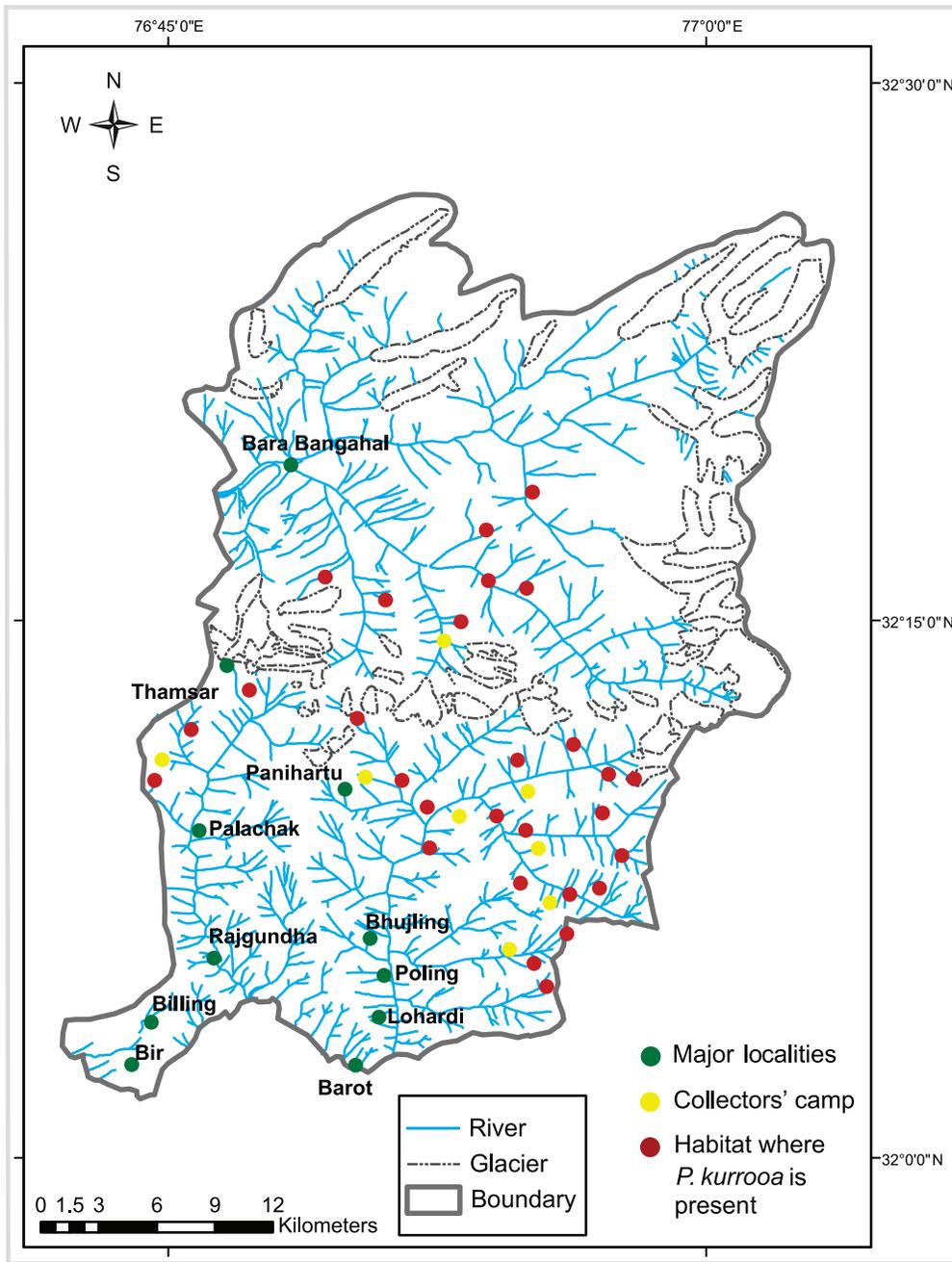
Results

Collectors

All 85 respondents revealed that medicinal plant collection was for their own use (99%) until the 1970s but is now primarily for commercial purposes (97.5%), with only a small fraction of medicinal plants (2.5%) collected for collectors' own use. Species and quantity collected depend on market demand. Collectors also reported a steady increase in the demand for *kutki* in the last 2 decades, while demand for other medicinal species such as *Aconitum heterophyllum*, *Jurinea macrocephala*, and *Dactylorhiza hatagirea* has varied from year to year. None of these plants were extracted by the collectors for commercial purposes in the last 5–6 years. However, owing to increased demand and a rise in the price of *kutki* (Samant et al 2007; Ved and Goraya 2008) in the last 2 decades, the number of *Picrorhiza* collectors has increased fourfold.

