

months. Fruits are light green, ovoid, conical and blunt apically. They are distinct with five-lobed persistent calyx and produce only a single seed. The seed has no dormancy and it immediately produces a spindle-shaped hypocotyl within 3 months, while still attached to the maternal parent. Then, it detaches from the residual fruit. The hypocotyl is slender, green, clearly ribbed, angular, sulcate, 15 cm long and broadened at the lower end (Figure 1j, k). The short period of hypocotyl attachment to the maternal parent is a characteristic of cryptoviviparous species⁸. However, *C. tagal* shows this characteristic, being a true viviparous species². Further, the hypocotyl in *C. decandra* grows upright and is an important characteristic to distinguish it from *C. tagal* in which the hypocotyl grows downward⁹.

In *C. decandra*, the hypocotyl is characteristically green and seems to have the potential to photosynthesize actively with water and necessary nutrients drawn from the parent tree. Viviparous reproduction allows hypocotyls to develop some salinity tolerance before being released from the parent tree¹⁰. It provides a store of nutrients before the hypocotyls fall-off from the plant and helps in quick rooting in the muddy environment. The hypocotyl characteristics also help to develop buoyancy for distribution of the seedlings and structural stability to protect seedling from damage¹¹. Therefore, vivipary could be an adaptive feature of the plant to overcome the harsh tidal environment for seedling establishment, especially in the parental sites.

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Quantitative assessment and traditional uses of high value medicinal plants in Chhota Bhangal area of Himachal Pradesh, western Himalaya

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Information on eight highly traded and locally used medicinal plants was collected from the alpine zones of Chhota Bhangal. The study aimed to quantify the current status of these plants in terms of density, frequency and biomass, and also document the indigenous use of these plants for traditional healthcare. Quadrats of 1 × 1 m were used for quantitative assessment of the plants. Informal interviews and discussions were held with local people for recording local uses of the plants. Based on the sampling, it was found that different species had different habitat requirements. Steep slopes of Chhota Bhangal had the highest species richness and diversity, while rocky areas had the least. Maximum similarity in terms of species distribution was observed between steep slopes and undulating meadows. It was found that these medicinal plants are regularly used by the local people for curing various ailments such as stomach ache, fever and kidney stones. However, illegal extraction of plants for commercial purposes seems to have affected their population in nature. However, in comparison to few other alpine areas of western Himalaya, the present study area supports higher population of medicinal plants.

Keywords: Chhota Bhangal, Western Himalaya, ethnobotany, trade, medicinal plants.

AMONG various uses of plants, medicine is a major one. Over-exploitation of medicinal plants for trade has placed many species on the verge of extinction and a rapid decline in the population of other species^{1,2}. In order to conserve

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the medicinal plants, trade in many of them has been banned³ and their cultivation practices are now being developed. In addition to being traded, these plants are used by the local people for traditional healthcare. While the demand for these plants has increased over the years, their availability in the wild has declined⁴. Out of ca. 3500 species of flowering plants reported from Himachal Pradesh (HP)⁵, more than 500 are believed to be of medicinal importance⁶, among which nearly 130 species are in great demand⁷ and about 68 have been listed in the various IUCN threat categories⁸. It is interesting to note that most of the important and threatened medicinal plants come from the alpine areas of the Himalaya. Yet, our knowledge on the availability and population status of these plants, especially from interior areas is limited. Lack of quantitative information has been a major limitation for assessing the status of these plants, according to the new IUCN guidelines⁹. Here quantitative information on eight important medicinal plants, which are used by local people for traditional healthcare and are also in great demand in market, has been presented.

The study was conducted in the Chhota Bhangal area of HP, which forms a part of the newly created Dhauladhar Wildlife Sanctuary (Figure 1). The terrain is hilly with many precipitous cliffs, comprising primarily of quartzite rocks of Saluni formation (Gupta, unpublished). The area is drained by the Uhl river that originates from the glacier near the Thamsar Pass. The catchment area of the river is covered with forests and is rich in diverse vegetation communities. These forests harbour a variety of rare and threatened medicinal plants and support the livelihood of the local people. The local people, called 'Bhangalis' are mainly agropastoralists and seasonally use the alpine pastures for livestock grazing. They are a storehouse of traditional knowledge, especially on the utilization of plants to cure various ailments. Judicious use of these resources has always been the prime concern of the Bhangalis. Prior

to 1990, extraction of medicinal plants from the area was leased out on a five-year rotation basis, which has been stopped now (Gupta, unpublished). Though qualitative information on plants in general is available from the area¹⁰, quantitative information on their population is lacking. The study, therefore, aims at quantifying the availability of eight high-value medicinal plants in terms of their density, frequency and biomass in the alpine areas of Chhota Bhangal vis-à-vis their utilization by the local people.

As most of these plants are habitat-specific, stratified random sampling was followed¹¹. Different habitats that were identified in the field include rocky areas (areas mainly having rocky outcrops and thin soil), undulating meadows (gentle sloping areas with less than 30° slope) and steep slopes (areas with more than 30° slope). In each habitat, a representative site of 1 ha was identified. Quadrats of 1 × 1 m were laid for sampling the plant population in these sites and data on species and number of individuals were recorded. A total of 10 quadrats were laid in each site. In addition, habitat parameters such as altitude, slope and terrain were also noted. Data were analysed for density and frequency¹². Species richness, diversity and evenness were also calculated¹³. For biomass estimation, destructive sampling was avoided considering the already threatened status of these plants. Instead, dry-weight estimates provided by other workers^{14,15} for these species from similar alpine areas of the Himalaya were used. Informal discussions were also held with the local people to record traditional uses of these plants. Samples of these species were collected and identified with the help of local floras^{16,17}.

The alpine areas of Chhota Bhangal support a diversity of habitats such as rocky areas, undulating meadows and steep slopes with their characteristic plant species. *Rheum australe* was the common species that was encountered in all the three habitats, while *Bergenia stracheyi* and *Selinum tenuifolium* were found only in the sampling plots at rocky areas and steep slopes respectively. The occurrence of *Aconitum heterophyllum* was more in steep slopes, where it recorded the maximum density (3.7/m²). Density of *Picrorhiza kurroo* was more (12.5/m²) in rocky areas, while *Rheum australe* had the highest density (5.3/m²) in undulating meadows (Table 1). Thus, the alpine areas of Chhota Bhangal harbour higher density of threatened medicinal plants when compared to other areas of western Himalaya^{14,18,19}. Maximum richness of the studied medicinal plants was found in the steep slopes, where six out of the eight quantified plants occurred in the sampling plots (Table 2). Similarly, species diversity was also highest on steep slopes. This could be because steep slopes provide variation in microhabitats and are thus more diverse. Undulating meadows had medium diversity, but had the highest evenness because more number of species were dominating this habitat. Rocky areas, which are dominated by specialized plants, had minimum diversity and evenness. However, they also reported the highest density and frequency. On the other hand, steep slopes which had the

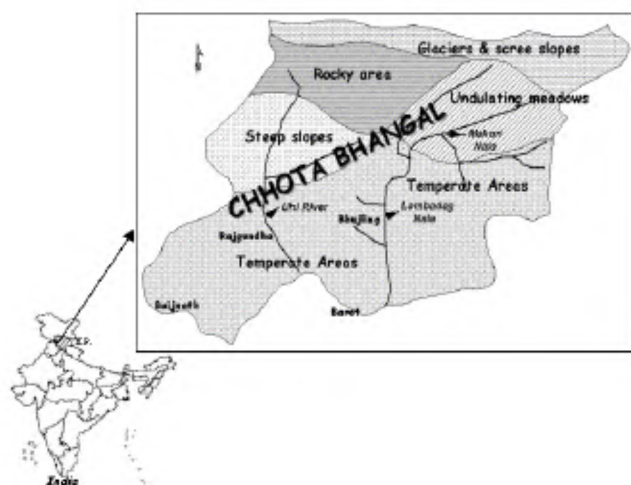


Figure 1. Map of the study area.