Although extraction of medicinal plants is legally prohibited from wildlife sanctuaries, the government of

FIGURE 1 Map of the Dhauladhar Wildlife Sanctuary (Himachal Pradesh), showing location of campsites. (Map by Dr Anjali Uniyal)



HP has not been able to settle the issue of the traditional rights of local people in the DWLS. Hence extraction of medicinal plants continues in this sanctuary. The collection sites of *Picrorhiza* lie in the interior areas of the DWLS (red dots in Figure 1). The increasing number of collectors and diminishing availability of the species is forcing individuals to collect farther away. For instance, villagers from Chhota Bhanghal cross various glaciers and passes to reach Bara Bhanghal and secretly collect *Picrorhiza*.

Camping

Based on the information recorded from collectors and personal observations, it was found that a minimum of 8 collectors had camped in Nagrota and a maximum of 40 collectors had camped in Umlakudo to extract *Picrorhiza*. With 8 such areas (yellow dots in Figure 1) being occupied by the extractors, the number of collectors totaled 185, and the mean number of collectors per area was 23.13 ± 12.43 .

FIGURE 2 Collectors' camp under rocks: note the living space and sun drying of *kutki* on rocks. (Photo by Dr Anjali Uniyal)



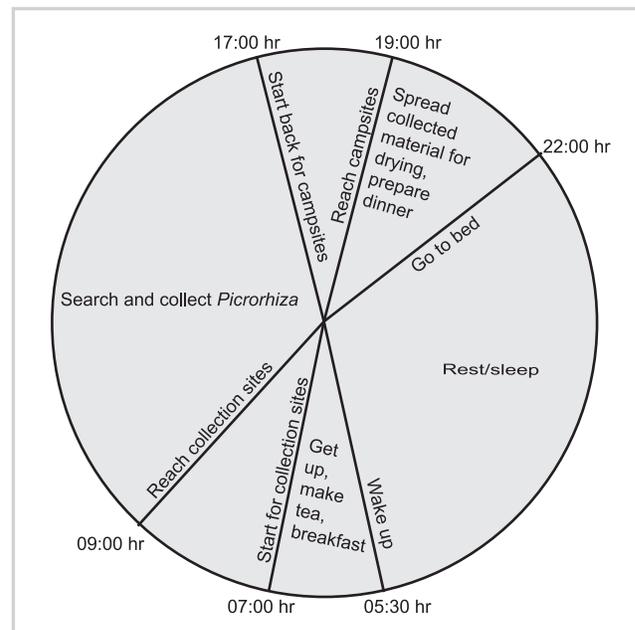
Of the 85 collectors interviewed, 95.29% ($n = 81$) were dedicated and 4.71% ($n = 4$) were opportunistic. Dedicated collectors are those who camp and collect medicinal plants for a longer duration (up to 3 weeks) in very remote areas and focus on collection of a single species, while opportunistic collectors combine this with other activities such as livestock grazing and fuelwood collection (Olsen 1998) and may include collection of multiple species. Women were generally opportunistic collectors in the study area. The collectors reported many serious injuries, including the death of 1 person in 2009 during *Picrorhiza* collection on steep slopes.

The collectors' camping sites, generally above 3600 m, are located at a day's distance from the village. Here collectors either camp in the rocky caves or set up temporary tents near water channels (Figure 2). Two to 3 people stay together so that they can maximize the use of resources. The peak *kutki* collection period is from mid-June to September, when collected material is regularly ferried to the villages. Interactions and observations revealed that 1 trip took 2 weeks (mean days /trip 14.7 ± 2.62 , $n = 85$), and collectors carried 15 kg of wheat flour and 3–4 kg of pulses on each trip.

Collection routine

Kutki extraction begins a day after the collectors reach the camp sites. A daily routine clock (Figure 3) prepared on the basis of their activities revealed that they spent 10 ± 0.5 hours each day on extraction. They take along a snack of 2 wheat flour *chapatis* and salt to collection sites and take a break of 15–30 minutes. It was revealed that most *kutki* around camp sites has been depleted, and hence the collectors take at least 1–2 hours to reach the collection sites. Although 2–3 collectors stay together in a camp, they spread out during collection to avoid competition. The entire plant is dug up and kept in gunny sack. Plants of all sizes and age classes are collected. On average, each person collected 5.2 ± 0.37 kg (fresh weight) *kutki*/day

FIGURE 3 The collectors' daily routine starts early in the morning and continues till late in the night. (Source: own data)



(based on $n = 5$, quantitative estimates on-site during collection, using a balance; $n = 80$, people interviewed and estimates based on the raw material in sacks). Based on moisture content and dry weight estimates, it was found that approximately 300 individual plants (flowering shoots) are needed to make 1 kg dry weight of *Picrorhiza*.