Table 1. Density (individuals/m²) and frequency (%) of the eight plants in different habitats

Species	SS*		RA*		UM*	
	Density	Frequency	Density	Frequency	Density	Frequency
<i>Aconitum heterophyllum</i>	3.7 ± 0.6	100	—	—	2.7 ± 1.7	66.6
<i>Bergenia stracheyi</i>	—	—	7.5 ± 1.44	100	—	—
<i>Heracleum candicans</i>	1.4 ± 0.8	33.3	—	—	1 ± 1	33.3
<i>Jurinella macrocephala</i>	—	—	7 ± 0.5	100	4.3 ± 2.2	66.6
<i>Podophyllum hexandrum</i>	0.1 ± 0.1	11.1	—	—	2 ± 1.2	66.6
<i>Picrorhiza kurrooa</i>	1.4 ± 1.4	11.1	12.5 ± 3	100	—	—
<i>Rheum australe</i>	1 ± 0.8	22.2	0.5 ± 0.5	25	5.3 ± 0.8	100
<i>Selinum tenuifolium</i>	3 ± 1.3	44.5	—	—	—	—

SS, Steep slopes; RA, Rocky areas; UM, Undulating meadows.

Table 2. Species richness, diversity and evenness in the three habitats

Area	Richness	Diversity	Evenness
Steep slopes	6	1.50	0.85
Rocky areas	4	1.13	0.81
Undulating meadows	5	1.47	0.91

highest diversity exhibited the least density and frequency. As expected, it was found that steep slopes and undulating meadows were more similar in terms of species distribution and composition, probably because of the relatively similar terrain features as opposed to the rocky areas that had comparatively different terrain.

These plants are in heavy demand in the market and are traded. The plants collected from the wild are sold in terms of weight and not in terms of number. Therefore, an estimate of the available biomass of traded part is important. The available biomass from different areas also indicates that different species had higher biomass in their preferred habitats, e.g. *A. heterophyllum* had higher available biomass on steep slopes, *R. australe* and *Podophyllum hexandrum* in undulating meadows, while *Jurinella macrocephala*, *B. stracheyi* and *P. kurrooa* had higher biomass in rocky areas (Table 3).

As elsewhere in the Himalaya, medicinal plants play an important role in the livelihood of the Bhangalis. In the absence of modern medical facilities, dependence on plants for healthcare is high. Plants are used by the local people to cure various ailments such as stomach ache, fever and orthopaedic problems. Roots of *A. heterophyllum* are used to cure stomach ache and fever, while those of *B. stracheyi* are used in the case of kidney stones. Root powder of *P. hexandrum* is used to cure gastric problems. Rhizomes of *P. kurrooa* are used against fever and joint pains. *R. australe* is used to cure fractured bones, while *S. tenuifolium* is used in the case of body swelling. *Heracleum candicans* is used to cure skin problems. In addition, *J. macrocephala* is used as incense during religious ceremonies. In majority of the cases, the underground part of the plant is used and hence uprooting of the entire plant becomes a necessary