With energy input of 1.96 MJ/man-hour (Gopalan et al 1980), the collectors spent around 19.6 MJ of energy only for collection and an extra 3.92 MJ for other daily work, resulting in a total of 23.52 MJ for 12 hours. Their energy intake included 1 kg of wheat flour/day (14.7 MJ/kg), 200 g of pulses/day (14.7 MJ/kg), and some sugar (5.3 MJ/kg) in tea, amounting to 17.86 MJ/day. Thus *kutki* collectors have to expend greater energy during their stay in alpine areas than in their villages (energy input: 20.19 MJ/day/person; energy expenditure: 23.52 MJ/day/person). The practice, therefore, appears to be energy demanding and strenuous.

Processing

The first step in processing *kutki* is to spread the collected material for sun drying. It is subsequently manually cleaned of leaves, mud, and other unwanted material. This process takes 1–2 hours for a day's collection and damages the collectors' hands. When the fresh weight collected reaches approximately 80 kg, the material is dried in hearths (Figure 4). Initially, the flame is kept high to reduce the moisture content of rhizomes rapidly without burning the material, and then the flame is adjusted to low. Hearth drying of 70–80 kg fresh material takes 10–12 hours during the rainy season. Proper drying is a critical process, because traders offer better prices for clean and dried material. On completion of drying, the

FIGURE 4 Drying of *kutki* in hearths, using local fuelwood. (Photo by Dr Sanjay Kr. Uniyal)



weight of fresh material is reduced by half. Around 70–80 kg of fuelwood is burned in the process. The major species used for fuelwood are *Juniperus indica*, *Rhododendron campanulatum*, and *Betula utilis*. The distance traveled to collect fuelwood varies from 1.5 to 2.5 km. This requires 4–8 hours per week. Thus, in addition to collection, processing of raw material is also a backbreaking task.

Trade

Once the material is completely dry, it is packed in gunny sacks and brought to the road heads on the backs of the collectors. Collectors stay in their villages for 3–6 days and then return to the camp sites. Two to 6 such cycles of collection are carried out each season, leading to a total collection of 80 kg to 2.5 quintals of *Picrorhiza* season. Depending on the quantity of material extracted, the annual income/household ranges from Rs. 24,000 to 120,000 (Rs. 48 = US\$ 1). On average this amounts to Rs. 67,050 ± 32,171 per household. Material collected in the months of July and August is supposed to have high moisture content and is generally rated low, while material collected in September is rated high because of low moisture content. Sometimes variation in the ratings also depends on competition among local contractors.

During the period 2007–2010, the price for *Picrorhiza* at the village level varied from Rs. 220 to 340/kg. Local contractors collect the material from extractors when the quantity is more than 8 quintals. A contractor generally markets 8–40 quintals of *Picrorhiza* season from the area. Contractors market the raw material to the nearest wholesale markets at Amritsar and Delhi for a commission of Rs. 10/kg. The price increases as it enters the market away from the collection site. The Amritsar *mandi* (market) acts as an intermediate *mandi* for many Himalayan species, including *Picrorhiza* (Ved and Goraya 2008). The price of *Picrorhiza* in different *mandis* varies significantly. Prices in Amritsar for 2005–2006 were

reported as Rs. 200–250/kg, whereas the price was greater (Rs. 260–300/kg) in Thrissur, which is far away.

Conservation status of *P. kurrooa*: rapid vulnerability assessment

Recognizing the ecological and trade value of *Picrorhiza*, and considering the observations of the present study, rapid vulnerability assessment (RVA) was carried out for *Picrorhiza* (Table 1). RVA integrates both indigenous and scientific knowledge available about a resource species. It takes into account different aspects of ecology, socio-economy, and economics to facilitate a quick and broad assessment of sustainability based on scores assigned. The score of the RVA was 30 for *Picrorhiza*, which is on the higher side of the RVA index, indicating a high degree of vulnerability. Thus, immediate and intensive efforts are needed for its conservation.

Discussion

Extraction of non-timber forest produce affects ecological processes at multiple scales (Ticktin 2004). Its impacts depend on the plant part collected, the method of collection, the quantity collected, and the ecosystem where the extraction takes place. In the DWLS, extraction of *Picrorhiza* has become an important income-generating activity. Although other species such as *A. heterophyllum*, *J. macrocephala*, *D. hatagirea*, and *Rheum australe* sharing the same ecological zones also have high medicinal value, *Picrorhiza* is preferred for extraction. The primary reason for this is high and steady market demand as well as relatively low moisture content (63.1%), resulting in collection of 3–5 kg/day as compared to *Aconitum* (0.5–1 kg/day, moisture content: 68.91%) and *Dactylorhiza* (0.1–0.2 kg/day, moisture content: 83.44%).

Considering that large-scale extraction from the wild is less selective and unregulated, its effects on the population of a species are far more severe (Ticktin 2004). In the present study, it was also observed that extraction of *kutki* is unselective and unmanaged. The plant is heavily uprooted irrespective of its age and class. Repeated collection, irrespective of age and class, affects the size of the plant part collected. As a consequence of frequent collection, smaller root sizes and dwarfing have been reported in a few species (Larsen 2002; Law and Salick 2005). The same also holds true for *Picrorhiza*. Collectors have reported that the length and size of *Picrorhiza* rhizomes have diminished in recent years, and so has regeneration.

Regeneration of *Picrorhiza* takes place through both the seeds and the rhizomes (Table 1). Seed germination is low, and since most extraction takes place prior to seed set, the sole path to regeneration is through rhizomes (Ghimiri et al 2005). *Picrorhiza*, owing to its long underground rhizomes, has greater chances of survival compared to its associates such as *Aconitum* and

TABLE 1 Rapid vulnerability assessment for *P. kurrooa*.

Factors influencing a medicinal plant's vulnerability	Remarks specific to <i>P. kurrooa</i>	Score (0–3) ^{a)}
1. Life form: Slow- versus fast-growing, regeneration.	Regeneration poor through seeds but good through rhizomes.	1
2. Habitat specificity: Narrow habitat requirements are likely to make species rarer and more vulnerable.	Very habitat specific. Grows only in moist rocks and steep slopes >3500 m.	3
3. Abundance and distribution: Abundant and widely distributed species are less vulnerable to overuse.	Widely distributed in west and northwest Himalaya, though population is low.	1
4. Growth rate: Slower growing species are more vulnerable to use.	Comparatively good, but overuse increases vulnerability.	2
5. Response to harvesting: The ability of a species to regrow or increase its growth rate as a response to harvesting affects its vulnerability.	Entire plant is extracted before seed sets, hence limiting the plant's regrowth.	3
6. Parts used: Parts used significantly affect sustainability, eg, use of leaves has less impact on a plant versus use of the roots or whole plant.	Rhizomes are the part used in trade, hence the entire plant is removed.	3
7. Patterns of selection and use: If a certain size, age, or quality of plant is used, the remaining population may ensure the survival of the species.	All age and size classes of <i>Picrorhiza</i> are extracted.	3
8. Demand: The level of demand has a major impact on the plant (both quantity and frequency).	Very high and steady market demand enticing more and more people to extract it.	3
9. Seasonal harvesting: Demand may be reduced if harvesting is restricted to certain seasons.	Collection season extends from mid-June to mid-September. This is also the growing period of plants in alpine areas.	3
10. Traditional conservation practices: Increased demand and commercial exploitation break the traditional conservation practices.	Traditional conservation practices are no longer followed.	3
11. Commercialization: Once a product moves from subsistence to commercialization, the chances of unsustainable use increase.	More than 99% is extracted for commercial purposes and has a well-established trade network.	3
12. Substitute: The availability of substitutes affects species vulnerability indirectly by reducing demand.	<i>N. scrophulariflora</i> is also traded under the name <i>kutki</i> , but in India <i>P. kurrooa</i> is extracted. Sometimes adulteration of <i>Lagotis cashmiriana</i> is done, especially in materials procured from Jammu and Kashmir.	2
Total vulnerability score		30

^{a)}0 = lowest vulnerability score; 3 = highest vulnerability score (based on CSIR 1950–1969; Polunin and Stainton 1984; Ghimiri et al 2005; Rawat 2005; Samant et al 2007; Ved and Goraya 2008; Sarin 2008; Uniyal et al 2002; Uniyal et al 2006; Uniyal et al 2009).

Dactylorhiza because of its “guerilla strategy” (Lovett Doust 1981). However, recovery is difficult even for such rhizomatous species if harvest levels exceed 50% (Ghimiri et al 2005).