evil. However, extraction of available resources for self-consumption has never posed a threat to the population status of these plants. For self-consumption and healing, requirements are low and also proper care is taken while harvesting the plant. Only mature individuals in minimum quantity are harvested. Though requirements for self-consumption were not quantified, however, based on discussions and observations it was found that hardly 0.5 to 1 kg of the dried material is stored and that too by traditional healers only. It is the over-exploitation of the plants for trade that has threatened their status in the wild. The plants selected for the present study are used in various systems of medicine such as Ayurveda and Unani. *A. heterophyllum*, the tubers of which are sold at a rate of Rs 1500/kg in the area, is one of the main ingredients of 'Ativishadi churna', 'Chandraprabha vati' and 'Amritarishta' in ayurvedic medicine. In the Unani system of medicine, it forms an important ingredient of 'Sufuf habib' and 'Ma'jun jograj guggal' that are used to cure pile and arthritis respectively²⁰. The dried rhizomes of *P. kurrooa*, which are sold at a rate of Rs 60/kg, form an important ingredient of 'Arogyawardhini', which is used to treat hepatobiliary disorders²¹, and also of 'Hepax' which is useful in pregnancy anaemia²². Similarly, roots of *R. australe* form an important constituent of many Unani medicines, such as 'Itrifal Mulayyin' that is used to cure constipation, 'Hab Shabyar' used to cure headaches, 'Haba Shafa' used for cough and cold and 'Roughan aqrah' used to treat piles²³. The dried roots are sold at a rate of Rs 55/kg. Due to their multiple uses in different systems of medicine, their market demands are high. Three plants, for which trade data are available from the present study area, indicate that this area has been a major collection ground (Table 4). The data show only a part of the actual amount of trade which has been legally extracted from the area²⁴, while majority of the trade is illegal and data for this are not available. *P. kurrooa* is the target species. As high as 9.06 tons of this species was extracted from the alpine areas of Chhota Bhangal during 1995–2000. This is almost 9% of the total *P. kurrooa* that was extracted from HP during this time. Next was the extraction of *J. macrocephala*, amounting

to 6.34 tons followed by *P. hexandrum*. Trade data for other Himalayan areas reveal that during 1990–92, about 62 quintals of *P. kurrooa* was extracted from Sikkim Himalaya¹⁵ and during the same time about 240 quintals of this species was extracted from Nepal Himalaya²⁵. From Chhota Bhangal area, *P. kurrooa* to the tune of 90 quintals was extracted during 1995–2000 (unpublished document, Palampur Forest Division, HP).

Thus it can be seen that the alpine areas of Chhota Bhangal have the potential to harbour rich populations of high-value medicinal plants. This can be attributed to its unique location at the conjugation of three biogeographic zones, viz. western, trans and northwestern Himalaya. The diversity of habitats in Chhota Bhangal, its remoteness and relatively difficult terrain further add to the richness of the area. However, increasing use of resources and excessive livestock grazing, in due course of time, are likely to affect the population status of these plants. It is to be noted that annually more than 180,000 livestock visit the Dhauladhar Wildlife Sanctuary (Gupta, unpublished). While extraction of medicinal plants for self-consumption is judicious and sustainable, unregulated harvest at commercial scale may not be sustainable in the long run. For self-consumption, local communities take care to harvest only mature plants, but it is not so if plants are extracted for trade; almost whatever is available is extracted. In addition, preliminary processing of the collected material, e.g. drying takes heavy toll of fuelwood that affects the timber-line species. The importance of these plants for sustaining the local people cannot be undermined. These plants form an integral part of the lifestyle of the local people, who use them in their day-to-day activities. The declining population of these plants would not only lead to their local extinction,

but will also affect the lifestyle of the local people leading to a decline in traditional knowledge. It is time that more emphasis is placed on developing agrotechniques for high-value medicinal plants. Agriculture in the Himalaya is subsistence-based and therefore, cultivation of medicinal plants in farmer's fields at the cost of traditional crops seems to be difficult and risky. Integration of medicinal plant cultivation with traditional agricultural system should be seriously looked into. More emphasis needs to be placed on quantitative studies so that the current status of these plants is known, especially from interior areas which contribute heavily to the trade market.