It has been reported that 200–300 plants are harvested as shoot parts and 500–600 as root parts to make 1 kg dry weight of *Picrorhiza* (Rai et al 2000; Uniyal et al 2009). If total extraction as reported from India is 415 MT, the number of plants extracted increases many fold, which would certainly influence plant population. The high

RVA scores for *kutki* in the present study also point to this (Table 1). Though temporal data on its availability and regeneration in the wild are meager, collectors report that the species is now restricted to steeper and less accessible areas. It was also observed during our surveys that though *Picrorhiza* habitats are widely distributed in the study area, population of *Picrorhiza* was low in sites close to collectors' camps ($2.5 \pm 0.56/m^2$, location: $32^\circ 08' 41.1''N$ and $76^\circ 54' 12.3''E$, Altitude: 3581 m) and high in areas where collection was negligible ($33.33 \pm 6.54/m^2$,

location: 32°08'55.9"N and 76°53'41.2"E, altitude: 3634 m). Thus, it seems that the time is not far off when the species will be locally extinct. Such trends have been observed in the Chhangu and Lachung valleys of Sikkim, where widespread collection of *Podophyllum hexandrum* and *Panax pseudoginseng* has now made these areas devoid of both these herbs (Rai and Sharma 2002).

An ecologically sensitive issue associated with *Picrorhiza* extraction is the demand for fuelwood to process the collected material (Figure 4). With 70–80 kg of fuelwood burned to dry 70–80 kg of *Picrorhiza*, the total quantity of fuelwood burned/collector/season is between 2 and 5 quintals. As the collectors camp above 3500 m, most of the demand for fuelwood is met from the alpine scrub community, which is an important habitat for various threatened fauna such as the Himalayan musk deer (Green 1987). Thus, fuelwood extraction not only affects the status of tree line species but also the survival of threatened wild fauna.

Another important aspect of medicinal plant extraction is associated with the collectors. In the collection of medicinal plants, collectors' gross and net margins are supposed to be almost similar, as products are freely available and the activity does not require any capital investment (Larsen and Olsen 2007). However, considering the complexities in trade and transaction at different levels (Ved and Goraya 2008), variations in margins are substantial. It has been reported that net margins for *Picrorhiza* collectors in Nepal average 46.6% of the Delhi wholesale price (Olsen 1998), while for interior areas of HP, the net share of collector is assumed to be 28% in consumer rupees (Negi and Bhalla 2002). In the present study as well, the economic benefits for *kutki* collectors appear to be high when compared to other activities in villages, but after taking into consideration the labor and energy and the hardships involved, the cost of this practice increases manifold. Moreover, margins are low in comparison to those of contractors, who sell medicinal plants for a much higher rate in the wholesale market than they pay to the collectors. It is said that the contractors have to deal with more risks and hence should have greater economic benefits (Olsen and Helles 1997), but the risks involved for collectors are no less. The former have to deal with risks involved in marketing of the raw material via roads,

while the latter have risks pertaining to natural calamities and hardships during their camping and collection. It is quite apparent that medicinal plant extraction contributes significantly toward the total cash income of collectors in many parts of Himalaya (Samant et al 2007; Winkler 2008; Weckerle et al 2010). However, collection takes an unmanaged and unregulated form in fulfilling market demands.

Hence, the main focus in conserving *Picrorhiza* should be on mitigation of extraction pressure. Sometimes conservationists have no choice but to devise sustainable harvest techniques for wild populations (Sheldon et al 1998). Developing good collection practices should be a step in this direction (Medicinal Plants Specialist Group 2007; Singh et al 2011). Market demand for various species should be monitored, and supply of these species should be spatiotemporally regulated. Another option considered suitable for the conservation of *Picrorhiza* is promotion of its large-scale cultivation. High ranking of *P. kurrooa* for ex situ propagation (Badola 2002) justifies its cultivation.

Despite the importance of ex situ conservation, in situ conservation is always essential to maintain the genetic and intraspecific diversity of a plant (Bhattacharya and Sharma 2010). Keeping in mind the targets of the Global Plant Conservation Strategy of the CBD for 2010 (Schippman et al 2002), under which no species of wild flora should be subject to unsustainable exploitation because of international trade, conservation of *Picrorhiza* is of paramount importance.

Conclusions

The present study concludes that extraction of *Picrorhiza* has become an important economic activity in the DWLS. Presently, extraction is unselective and unmanaged, thereby posing a serious threat to the plant's status in the wild. Moreover, processing of the collected material in the field is an indirect threat to the sensitive tree line. Spatiotemporal regulation of this practice is essential to conserve the species and the ecosystem. It is also emphasized that for studies of such sensitive issues, an integrated approach that is primarily driven by confidence building with local people is a must.

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