Table 3. Availability of herbs in terms of kg/ha in different habitats

Species	Steep Slopes	Rocky areas	Undulating meadows
<i>A. heterophyllum</i>	489.3	–	356
<i>B. stracheyi</i>	–	9375	–
<i>J. macrocephala</i>	–	4375	2706.3
<i>P. hexandrum</i>	84.6	–	1538.4
<i>P. kurrooa</i>	24.5	212.6	–
<i>R. australe</i>	1666.6	833.3	8883.3

Table 4. Quantity of herbs extracted from the area in (tons) during 1995–2000

Species	From CB ^a	From HP ²⁴	Percentage of HP from CB
<i>J. macrocephala</i>	6.34	632.7	1.02
<i>P. kurrooa</i>	9.06	108.3	8.37
<i>P. hexandrum</i>	1.04	37.3	2.78

^aChhota Bhangal, Unpublished document, Palampur Forest Division, HP.

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Evidence of ancient sea surges at the Mamallapuram coast of India and implications for previous Indian Ocean tsunami events

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The Indian Ocean may have a geologic history of tsunami events similar in size and source area comparable to that of the 26 December 2004 event. Searching for geological evidence for previous tsunamis in the near-source region is one way to constrain previous occurrence of such events. Since the 2004 tsunami proved devastating even far from its source, evidence for predecessors can be sought in remote locations, including the east and southwest coasts of India. Here we report observations from two trenches in the Mamallapuram (Mahabalipuram) beach, 55 km south of Chennai (Madras) on the east coast of India, an area also affected by the 2004 tsunami. We discuss the possibility that the sections in question may contain evidence to suggest two pre-2004 tsunami events occurring ~ 1000 years and ~ 1500 years ago respectively.

Keywords: Geological evidence, Indian Ocean, Mamallapuram, tsunami.

THE great tsunami of 26 December 2004 affected most parts of the east coast of India (Figure 1). Thousands of people living in the coastal regions of the Indian Ocean fell victims to this unprecedented event. Although smaller tsunami events have been registered in the past, events comparable to that of 2004 have not been documented. Telltale evidence for such occurrences provides constraints on the regional tsunami history, an important input for future hazard evaluation. We believe that with a rich cultural heritage, some of the ancient settlements along the east coast of India may prove to be potential sites for preservation of such evidence of destruction. We made a preliminary search at Mamallapuram, an important port built under the Pallava kings about 1000–1300 years ago (see Keay¹) for historical details on the AD 4–9 century Pallava dynasty, which ruled parts of the present-day State of Tamil Nadu and its neighbouring areas). There are two important reasons that motivated us to begin investigations here. One, the 2004 tsunami, surging as much as 3–6 m above datum, stripped beaches and created circular depressions along the Mamallapuram coast, now filled with tidal water (see also Chadha *et al.*²). We suspect that the events in the past could have affected the coast in a similar fashion. Two, scouring along the beach exposed buried rock sculptures and temple basements that prompted the Archeological Survey of India (ASI) to excavate these sites, exposing multiple occupational levels. This gave an opportunity to examine the deep trenches (~ 4 m) that were also expected to provide reliable chronological constraints of the event horizons.

Early navigators refer to Mamallapuram as a town of the seven pagodas (turrets of the Hindu temples). Many scholars believe that the sea had encroached on these temples in the past; the only surviving structure is the Shore Temple (a world heritage site) that escaped the 2004 tsunami because it stands behind a shore protection wall. Further, this temple built on hard rock, would have resisted the scouring action by the tsunami at the foundation level, which probably explains its long-term stability. The other temples are completely submerged today, but their top parts were visible until a few centuries ago³. If this is caused by rise in sea level relative to land, coastal retreat may explain the references in the ancient South Indian texts about episodes of great flooding⁴. Chambers⁵, an early British explorer, attributed the submergence to ‘overflowing sea’, which he suspected was caused by an earthquake.

Positive evidence for coastal retreat was recently found through underwater exploration on the northeastern side of the Shore Temple, about 600 m from the present coast. The exploration revealed remains of huge stone constructions, dating to 8th century AD, at 6–15 m below the present sea level⁵. Considering an average erosion of 55 cm/yr, the shoreline 1500 years ago must have been about 800 m seaward of the present coast⁶. It is therefore reasonable to believe that structures now offshore must have been onshore ~ 1000 years ago⁵.

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